# BURNING GROUND COVER AND ITS EFFECT ON ARTHROPODS

By

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BURNING GROUND COVER AND ITS EFFECT ON ARTHROPODS



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# PREFACE

The practice of burning ground cover either by controlled methods or indiscriminately in an effort to eradicate or control some particular species of crop pest is one about which there has been a great deal of controversy and a very limited amount of experimental work. Some of the studies that have been made indicate that burning was practical in some areas for the control of certain pests when cultural practices and chemical control had failed. Workers in other fields who are not primarily interested in the effects of burning on arthropod populations have shown by experimental methods that the deleterious effects of such practices tend to be greater than any benefits.

With these and many of the other points of controversy in mind my major advisor, Dr. F. A. Fenton, Professor of Entomology and Head Emeritus of the Department of Entomology suggested that I conduct an experiment and study the immediate and delayed effects of burning different grasses on arthropod populations. Through a series of similar experiments I have made an effort to determine some of the major factors that should be taken into consideration before burning is indiscriminately done or relied upon as a measure of control.

I wish to express my appreciation to my major advisor for his valuable assistance and constructive criticism during the time this experiment was conducted. I wish to thank Dr. D. E. Howell, Professor and Head of the Entomology Department for his constructive criticism and suggestions; Drs. R. R. Walton, Associate Professor of Entomology, J. M. Green, Professor of Agronomy and Head of Cotton and Fiber Research and D. E. Bryan, Assistant Professor of Entomology who served as my thesis committee. Grateful acknowledgment is made to Professor Glenn R. Durrell, Head of the Forestry Department; to Drs. W. W. Hansen, Professor and Head of the Botany Department and H. I. Featherly, Professor of Botany, for the loan of equipment and for their suggestions in making quadrat maps; W. L. Wray, Division of Entomology, North Carolina Department of Agriculture, Raleigh, North Carolina, E. W. Baker and Miss Kellie O'Neill, U. S. D. A., Insect Identification Section; to C. C. Hoff, Associate Professor of Biology, University of New Mexico and J. H. Young, a major student in Entomology, Oklahoma A and M College, for identification of the majority of arthropods listed in this thesis. My sincere thanks to G. A. Bieberdorf, Assistant Professor of Entomology, D. A. Garrett and R. E. Furr, Graduate Students for photographic work; to R. D. Caid, Graduate Student, M. J. Owen and C. M. Wade, for their assistance in project manipulations.

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# INTRODUCTION

Prior to the discovery of some of the new insecticides, it was a common occurrence to see farmers and ranchers burning off ground cover on waste land and sometimes even on crop land, in an effort to eradicate or control some species of insects. This practice has, at times, been recommended by some entomologists in the United States.

There has always been a doubt as to the value of periodical burning of pastures and wastelands. There has been much speculation and a very limited amount of experimental work as to its effect on insects. There are those entomologists who have advocated burning crop, grassy and weedy areas as a community project to aid in control of a certain insect pest.

Others claim that the deleterious effects of burning ground cover will, over a period of time, overshadow any usefulness of such practices.

The experiment was to have a two-fold purpose: first, to study the immediate effect upon populations and second, to see what the effects would be over a period of time after the ground cover had been removed by burning.

# REVIEW OF THE LITERATURE

Some of the literature on burning ground cover and its effects on arthropod populations has been based on experimental data. Much, however, is only supported by theory or visual observations. In the literature reviewed on burning for insect control, there was practically no consideration given to the deleterious effects that have been shown to occur in some areas where burning was done. Some of these are: reduced soil fertility, detrimental effects to farm structures and destruction of certain predators of injurious insects. The removal of cover for small game is a detrimental factor that has been given much attention by workers in wildlife conservation (Baumgartner, 1945). On the other hand there have been some cases where burning was beneficial to plant life (Green, 1931).

The effect of burning ground cover on arthropods

Bissell (1939) in an examination of 561 broomsedge clumps found that burning killed 15 of 17 spotted cucumber beetles, *Diabrotica undecimpunctata howardi* Barb.,[1] and 21 of 92 cowpea curculios, *Chalcodermus aeneus* Boh. Burning was done at different times, between December, 1937 and March, 1938. Counts made in the 302 unburned clumps showed that natural mortality was low. This was probably due to the depth the above named species had penetrated in the soil at the broomsedge base thus avoiding winter freezes. He suggested that spotted cucumber beetles hibernating in broomsedge may be readily killed by burning.

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[1]These and all subsequent specific names except in the order Acarina and Thysanoptera are those approved by the Am. Assn. of Econ. Entomologists. Jour. Econ. Ent. 43 (1): 117 pp.

Blanchard (1933) stated that the successful control of aphids and weeds in alfalfa growing in the Antelope Valley of California, necessitated the burning over and destruction of all green growth in alfalfa fields. This was usually accomplished by simply setting fire to the dry plant growth along ditch banks and fence rows, or in the main part of the field. Such burning was found to be thorough only in the areas having an abundance of dry vegetation, and was accordingly very irregular in most fields. Some attempts to burn fields were made by spraying fuel oil over them and then igniting it. This was found to be very satisfactory. A number of machines known as "stubble burners," manufactured in Canada were used in 1926 for burning aphid-infested fields. Other types of commercial field burners were tried with varying success. Burning was found to be a profitable operation during a very restricted period from March 12 to April 1. Earlier burning permitted serious reinfestation.

Davis (1934) found that burning of the winter quarters of the chinch bug, Blissus leucopterus Say, would in some cases reduce the population 25 to 50 percent. He advised that when burning of winter quarters of the chinch bug was done that it should be as a community project.

Bird (1934) from visual observations, stated that the indiscriminate burning of hedge-rows, swamps and fence corners, or any other wasteland, was the cause of the decline or almost complete extermination of the Noctuid genus Papaipema (Lepidoptera)!

Beal (1932) found that the turpentine borer, Dendroctonus valens Lec., attacked principally the faces of long leaf and slash pines which had been exposed by fire or otherwise injured so as to expose the sapwood. He found that the fire removed the protective covering of gum on the faces, thus giving the borers a chance to enter the sapwood.

Craighead, et al., (1928) found the death of 16 shortleaf pines was due to attack of the southern pine beetle, Dendroctonus frontalis Zimm. This attack followed a fire that had burned over the forest and had not killed the trees but did enough damage so the beetles could gain entry. This insect was not noticed in large numbers until after the fire.

Dahms (1935) stated that overwintering chinch bug populations were reduced by burning as a direct result of the heat and indirectly by removing the shelter so they were exposed to winter freeze.

Rice (1932) demonstrated that the animal population, exclusive of ants, decreased in burned over areas. Comparison of an unburned clump of bunch grass with one that had been burned showed that all animals not killed by burning migrated to nearby areas affording cover.

Hughes (1943) found that burning over alfalfa when it was heavily infested with the alfalfa plant bug, Adelphocoris lineolatus (Goeze), rapid plant bug Adelphocoris rapidus (Say), and the tarnished plant bug *Lygus oblineatus* (Say), gave the only practical control results. He also recommended that, in the area of Minnesota where this experiment was conducted, burning should be done on a community basis. In thoroughly burned over fields from June to September 1942 the plant bug population was low enough to assure a seed set. The average for the burned over plots was 32 per 50 sweeps. In check areas the count average for the same period was 146 per 50 sweeps.

The effect of burning on vegetation

Burning, with the thought in mind that grasses will appear earlier in the spring, is one that is believed to have been started by the American Indians. Some authors think perhaps the Indians burned off small areas, so the wild game would graze there earlier and thus make hunting easier. There is the major question now as to whether or not the grasses actually came up quicker or could be seen earlier because the dead grasses and debris had been removed by fire.

Observations of Pickford (1932) on a foothill range in Utah indicated that the total plant density was about the same on the ungrazed burned area as on the ungrazed unburned one. The burning had a tendency to decrease the density of the perennial grasses and increase the density of annual grasses. The sage brush was destroyed by burning and the total grazing capacity was reduced 50 percent. The annual grass that showed a tendency to increase sharply in density, was downy brome. This grass, unlike some of the native perennials, is only palatable for a short period of time.

Aldous (1934) found the yield of bluestem to be sharply reduced, in Kansas, in burned over pastures.

Elwell, et al., (1941) found the hay yield to be decreased by 1,366 pounds per acre or 52 percent. The total yield of hay was reduced 40 percent by two years of fall burning.

Effect of burning vegetation on soil fertility

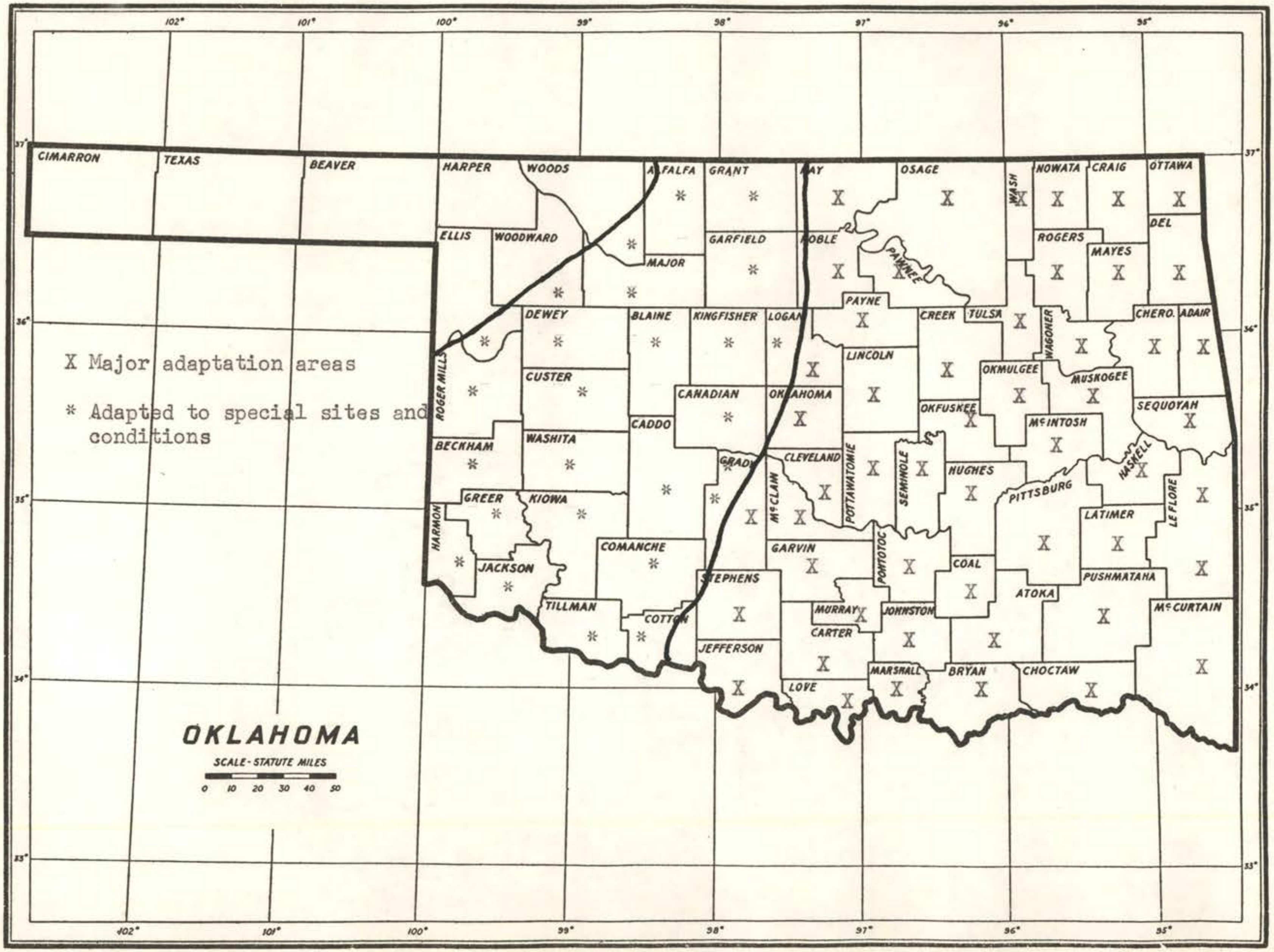
For the past few years, there has been much consideration and experimental data on burning to determine its effect on soil fertility. The literature available on this subject, is probably more comprehensive than that published on any other phase on the effect of burning. The reduction of soil fertility as a rule is brought about slowly, however, there have been cases where this was not true, and immediate serious losses of plant nutrients could be detected.

Barnette and Hester (1930) found that burning over a period of 42 years caused a decrease of 121,289 pounds of organic matter per acre to a depth of 45 inches. This amounted to total loss of 1,126 pounds of nitrogen or an annual loss of 27 pounds per acre.

Aldous (1934) demonstrated that over a five-year period, burning of bluestem in Kansas did not cause a decrease in organic matter or nitrogen.

Elwell, et al., (1941) stated that burning reduces the reproductivity of pasture soil by rapidly oxidizing the partially decomposed organic matter, thus placing the minerals contained in the vegetation in a form which may readily be removed by leaching or erosion. A less desirable condition for soil microorganisms is also brought about.

Map 1, Areas of Oklahoma having an adaptation to bermuda grass.[1]




[1]Elder, (1953).

# METHODS AND MATERIALS

Experiments on burning three types of ground cover, with especial reference to its effect on arthropod populations, were conducted between October 19, 1954 and March 31, 1955. The different types of grasses were bermuda, weeping lovegrass, and bunch grass. These types of cover were selected because they best represent the general pasture and wastelands of this state that are burned periodically in an effort to control some species of insect.

## Plot locations, descriptions and importance of grasses

Bermuda plot: This plot was located east of the spillway of Lake Carl Blackwell, in an experimental area of the Entomology Department. The predominant grass growing in this plot was bermuda, *Cynodon dactylon* of average height and distribution (Plate 1). The size of this area was approximately 50 by 50 feet. It was joined on the north by a field of alfalfa, on the south by a county road and on the west by a field of mixed grasses.

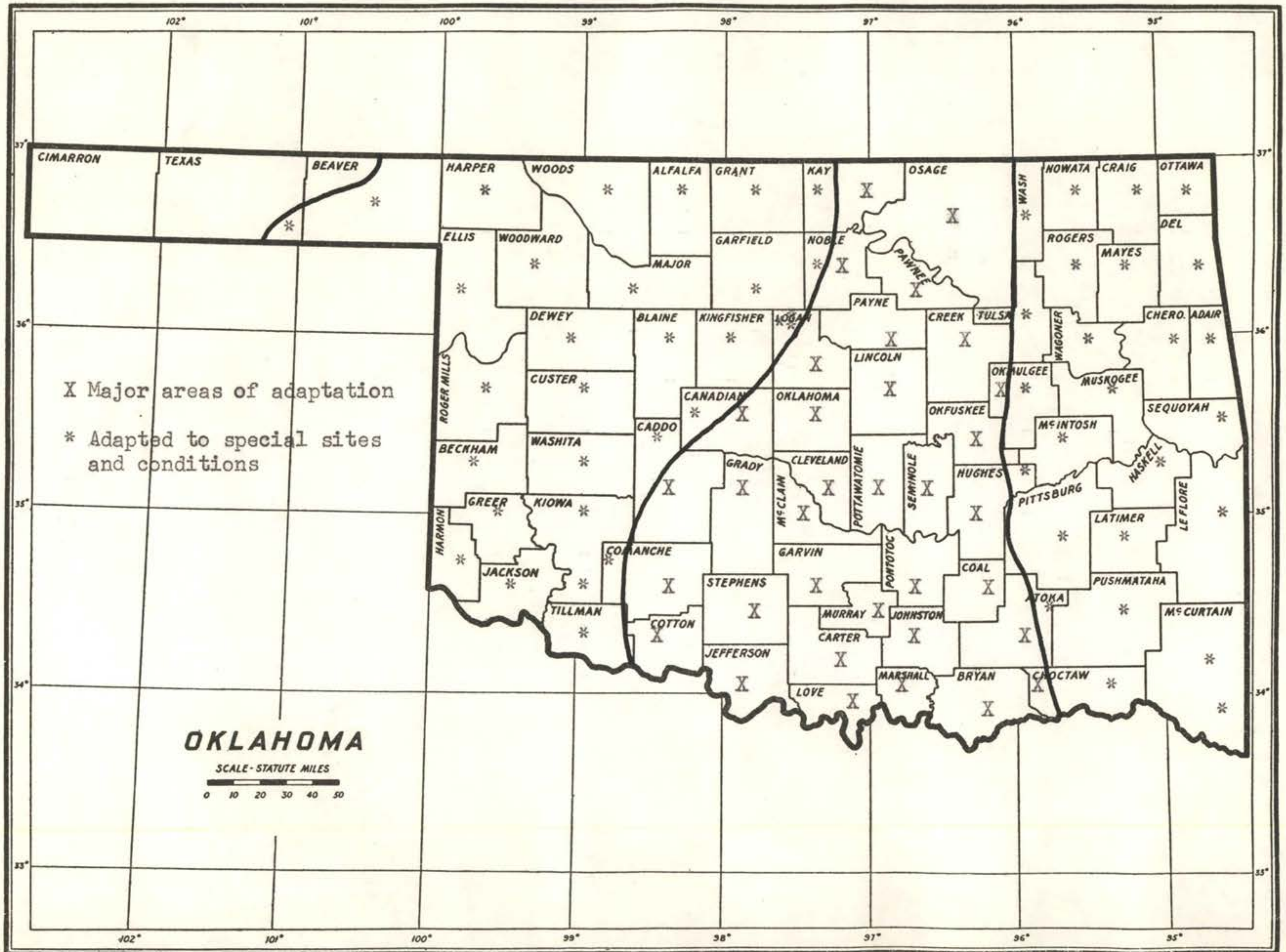
According to Elder (1953) bermuda grass is a dependable pasture grass in Eastern Oklahoma and has a major adaptation in 40 counties (Map 1). Besides being a good pasture grass in over half of the state, bermuda aids in checking erosion on cultivated hillsides.

Bermuda is criticized justly because of its persistance in an area once it is established and because there is little chance of reclaiming such areas for farming or other grasses. According to Matlock, et al., (1954) the palatability of bermuda is rated medium as a hay and high as a green forage for livestock consumption.

Weeping lovegrass plot: This plot was located in the southwest corner of the agronomy farm at Perkins Corner. The general area to the west of this plot was used by the Agronomy Department in 1954 for experimental chemical weed control in legumes. The predominant cover was weeping lovegrass, *Eragrostis curvula*, sometimes erroneously called "African lovegrass" or just "lovegrass" (Harlan, 1953), of medium height and very uniform distribution (Plate 2). The size of this plot was about 30 by 50 feet and included one-half of a terrace in its width. The amount of surface trash in this area was very abundant as it had not been mowed, plowed or burned for at least five years (Plate 3).

The principal use of this grass in Oklahoma, according to Harlan (1953), is for winter roughage, spring grazing, soil and water conservation and soil building for soils low in organic matter. The grass may also be used for grazing in the summer and for hay in the fall when properly managed. Matlock, et al., (1954) rated the palatability of weeping lovegrass forage low to medium and dry hay as low, for livestock consumption.

Map 2, Areas of Oklahoma having an adaptation to weeping lovegrass.[1]




[1]Harlan et al. (1953).

Bunch grass plot: The last plot used in this experiment had about equal amounts of two species of bluestem, *Andropogon scoparius* and *A. furcatus*, as the predominant cover. This plot was located in a typical fence row about one-fourth mile north of highway 51 and on the east of Stillwater creek. A cultivated field, where grain sorghum was grown in 1954, was on the east side of the plot. The size of this area was about 20 by 100 feet.

The two types of grasses used in this plot are distributed over a large part of this state and have a very high palatability rating for livestock both as a forage and dry hay (Matlock, 1954).

Plate 1. Bermuda grass plot one month after burning, Lake Carl Blackwell

Plate 2, Weeping lovegrass plot before burning, Perkins

Plate 3. Weeping lovegrass plot one month after burning

Plate 4. Bunch grass plot before burning, Stillwater

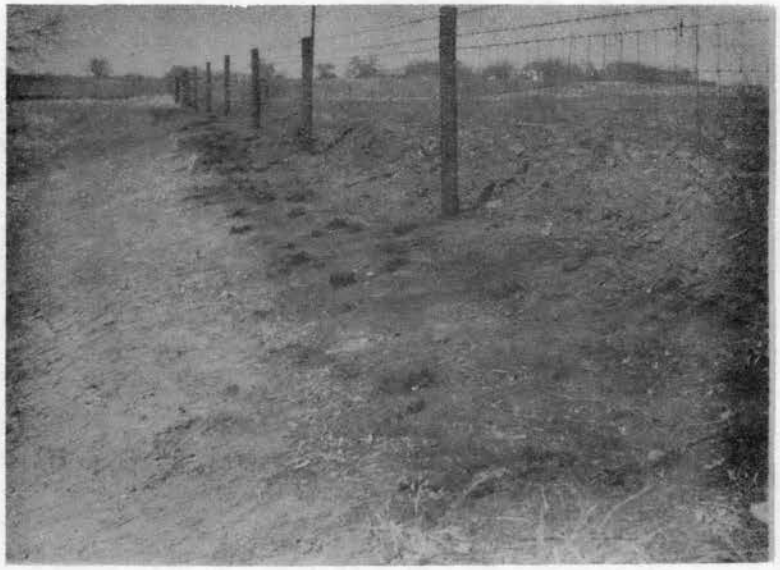


Plate 5. Bunch grass plot one month after burning

Plate 6. The average surface trash condition in the weeping lovegrass area before burning

Plate 7. A typical clump of bunch grass where 1,192 chinch bugs were collected

Plate 8. A partially burned clump of bunch grass where 469 chinch bugs were collected after burning

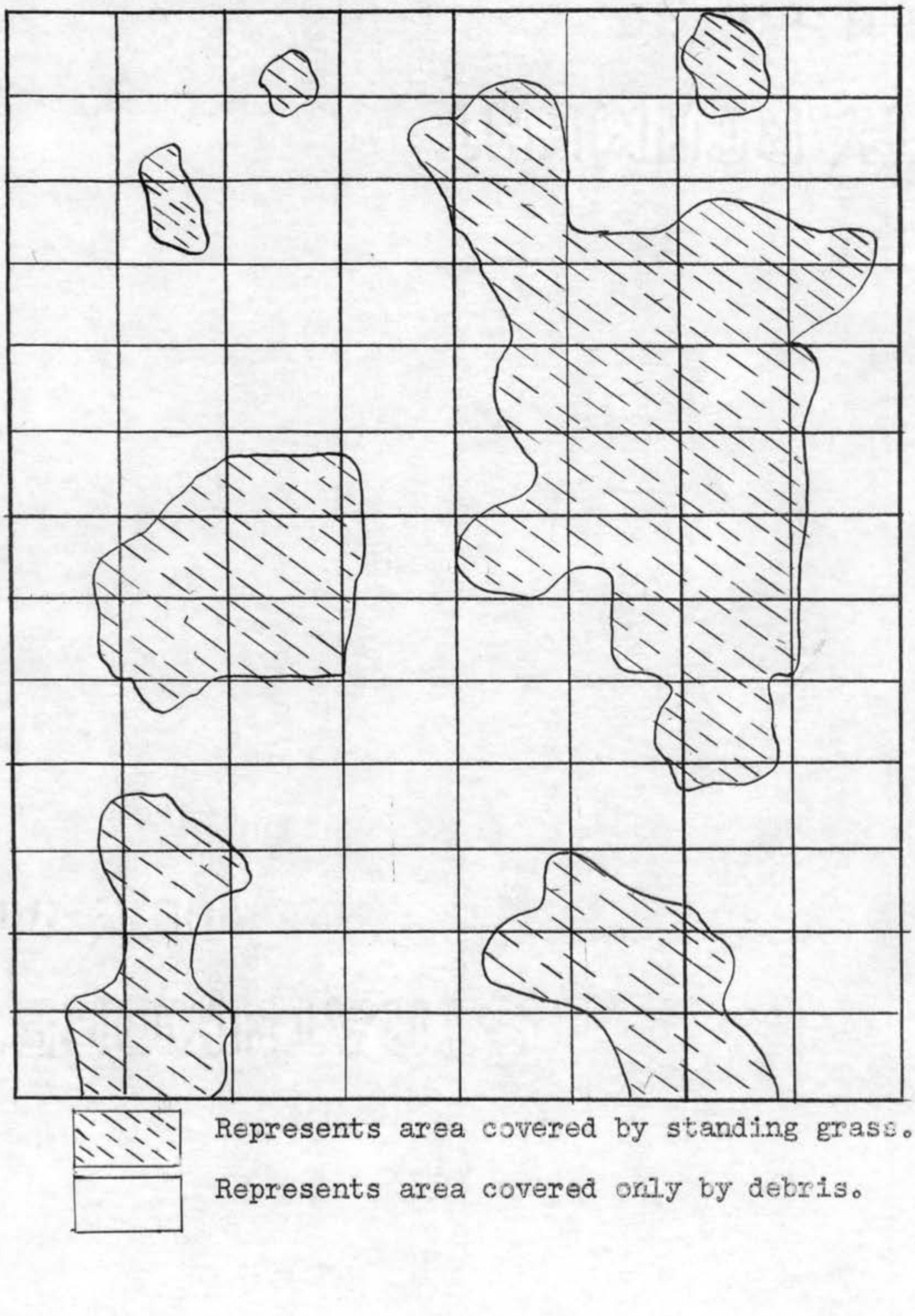
## Procedures

Selection of plots: The choice of these different plots was made on college property, where adequate areas could be found to burn and yet not disturb other experimental work. No effort was made to choose a plot where an economic pest was known to be hibernating, except in the case of the bunch grass. This area was selected because a fairly heavy overwintering chinch bug population was known to be there.

The weeping lovegrass and bermuda areas were chosen primarily because they represent the extremes of height of pasture grasses in Oklahoma (Plates 1, 2). It was also thought that the difference in height and amount of ground cover could be correlated with the temperature levels produced during burning.

Quadrat mapping: The percentage of vegetation of each plot was calculated by a randomized system of quadrat mapping. A metal frame, one meter square was used for plotting the vegetation. This could be divided by a cross bar system into one-hundred equal units so the vegetation could be plotted more accurately on a small paper replica of the qradrat. The amount of plant cover shown in this paper was plotted and then measured with a planimeter. Five areas were mapped and measured in each plot. The average was taken as the percent of ground cover for each entire plot (Map 3).

Map 3 Shows 31 percent ground cover in one area of the weeping lovegrass plot.



Represents area covered by standing grass.

Represents area covered only by debris.

Sampling for Arthropods

Sweeping: Sweep samples were taken only in the bermuda plot (Table 1). This was done because on October 19, when this plot was first sampled, some arthropods could be collected by such methods. When the other plots were sampled most arthropods were in hibernation and relatively few or none could be picked up by sweeping. These samples were taken in an ordinary sweep net by making 25-sweeps as close to the ground as possible. Approximately one-fifth of the area in the plot was covered in making the 25-sweeps. Five such samples were made each in a different area of the plot.

After each sample was taken the arthropods were killed with fumes of a small amount of carbon tetrachloride. Only a short time was needed before they became incapacitated and could be removed from the net thereby eliminating any possibility of escape. They were then preserved in a small amount of alcohol and kept for later identification.

Soil and trash samples: Twenty trash samples were taken at random in the bermuda and lovegrass plots by placing a one-half square foot metal sampling device on the surface of the soil and taking all the trash within that area. This trash was placed in paper bags and transferred to Berlese funnels as soon as they were brought in from the field. This random type of sampling was not employed in the last plot because a clump of bunch grass was purposely included in each sample. At first the trash and surface soil samples were taken separately in the bermuda and lovegrass plot to get some idea of the different species that were to be found in each habitat. When the analysis of these samples was made and compared with samples where both trash and the first one-inch of soil were combined, no particular advantage was found in keeping the soil and surface trash separated.

Use of Berlese funnels: Several methods of using the Berlese funnels for the recovery of arthropods from the samples were tried. All methods apparently gave good results in the recovery. The method finally decided upon was as follows: All of the excelsior was removed except a layer about one-half inch thick. The sample was then placed in a 10-inch paper plate having a hole in the center about six inches in diameter which was covered with wire of one-fourth inch mesh. A small amount of excelsior was placed over the wire before the samples were put in the plate. These were then left in the funnels from four to eight hours depending on how wet and cold the samples were. This method was very successful in keeping the trash out of the preserving fluid. A 200-watt bulb was used in each funnel to drive the arthropods down into the preserving media. Precautions were used where samples contained considerable amounts of grass because sufficiently high temperatures were created to set fire to grass and excelsior.

Meteorological data: The wind velocity, atmospheric temperature and humidity were recorded immediately before each plot was burned (Tables 1, 2, 3). The wind velocity was measured with a small anemometer. The atmospheric temperature and humidity were calculated with an ordinary wet and dry blub thermometer.

Soil moisture: The percent of soil moisture was determined on a weight per weight ratio, by drying five samples of approximately 100 grams of soil in a 100°C. oven until no further loss of weight could be detected. Five metal containers were weighed separately before and after the soil was placed in them and weighed again after removal from the oven. The percent of soil moisture was then determined by the weight loss from five samples in each plot prior to burning (Tables 1, 2, 3). This was done because of the possibility that the depth of heat penetration in the soil and the amount of temperature produced could be correlated with the amount of soil moisture present at the time of burning each plot.

Burning methods and precautions: Precautions were taken to have ample fire fighting equipment and help on hand at the time of burning each plot. Soil was also placed around fence posts to keep fire away from them. All plots were started as back fires. This usually caused the fire to burn slower and the grasses were burned off closer to the ground than when a fire was set with the wind. No additional fuel was used because there was a sufficient stand in all cases to get fairly even burning. Also the use of fuel oils could kill some of the insects present. After plots were burned off they were checked to make sure that no danger of fire breaking out into other areas existed. In the bermuda and love-grass plots, the edges were soaked with water as a further precaution.

Recording soil temperatures while burning ground cover: Devices for recording maximum temperatures during burning were installed prior to igniting the grass except for the bermuda plot. At the time this plot was burned no such devices were available for recording temperatures. The records presented for the bermuda plot (Table 5), were taken at a later date in an adjoining but very similar area. They should be quite similar to the temperature readings at the time the first area was burned. The system of taking temperature records consisted of making a series of marks with the Tempil Sticks[1] on a small piece of asbestos shingle. A definite pattern was used in making the marks in a regular series according to their melting points. The plan was to start with the one melting at the lowest temperature and subsequent marks were made in a series progressing from this point to the one melting at the highest temperature.

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[1]The name for crayons made of hard materials each having a different melting point.

The fact that the crayons were given different colors aided in identifying the marks after the plots were burned.

Five points for determining maximum temperatures reached were selected at random in each plot. At each point a plug of soil and grass was carefully removed after which shingles each bearing the mark of all Tempil Sticks was placed at different levels. The plug was then replaced, a piece of shingle left for measuring surface temperatures, and the point marked. After burning the plug was again removed, the shingles taken out and read. A permanent smear of each colored mark on the asbestos shingle was made when its melting point was reached (Tables 4, 5).

Analysis of samples: All samples were examined under a 45X -- 90X binocular microscope using a gridded petri-dish and mechanical counters to facilitate a more accurate count of the species present. It was found best to count those species first that occurred most frequently. A series of all species of arthropods was kept for the purpose of identification. Some samples, when very trashy, had to be analyzed in small parts. As the efficiency in using the funnels became better, the necessity of separating samples into small parts became unnecessary.

# RESULTS

The results of burning ground cover on the three different plots varied considerably. This was true in each experiment in regard to total number of arthropods collected immediately before and after burning. There was also some variation in the delayed results of these burned over areas. Since this was the case, each experiment was considered separately and then a comparison made between the three plots.

## BERMUDA PLOT

A. Species and orders present before burning and their economic significance

From the data collected in this particular plot it is evident that the area was one that had a very sparse population of all arthropods (Table 1). This area was burned October 21, 1954 before the first killing frost. At that time it is probable that no species of any orders collected were in hibernation. This is one of the reasons that the sweep samples were taken prior to burning. The other is because at least some of the species collected by this method would not normally be taken by other methods used.

The final tabulations show that the Acarina were the most abundant of all arthropods collected in this plot. They were found to constitute slightly more than 50 percent

Table 1, Effects of burning bermuda grass on the arthropod population, October 21, 1954, Lake Carl Blackwell.

| Relative Humidity 55%<br>Temperature 77°F.<br>Soil Moisture 7% | | Number of Arthropods Found | | | | | Wind NW<br>MPH 0[2] |
|---|---|---|---|---|---|---|---|
| | | Samples Taken Before Burning | | | Samples Taken After Burning | | |
| | | Sweep | Soil | Trash | Soil and Trash | Soil and Trash | Percentage Reduction |
| No. Of Samples | | 5 | 20 | 20 | 20[3] | 20[4] | |
| ORDERS | No. Sp. | | | | | | |
| Lepidoptera[1] | 2 | 6 | - | 4 | - | - | - |
| larvae | 2 | 9 | 32 | 2 | 4 | 32 | - |
| Coleoptera[1] | 11 | 7 | 20 | 2 | 8 | 15 | - |
| larvae | 2 | - | - | - | 6 | 17 | - |
| Collembola | 7 | - | 36 | 15 | 130 | 547 | - |
| Thysanoptera | 4 | 2 | 4 | - | 3 | 37 | - |
| Corrodentia | 1 | - | 11 | - | 45 | 40 | - |
| Homoptera | 1 | 55 | 1 | - | 1 | - | - |
| Hemiptera | 1 | 2 | 4 | 2 | 2 | - | - |
| Diptera | 2 | 25 | 2 | - | 3 | 1 | - |
| larvae | 1 | - | 6 | - | 2 | - | - |
| Araneida | | 15 | 3 | 2 | 4 | 2 | - |
| Acarina | 12 | - | 102 | 138 | 258 | 662 | - |
| Isopoda | 1 | - | 16 | 1 | 13 | 5 | - |
| Hymenoptera | 6 | - | - | 33 | 9 | - | - |
| Totals and Averages | 53 | 121 | 237 | 199 | 488 | 1358 | - |

[1]Indicates the adults of the orders.

[2]A gusty wind was blowing but not enough to be recorded.

[3]These samples were taken just after burning.

[4]These samples were taken 83 days after burning.

of the total arthropod population taken in the soil and trash samples before burning. Nearly the same condition still existed on both sampling dates after the plot was burned. On both dates the results show that the Acarina amounted to slightly over 49 percent of the total population. The distribution of the Acarina appears to have been fairly even. They occurred in 98 percent of the soil samples and 51 percent of the trash samples taken prior to burning.

Collembola were collected next in order of abundance. The population was evidently fairly low at that particular time. They were found in only 50 percent of both the trash and soil samples before burning. This became even more evident when the total populations of the samples taken before and after burning were compared (Table 1). A total of 677 were found after burning as compared to 51 before.

Lepidopterous larvae were next to the Collembola in numbers. The total collected in soil and trash samples before burning was too low to be considered in figuring any percent of reduction due to burning. These larvae were found in only 50 percent of the first soil samples and in 20 percent of the trash samples. The total population of the adult Coleoptera was rather small. The species taken (Table 1) have not all been identified. It is rather interesting to notice the comparatively large number of species of this order for such a small total population.

The rest of the orders collected were not represented in sufficient numbers to have a direct bearing on the purposes for which this experiment was conducted. They have been listed because it is of interest to see at least a partial list of orders and species that occupy this type of habitat.

The majority of the specimens collected in the 12 orders represented have been identified to species. The rest have thus far been identified only to family and/or genus. Only in the orders Araneida and Isopoda were no species determined.

B. Temperatures recorded during burning

Maximum surface temperatures ranged from 113 to 117 degrees F. with an average of 112 degrees (Table 5). The temperature readings presented for this plot were not taken at the time of the initial burning. When the Tempil Sticks became available part of this plot that was left unburned was burned and records were taken. The temperatures recorded in this delayed test were probably similar to those when this plot was burned earlier. There was of course the possibility that the temperatures recorded might have been somewhat higher because the grass was dead at the later date and made a much better fuel. Such factors as atmospheric temperature, relative humidity, wind velocity, height and percent of grasses and debris present, were about the same when temperatures were recorded as then the first plot was burned.

Soil surface temperatures were the only readings obtained in this area while the ground cover was burning. These were probably influenced more by the limited amount of surface debris and the size of the grass at that particular time than any other existing factor (Table 5). This seems even more evident when a comparison is made of the surface temperatures recorded for bermuda as compared to those for weeping lovegrass and bunch grasses where it averaged 154 and 160 degrees F. respectively at burning time. It can also be seen that the average temperature reading for five check points on the soil surface of the bermuda plot was well below the thermal death point of 125°F. (Table 5).

C. Results of burning

The area burned over very rapidly. The total time necessary for the entire plot to burn was approximately 30 minutes.

The immediate effects of burning the ground cover in this plot on the arthropod populations, seem to question the possibility of there being any value in burning bermuda grass for the eradication or control of such species as were present in this test. There was also no apparent injurious effect on such beneficial forms as the spiders. There was a significant increase of Collembola and a slight increase of the Acarina populations in the samples taken immediately after burning. The entire population of this area was rather low at the time it was burned and therefore what seems to be an immediate slight increase in the Acarina population was probably the result of error in sampling. No explanation is offered for the very large increase in the numbers of Collembola taken after burning.

Weather conditions had been rather adverse for a period of time during 1954 and also just prior to the start of this work. The amount of precipitation for the nine months previous to the beginning of this experiment was 14 inches. For a total of 57 days during the summer months the maximum daily temperature reached or exceeded 100°F. After this work was started those conditions became somewhat more favorable (Table 7).

The only indication of a reduction in species of any order collected in this plot was the immature Lepidoptera. Those collected by sweeping were Geometridae and they were completely wiped out. On the other hand the 34 larvae collected in the soil and trash represented another species. Final samples taken 83 days after burning (Table 1) show them to have been equally numerous as 32 were recorded.

Incomplete burning of this area was expected because it was done before frost had completely killed the grass. The general appearance of this plot (Plate 1) shows practically no evidence, except for the few blackened bunch grass stools, of ever having been burned. Between October 21 when this plot was burned and the time the area was photographed there had only been 1.84 inches of rain to destroy the blackened color caused by burning. There are many factors that influence the results of burning bermuda grass on arthropod populations. It is the opinion of the writer that the height of grass and the amount of surface debris in this plot were not sufficient to cause average temperatures above the thermal death point, either on the surface of the soil or at any depth below.

WEEPING LOVEGRASS PLOT

A. Species and orders present before burning and their economic significance

All the data presented for this area (Table 2) indicate that it had a rather high population of some orders before it was burned. The order of abundance for the different groups of arthropods in this plot is similar to that found in the bermuda plot.

Acarina were found to be more abundant in this area than in the bermuda. They occurred in all of the trash and soil samples taken before burning. Those collected in this area were for the most part predacious and they were found to constitute over 50 percent of the total arthropod population. Collembola were found to be fairly abundant in this plot. At the time the first samples were

Table 2, Effects of burning weeping lovegrass on the arthropod population, November 23, 1954, Perkins.

| Relative Humidity 45%; Temperature 77°F.; Soil Moisture 7%; Wind NW MPH 15[2] | | Number of Arthropods Found | | | | Percentage Reduction | |
|---|---|---|---|---|---|---|---|
| | | Before Burning Grass | | Just After Burning | 50 Days After Burning | Just After Burning | 50 Days After Burning |
| | | Soil | Trash | Soil and Trash | Soil and Trash | | |
| No. of Samples | | 20 | 20 | 20 | 20 | | |
| ORDERS | No. Sp. | | | | | | |
| Lepidoptera[3] | 1 | 3 | 2 | - | - | - | - |
| Coleoptera[1] | 15 | 37 | 33 | 13 | 2 | 81.5 | 97.2 |
| larvae | 2 | 87 | 36 | 13 | 2 | 89.5 | 98.4 |
| Collembola | 6 | 157 | 282 | - | - | 100.0 | 100.0 |
| Thysanoptera | 7 | 142 | 146 | 5 | - | 98.3 | 100.0 |
| Corrodentia | 1 | 2 | 31 | - | - | - | - |
| Homoptera | 1 | 1 | 1 | - | - | - | - |
| Hemiptera | 3 | 26 | - | 8 | - | - | - |
| Diptera[1] | 1 | - | 1 | - | - | - | - |
| larvae | 1 | 10 | 28 | - | - | 100.0 | 100.0 |
| Araneida | | 10 | 11 | - | - | - | - |
| Acarina | 11 | 871 | 907 | 1 | - | 99.9 | 100.0 |
| Hymenoptera | 2 | 2 | 5 | - | - | - | - |
| Totals and Averages | 51 | 2348 | 1483 | 40 | 4 | 99.8 | 99.9 |

[1]Adults of the orders.

[2]A gusty wind was blowing from the southwest at 7.5 miles per hour when the fire was set but changed to the northwest and increased to 15 miles per hour.

[3]Only the larval stage is represented.

taken they made up 40 percent of the total population.

The remaining nine orders account for only 10 percent of the total population. The only species collected that could ever be considered economically important from the standpoint of crop production were in the orders Hemiptera, Homoptera, Lepidoptera and Thysanoptera. The latter was the only one where species were collected in very large numbers and it was represented by at least one species in all soil samples and in 70 percent of the trash taken when work was started in this area.

Larvae and adults of the order Coleoptera were found to be next to Collembola in abundance. The larvae were collected in 70 percent of the first trash and in 80 percent of the first soil samples. The adults occurred in the same samples with equal frequency.

The orders Hymenoptera, Diptera, Araneida, Corrodentia and Lepidoptera were collected in such small numbers that no significance has been placed on them in considering whether or not there was a reduction of the populations. They have been considered only in the percent of reduction of the entire population.

B. Temperatures recorded during burning

This plot was burned November 23. The complete burning of all grass and debris (Plate 3) was directly affected by a strong wind that kept regenerating the fire to a flaming state. The clumps of grass in all plots were found to burn off closer to the sod when there was abundant surface

Table 3, Effects of burning bunch grass on the arthropod population, February 7, 1955, Stillwater.

| Relative Humidity 48% / Temperature 63°F. / Soil Moisture 12% / Wind SW MPH 0[3] | | Number of Arthropods Found | | | Percentage Reduction | |
|---|---|---|---|---|---|---|
| | | Before Burning Soil and Trash | Just After Burning Soil and Trash | 52 Days After Burning Soil and Trash | Just After Burning | 52 Days After Burning |
| No. of Samples[1] | | 15 | 15 | 15 | | |
| ORDERS | No. Sp. | | | | | |
| Lepidoptera | 1 | 2 | - | - | - | - |
| Coleoptera[2] | 9 | 60 | 18 | 17 | 70.0 | 71.7 |
| larvae | 3 | 6 | 11 | 2 | - | - |
| Collembola | 4 | 385 | 98 | 111 | 74.6 | 71.2 |
| Thysanoptera | 3 | 48 | 1 | - | 99.8 | 100.0 |
| Corrodentia | 1 | 17 | 3 | - | - | - |
| Homoptera[4] | 1 | 32 | 9 | - | - | - |
| Hemiptera | 1 | 3598 | 435 | 236 | 88.0 | 93.5 |
| Diptera | 2 | 6 | - | - | - | - |
| larvae | 1 | 5 | - | - | - | - |
| Araneida | | 42 | 11 | 1 | 73.1 | 99.8 |
| Acarina | 3 | 223 | 67 | 43 | 70.0 | 80.8 |
| Hymenoptera | 3 | 5 | 6 | - | - | - |
| Totals and Averages | 32 | 4427 | 645 | 410 | 85.5 | 90.8 |

[1]The total number of arthropods were calculated on the basis of 20 samples.

[2]Indicates adults of the order.

[3]A gusty wind was blowing but not enough to be recorded.

[4]All were immature and apparently of the same species.

debris as was the case in this area (Plate 6).

Temperatures were recorded in only three of the five check points at a depth lower than one inch (Table 4). Two of these recorded at that depth were above the thermal death point. It is not known just how high the temperatures were above the minimum 113° F. at the one-inch depth or the maximum 175° F. at other depths. Any temperature above either of these melting points would have had bo be less than 13° F. or another Tempil Stick marking would have been smeared. Temperatures at the two-inch depth were undoubtedly influenced by the extra amount of fuel on the side of the check next to the terrace and the wind that kept the plot smoldering for at least two hours.

It is believed that the lethal readings in check areas two and three were due to a great amount of debris present on one side of these check areas. This probably caused deeper penetration of heat into the soil. This seems to be the case even more so when it is noted that only two readings were obtained at the one inch depth and both were below the thermal death point. It is most probable, that had the pieces of shingles been placed directly above each other at the different depths in each area, that temperatures above 150° F. would have been recorded at the one-inch level in check areas one and two.

In this plot (Table 4) the temperature was

Table 4, Highest smear points in temperature degrees F. for Tempil Stick markings at different depths during the burning of weeping lovegrass, November 23, 1954, Perkins.

| Check Point | 1 | 2 | 3 | 4 | 5 | Averages of the Highest Temperature Readings[1] | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth Of Readings | READINGS IN DEGREES F. | | | | | 2 | 3 | 4 | 5 |
| Soil Surface | 138 | 138 | 163 | 175 | 150 | 169 | 162 | 156 | 153 |
| 1-4 Inch | 150 | 163 | 175 | 163 | 113 | 169 | 167 | 162 | 152 |
| 1-2 Inch | 125 | 138 | 175 | 163 | - | 169 | 158 | 150 | - |
| 1- Inch | 113 | - | - | 113 | - | 113 | - | - | - |
| 2- Inch | - | 150 | 125 | 113 | - | 137 | 144 | - | - |

[1]These averages were calculated in order from the highest two readings at each depth to the average of the maximum readings at that depth.

Table 5, Maximum surface temperatures recorded during burning of the three different plots.

| Check Point | Bermuda[1] | Weeping Lovegrass[2] | Bunchgrass[3] |
|---|---|---|---|
| 1 | 125°F. | 150°F. | 175°F. |
| 2 | 113 | 163 | 163 |
| 3 | 175 | 175 | 175 |
| 4 | 150 | 163 | 175 |
| 5 | - | 113 | 113 |
| Ave. | 112 | 154 | 160 |

[1]Highest percent of ground cover and the least debris.

[2]Highest percent of debris, second in ground cover.

[3]Lowest percent of ground cover and surface trash.

essentially the same at the soil surface and to a depth of one-fourth inch averaging 153 and 152 degrees respectively. Between the mean temperatures at the surface and the one-inch levels there was a noticeable difference. The average was six degrees lower for the one-half inch level. The greatest change in mean temperatures occurred between the surface and one-inch level. However, a study of this table shows that lethal temperatures were reached or exceeded at most check points for all depths except at the one and two-inch levels.

From these data it appears that the depths at which high temperatures were recorded was somewhat dependent on the amount of fuel present and at least some wind to keep the trash and debris flaming.

The results of this test show that the most complete burning took place when the wind velocity was the highest. The oxygen supply seemed to have some relationship to the degree of temperature reached when burning surface fuel. Higher temperatures were recorded on the surface of the soil, when a moderate density of grass was present.

C. Results of burning

The immediate results of burning this area show a reduction of 99.8 percent of the population considered. These results have a rather impressive meaning to the writer. This is said because a fairly high population (Table 2) was found to be in the area prior to burning and the results should be significant from the standpoint of numbers considered. The minimum reduction obtained just after burning was for the adult Coleoptera. This percentage was 81.5 and is based on the total number collected before burning. The highest percentage reduction was for the dipterous larvae and Collembola. Samples taken immediately after burning showed a 100 percent reduction of both orders.

The analysis of samples taken in this area 50 days after burning show practically no change in total numbers of arthropods collected.

When all of the factors for this area are considered the results are as would be expected. The dense stand of grass and large amount of surface debris caused a longer burning fire which had a direct influence on the depth that lethal temperature readings were obtained. It is evident from these data that a drastic reduction of all arthropods to a depth of at least one-half inch was caused directly by the heat created while burning the ground cover of this area.

## BUNCH GRASS PLOT

A. Species and orders present before burning and their economic significance

This is the only plot where an insect of much economic importance was found in large numbers. The chinch bug was known to inhabit this area in fairly large numbers and as previously stated was the reason this plot was chosen for study. This pest represented more than 80 percent of the total arthropod population collected in samples before burning.

Collembola were found to be next in abundance. These, along with the Acarina and chinch bugs, accounted for all but 221 of the total population of these samples.

Of the remaining eight orders only the adult Coleoptera, Thysanoptera and Araneida were collected in sufficient numbers to be considered when calculating the percentages of reduction that are given (Table 3). The only other order that was sufficiently numerous so that reduction percentages could be calculated was the Homoptera. These were all immature leafhoppers and apparently all of the same species.

B. Temperatures recorded during burning

The maximum and minimum temperatures recorded on the soil surface during the time of burning were the same as for the other two plots. However, the mean surface temperature was the highest of the three plots (Table 5).

The thermal death point was reached in four of the five check areas in this plot. The pieces of shingles used for taking Tempil Stick smear records were placed at random near clumps of grass. This was done because of the sparse stand of grass (Table 6) and small amount of surface trash in areas between clumps (Plate 7). Plates for recording Tempil Stick smears were placed at the same levels as in

Table 6, Summary of the number of arthropods, percentage of ground cover, average heights of grasses and amount of debris in each of the three plots used in this experiment.

| PLOT | Number of Arthropods[1] | Percent of cover[2] | Soil Moisture[3] | Height of Grasses[4] | Debris[5] |
|---|---|---|---|---|---|
| Bermuda | 2403 | 70 | 7% | 3 in. | Medium |
| Weeping Lovegrass | 3875 | 30 | 7% | 2 ft. | Heavy |
| Bunch Grasses | 5482 | 13 | 12% | 1 ft. | Light |

[1]Total number found in each plot.

[2]Determined by quadrat mapping.

[3]Measured by drying samples in 100°C. oven.

[4]The approximate heights determined by measuring the grass at five different places in each plot.

[5]Based only on visual observations and rated by comparing the three plots.

Table 7, Maximum and minimum temperatures and amount of rainfall from October 1, 1954 to March 31, 1955, Stillwater.

| OCTOBER | | | | | | | | NOVEMBER | | | | | | | | DECEMBER | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| 1 | 79 | 66 | T | 17 | 88 | 46 | | 1 | 58 | 36 | | 17 | 73 | 52 | | 1 | 55 | 34 | | 17 | 46 | 33 | T |
| 2 | 90 | 69 | .26 | 18 | 88 | 49 | | 2 | 57 | 21 | | 18 | 67 | 50 | | 2 | 34 | 28 | | 18 | 54 | 7 | |
| 3 | 92 | 72 | | 19 | 84 | 55 | | 3 | 43 | 30 | .17 | 19 | 68 | 37 | T | 3 | 70 | 36 | | 19 | 63 | 30 | |
| 4 | 93 | 72 | | 20 | 78 | 54 | | 4 | 54 | 36 | | 20 | 71 | 37 | | 4 | 70 | 45 | | 20 | 59 | 29 | |
| 5 | 73 | 58 | | 21 | 74 | 55 | | 5 | 67 | 26 | | 21 | 65 | 41 | | 5 | 51 | 24 | | 21 | 68 | 26 | |
| 6 | 63 | 54 | .17 | 22 | 71 | 52 | .60 | 6 | 79 | 43 | | 22 | 58 | 33 | | 6 | 47 | 30 | | 22 | 66 | 32 | |
| 7 | 80 | 51 | | 23 | 71 | 50 | | 7 | 82 | 40 | | 23 | 73 | 38 | | 7 | 54 | 25 | | 23 | 60 | 28 | |
| 8 | 84 | 60 | | 24 | 69 | 54 | | 8 | 76 | 41 | | 24 | 65 | 41 | | 8 | 54 | 28 | | 24 | 63 | 43 | |
| 9 | 91 | 65 | | 25 | 75 | 57 | .13 | 9 | 75 | 51 | | 25 | 51 | 35 | | 9 | 58 | 29 | | 25 | 63 | 49 | 1.11 |
| 10 | 92 | 75 | | 26 | 73 | 47 | T | 10 | 76 | 43 | | 26 | 66 | 35 | .30 | 10 | 59 | 38 | | 26 | 49 | 37 | .29 |
| 11 | 90 | 74 | .54 | 27 | 51 | 36 | T | 11 | 75 | 44 | | 27 | 68 | 37 | | 11 | 41 | 29 | .42 | 27 | 38 | 77 | .40 |
| 12 | 86 | 59 | | 28 | 68 | 38 | | 12 | 74 | 41 | | 28 | 63 | 42 | | 12 | 41 | 16 | .22 | 28 | 36 | 24 | |
| 13 | 92 | 63 | | 29 | 63 | 45 | | 13 | 75 | 42 | | 29 | 53 | 28 | | 13 | 55 | 26 | | 29 | 43 | 9 | |
| 14 | 84 | 51 | | 30 | 62 | 29 | | 14 | 71 | 44 | | 30 | 58 | 39 | | 14 | 58 | 27 | | 30 | 45 | 22 | |
| 15 | 66 | 40 | | 31 | 59 | 30 | | 15 | 74 | 41 | | | | | | 15 | 57 | 43 | | 31 | 40 | 20 | |
| 16 | 74 | 37 | | | | | | 16 | 77 | 44 | | | | | | 16 | 49 | 31 | T | | | | |

| JANUARY | | | | | | | | FEBRUARY | | | | | | | | MARCH | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 59 | 31 | | 17 | 45 | 42 | 1.70 | 1 | 62 | 38 | | 17 | 63 | 27 | | 1 | 77 | 30 | | 17 | 51 | 38 | 0.02 |
| 2 | 57 | 29 | | 18 | 47 | 26 | .06 | 2 | 41 | 31 | | 18 | 61 | 46 | .18 | 2 | 81 | 44 | | 18 | 52 | 41 | |
| 3 | 67 | 52 | | 19 | 29 | 23 | | 3 | 40 | 31 | T | 19 | 61 | 25 | .10 | 3 | 88 | 62 | | 19 | 62 | 42 | T |
| 4 | 68 | 61 | | 20 | 35 | 28 | | 4 | 38 | 31 | 1.03 | 20 | 37 | 16 | | 4 | 85 | 39 | | 20 | 65 | 51 | 1.11 |
| 5 | 67 | 37 | .10 | 21 | 46 | 28 | | 5 | 48 | 28 | T | 21 | 41 | 39 | | 5 | 51 | 35 | | 21 | 63 | 19 | 0.14 |
| 6 | 47 | 31 | | 22 | 41 | 25 | | 6 | 47 | 28 | | 22 | 48 | 19 | | 6 | 50 | 25 | | 22 | 51 | 11 | 0.55 |
| 7 | 45 | 25 | | 23 | 44 | 20 | | 7 | 47 | 20 | | 23 | 56 | 27 | | 7 | 60 | 27 | | 23 | 66 | 39 | |
| 8 | 50 | 34 | | 24 | 48 | 33 | | 8 | 67 | 31 | | 24 | 52 | 21 | | 8 | 72 | 38 | | 24 | 62 | 32 | |
| 9 | 48 | 29 | | 25 | 57 | 25 | | 9 | 70 | 44 | | 25 | 66 | 28 | | 9 | 76 | 48 | | 25 | 63 | 21 | T |
| 10 | 41 | 30 | T | 26 | 57 | 33 | | 10 | 67 | 17 | T | 26 | 76 | 50 | | 10 | 90 | 52 | | 26 | 33 | 12 | |
| 11 | 40 | 24 | | 27 | 48 | 14 | | 11 | 38 | 8 | | 27 | 56 | 28 | | 11 | 87 | 52 | | 27 | 44 | 18 | |
| 12 | 47 | 31 | | 28 | 40 | 27 | | 12 | 39 | 12 | | 28 | 79 | 45 | | 12 | 79 | 53 | | 28 | 56 | 25 | |
| 13 | 44 | 17 | | 29 | 55 | 29 | | 13 | 61 | 29 | | | | | | 13 | 80 | 40 | | 29 | 67 | 34 | |
| 14 | 52 | 31 | | 30 | 52 | 28 | | 14 | 68 | 26 | | | | | | 14 | 84 | 57 | | 30 | 70 | 43 | |
| 15 | 51 | 28 | | 31 | 64 | 38 | | 15 | 67 | 43 | | | | | | 15 | 79 | 42 | 0.24 | 31 | 69 | 51 | 0.09 |
| 16 | 46 | 39 | | | | | | 16 | 60 | 32 | | | | | | 16 | 52 | 38 | | | | | |

A-Date B-Maximum Temperature C-Minimum Temperature D-Rainfall the other areas. No temperature readings were recorded at any depth below the surface in this plot as high as 113°F.

The mean temperature on the surface in this area was six degrees higher than surface readings of the weeping lovegrass area. This is not enough difference in mean temperatures of the two areas to be of any significance when they are compared with the results obtained since both were far above the lethal level. The greatest difference in mean temperatures recorded on the surface while burning is between the bermuda and bunch grass plots (Table 5).

C. Results of burning

The results of burning the grass in this plot conform very closely to the lovegrass plot. They show an immediate reduction of 85.5 percent of the total arthropod population. The Thysanoptera appear to have been completely eliminated. The chinch bugs were immediately reduced 88.0 percent as a result of the burning.

This area contained only a sparse stand of bunch grasses and a very light amount of surface debris which may explain the smaller Collembola and mite population found (Table 6).

The minimum percentage reduction of an order was for the adult Coleoptera. They were reduced immediately by 70.0 percent and the check 52 days later shows approximately the same picture (Table 3). The maximum percent of reduction due to burning was for the Thysanoptera. An immediate reduction of 99.8 percent is shown. In the last samples taken in this area the order was not represented.

The results of this work that appears to have the most significance is the immediate reduction of chinch bugs by 88 percent, and a final reduction after 52 days of 93.5 percent. This immediate reduction is slightly lower for this pest than is shown by Dahms (1935).

This is the only plot where the Collembola were found in greater numbers than the Acarina. They were reduced 70 percent immediately and 81 percent 52 days later.

In connection with this work on bunch grass, two clumps of approximately the same size were given special consideration (Plate 7). One of these clumps was taken up unburned and the chinch bugs collected from it using the Berlese funnel method. The other clump was burned by igniting with a match (Plate 8). The chinch bugs were collected from this clump by the same method. There were 1,192 chinch bugs in the unburned clump and 469 in the burned clump. This is not presented as a percent of reduction but only as a comparative figure. The relatively high population found in the burned clump is quite contrary to the findings in the bunch grass plot as a whole. The most probable reason for this is that no wind was blowing at the time this clump was burned and very incomplete burning resulted (Plate 8). It does show, however, that under some conditions, not as yet completely understood, many chinch bugs may survive after bunch grasses are burned.

Comparative Effects of Burning The Three Plots

The end results of burning and its effect upon the arthropod populations in the three test areas was correlated chiefly with the temperatures reached on the surface and in the upper two inches of soil. Such factors as wind velocity, percent, relative humidity, air temperatures and soil moisture had little effect upon these temperatures. On the other hand the time it took for a plot to be completely burned over, together with the amount and condition of fuel present, were very important.

The time necessary for each plot to burn over completely was approximately 20 minutes for the bunch grass, 30 minutes for the bermuda grass and two hours for the weeping lovegrass. Mortalities recorded as a direct result of the burning were definitely correlated with the above. An abundance of flammable material slightly moist in condition, created a long-hot fire and caused high mortalities. A sparse dry vegetation was burned over quickly and few arthropods were killed.

## PRINCIPAL GROUPS REPRESENTED AND THEIR SIGNIFICANCE

### A. Collembola

According to Scott (1953) the Collembola are a comparatively unknown order of insects some species of which may occasionally cause considerable damage. He stated further that 70 of the 2,200 known species are of economic importance. The habitat of the Collembola is by no means a general one. They may be collected in such varied places as snow and frequently on the surface of water.

The species of Collembola were identified by a specialist except some of those taken in the bunch grass area. These were identified by the writer in comparison with those determined by Dr. Wray*.

When a comparison of the numbers of Collembola found in each plot is made it is readily seen that the highest population was taken from the weeping lovegrass (Tables 1, 2, 3). The lowest population was found in the bunch grass. When the combined totals of Collembola taken from all samples in each of the three areas are compared (Table 8) there again appears to be a direct relationship in numbers of this order and the amount of ground cover.

Because all species given were not collected in all areas is no indication that they do not inhabit them.

B. Habitats, species and their economic importance

(1) Entomobryidae

a. Drepanocyrtus sp. Habitat; decaying organic matter. As a whole the genus is of negative importance; collected in all three plots.

b. Entomobrya multifasciata Tulberg. Habitats; loose bark, old hay stacks, dead leaves and wherever there is shelter. Economically important as a household pest; collected in bermuda and in weeping lovegrass.

c. Isotoma viridis (Bourlet). Habitats; humus, dead leaves, short vegetation in the early spring; of negative economic importance; collected in bermuda and bunch grass.

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*These classifications are those proposed by W. L. Wray.

Table 8, Total numbers of various arthropods included in this experiment[2].

| The Totals Are Based on All Samples Taken | Plots and Number of Arthropods Found in Each Before and After Burning. | | | | | |
|---|---|---|---|---|---|---|
| | BERMUDA | | LOVEGRASS | | BUNCH GRASSES | |
| ORDERS | Before | After | Before | After | Before | After |
| Lepidoptera[1] | 10 | - | - | - | - | - |
| larvae | 43 | 36 | 5 | - | 2 | - |
| Coleoptera[1] | 29 | 23 | 70 | 15 | 60 | 35 |
| larvae | - | 23 | 123 | 15 | 7 | 3 |
| Collembola | 51 | 667 | 1439 | - | 385 | 209 |
| Thysanoptera | 6 | 40 | 288 | 5 | 48 | 1 |
| Corrodentia | 11 | 85 | 33 | - | 17 | 3 |
| Homoptera | 56 | 1 | 2 | - | 32 | 5 |
| Hemiptera | 8 | 2 | 26 | 8 | 3598 | 672 |
| Diptera | 27 | 4 | 1 | - | 6 | - |
| larvae | 6 | 2 | 38 | - | 5 | - |
| Araneida | 20 | 6 | 21 | - | 42 | 12 |
| Acarina | 240 | 920 | 1778 | 1 | 223 | 110 |
| Isopoda | 17 | 18 | - | - | - | - |
| Hymenoptera | 33 | 9 | 7 | - | 3 | 6 |
| Totals | 557 | 1846 | 3831 | 44 | 4427 | 1055 |
| Combined Totals | 2403 | | 3875 | | 5482 | |

[1]Indicates adults of those orders.

[2]Orders not listed were collected with such rare frequency that no consideration was given them in this experiment.

d. Lepidocyrtus unifasciatus James. Habitats; humus, decaying organic matter, loose bark on standing trees; of negative importance; collected in bunch grass and weeping lovegrass.

e. Orchesella ainsliei Folsom. Habitats; moss, dead leaves, decaying organic matter; no data as to economic importance; collected in bermuda and bunch grass.

(2) Isotomidae

a. Brachystomella parvula Schaffer. Habitat; decaying organic matter; of negative importance; collected in weeping lovegrass.

b. Proisotoma aquae Bacon. Habitats; leaves, leaf mold, organic matter; no data as to economic importance; collected in bermuda and weeping lovegrass.

(3) Poduridae

a. Achorutes armatus (Nicolet). Habitats; decaying organic matter; economically important as a pest in mushroom beds; collected in bermuda and weeping lovegrass.

b. Achorutes humi Folsom. Habitats; leaf mold, under fallen decaying bark; of negative importance; collected in bermuda.

C. Acarina

According to Baker (1955) the fauna of this state is highly unexplored in reference to the soil inhabiting species**. This made the identification of those listed even more difficult. They have in most cases been identified only to genus. These are mostly of the predaceous type.

From the standpoint of economic importance in the field of agriculture the Acarina collected in the different study areas are usually considered unimportant. These are those that may be predaceous on members of both harmful and

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**These classifications are those proposed by E. W. Baker.

beneficial species of insects as well as their eggs and others that are economic pests. For these reasons it is difficult to say whether or not some of the soil inhabiting mites are either beneficial or harmful.

(1) Ascaidae

a. The specimen belonging to this family was not identified further; the family as a whole are predaceous; collected in bermuda.

(2) Bdellidae

a. *Bdella* sp. Habitats; moss, mold, lichens; predaceous on other mites and small insects; collected in bermuda and lovegrass.

b. *Spinibdella* sp. At least some of those in this genus are predaceous; collected in bermuda and lovegrass.

(3) Camisiidae

a. *Nothrus* sp. Collected in bermuda and lovegrass.

(4) Cunaxidae

a. *Cunaxa taurus* (Kramer). Habitats; leaf mold, leaves; predaceous on other mites and small insects; collected in all plots.

(5) Eupodidae

a. *Penthaleus major* (Duges). Infests peas, clover, oats, wild mustard and lupines in California, barley in Arizona, wheat in Oklahoma and Texas; collected in bermuda grass.

(6) Galumnidae

a. *Galumna* sp. Some of the species in this genus serve as an intermediate host of tapeworms; collected in bermuda and lovegrass.

(7) Hypochthoniidae

a. *Hypochthonius* sp. No information; collected in bermuda and lovegrass.

(8) Laelaptidae

a. *Laelaspis* sp. Usually parasitic on vertebrates as well as invertebrates. Serves as a definitive host for some protozoan parasites of rats and hamsters; collected in bermuda and lovegrass.

(9) Phthiracaridae

a. *Pseudotritia* sp. No information; collected in bermuda and lovegrass.

(10) Raphignathidae

a. *Raphignathus* sp. Habitats; moss, lichens, straw, leaves; collected in bunch grass.

(11) Tetranychidae

a. *Petrobia harti* (E.). Habitat; plant feeders; collected in lovegrass.

(12) Teneriffiidae

a. *Austroteneriffia* sp. Their structure indicates a predaceous habit; collected in all plots*.

D. Thysanoptera

As a general rule thrips are classed in two different groups when considered from an economic standpoint. There are those that are beneficial as they are pollinators and yet the same species may be injurious at times. There are at least three cases where thrips have been known to destroy spider mites by sucking out the body fluids (Kelly, 1934).

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* The authors of Acarina species are those used by Banks (1915).

Since a very limited amount of work has been done in the way of species identification it is rather difficult to find suitable material to give in regards to habitats and economic importance. The following were identified by a specialist***.

(1) Phloeothripidae

a. *Eurythrips* sp. Habitats; grasses, fruit trees; some species feed on orchids, others on grasses and deciduous fruits; collected in bermuda and lovegrass.

b. *Malacothrips zonatus* Hinds. Habitat; turf; collected in lovegrass.

(2) Thripidae

a. *Bregmatothrips venastus* Hood. No information; collected in bermuda and lovegrass.

b. *Frankliniella occidentalis* (Perg.). May be a pest of some fruits in California; causes "cat facing" on apricots and peaches; it is known to be a carrier of some plant viruses; collected in bermuda grass; the most common species collected on alfalfa in 1954 at Stillwater.

c. *Leptogastrothrips* sp. No information; collected in lovegrass.

d. *Plesiothrips perplexus* (Beach). Rarely reported to be injurious; collected in bermuda and bunch grass.

e. *Trachythrips* sp. No information; collected in lovegrass and bunch grass.

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*** These classifications are those proposed by Kellie O'Neill.

## SUMMARY AND CONCLUSIONS

An experiment designed to study the effects of burning three different types of ground cover on arthropod populations was conducted between October 19, 1954 and March 31, 1955. Each of the three areas used had a predominant cover of either bermuda grass, weeping love-grass, or a mixture of bunch grasses, the latter being big and little bluestem.

The purpose for which this work was done was to study the immediate and delayed effects that burning ground cover would cause on all arthropod populations in these areas.

Samples of various types and numbers were taken in each area immediately before and after burning. The arthropods from these were recovered by the Berlese funnel method. The total number varied considerably in the different plots. All species of some groups have been identified (Pages 44, 46, 49).

Observations made during this experiment seem to indicate that more thorough burning takes place when there is some wind to keep regenerating the fire.

Soil samples to determine the amount of moisture present were collected in each plot just prior to burning. This was done because there is no doubt that penetration of heat into the soil can be correlated to some extent with the percentage of moisture present at the time of burning. However, there was little difference in the moisture content in the three plots so this factor could not be evaluated.

Maximum temperature readings were recorded on the surface of the soil in all plots and at varied depths down to a level of two-inches during the burning period by means of Tempil Stick markings on asbestos shingles.

The bermuda grass had the highest percent of ground cover, a very moderate amount of burnable surface trash and a short stand of grass. When this area was burned over it was a rather fast fire that only burned the tops of the grass. This may explain why there was little or no reduction of arthropods in this area.

The only orders that were collected in sufficient numbers in bermuda grass to be of significance were the Acarina and Collembola. No reduction occurred in these orders either immediately after burning or when the last samples were taken 83 days later.

Results of burning the weeping lovegrass area showed approximately one-hundred percent reduction of all orders.

Temperatures above the thermal death point (125°F.) of most arthropods were recorded in parts of this plot down to a depth of two-inches.

All arthropods were reduced by 85 percent immediately by burning bunch grass and by 90.8 percent 52 days later.

Burning has been shown to reduce the arthropod population from 85.5 to 99.8 percent in two of the three areas used in this experiment. The results of burning in these areas with reference to reduction in arthropod populations suggest that some correlation exists between the results obtained and the amount and condition of burnable material on the soil surface.

Some specificity of habitat for chinch bugs was noticed which suggests that before burning areas to try and control this pest a survey should be made to determine the preferred winter quarters.

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## SUPPLEMENTAL LIST OF IDENTIFIED SPECIMENS

A. COLEOPTERA*

(1) Carabidae:

a. Badister pulchellus Lec. Range: Central and Eastern States; collected in bermuda and lovegrass.

b. Carabus sp. Range: U. S. not abundant; collected in bermuda grass.

c. Casnonia pennsylvania L. Range: U. S. and Canada; collected in bunch grass.

d. Clivina sp. Range: Eastern half of the U. S. Collected in bermuda and lovegrass.

e. Patrobus sp. Range NE U. S. and SE Canada; collected in the bunch grass and lovegrass areas.

f. Stenolophus ochropezus (Say) Range: U. S. and Canada East of the Rockies. Collected in bermuda grass.

g. Tachyura sp. Range: U. S. and Canada; collected in bermuda grass and bunch grass.

(2) Chrysomelidae:

a. Arthrocyhlamys gibbosa (Fab.) Range: Eastern half of the U. S. Collected in all plots.

b. Chaetocnema denticulata (Ill.) Range: U. S. Collected in all three plots.

c. Diabrotica undecimpunctata howardi Barb. Range: general; collected in bunch grass and lovegrass.

d. Haltica sp. Range: general; collected in bermuda and lovegrass.

(3) Curculionidae:

a. Anacentrinus diplanatus (Csy.) Range: general; collected in bermuda grass.

b. Calendra sp. Range: general; collected in bermuda and lovegrass.

c. Chalcodermus aeneus Boh. Range: general; Midwest to Texas; collected in bermuda grass.

* Classifications proposed by the writer.

(4) Scarabaeidae:

a. *Ataenius* sp. Range: general; collected in bermuda grass.

b. *Pinotus carolinus* (L) Range: widely distributed; collected in all three plots.

(5) Staphylinidae:

a. *Homoectarsus* sp. Range: Central U. S. Collected in bunch grass.

b. *Mycetoporus* sp. Range: U. S. Collected in bunch grass and lovegrass.

c. *Stenus* sp. Range: U. S. Collected in bunch grass and lovegrass.

B. CHELONETHIDA***

(1) Neobisiidae:

a. *Microbisum parvulum* (Banks). Range: SW U. S. Collected in lovegrass.

C. CORRODENTIA*

(1) Liposcelidae:

a. *Liposcelis* sp. Range: cosmopolitan; collected in all three plots.

D. DIPTERA*

(1) Chloropidae:

a. *Chloropisca glabra* sp. Range: general; collected in bermuda grass.

(2) Anthomyiidae:

a. *Hylemyia cilicrura* (Rond.) Range: general; collected in bermuda grass.

*** This classification was proposed by C. C. Hoff.

E. HEMIPTERA*

(1) Nabidae:

a. _Nabus ferus_ Linn. Range: general; collected in bermuda grass.

(2) Aradidae:

a. _Aradus_ sp. Range: general; sometimes mistaken for bedbugs; collected in bermuda grass.

(3) Cydnidae:

a. _Allocoris pulcaria_ (Germ.) Range: general; collected in all three areas.

F. HOMOPTERA*

(1) Cicadellidae:

a. _Polyamia inimicus_ (Say) Range: general; collected in all three areas.

(2) Membracidae:

a. _Ceresa bubalis_ Fab. Range: U. S. Collected in bermuda grass.

G. HYMENOPTERA**

(1) Braconidae:

a. _Chelonus_ sp. Range: general; collected in bermuda grass.

(2) Formicidae:

a. _Crematogaster_ sp. Range: general; collected in bermuda and lovegrass.

b. _Monomorium minimum_ (Buckley) Range: general; collected in lovegrass.

c. _Paratrechina melanderi_ (Wheeler) Range: general; collected in bermuda and bunch grass.

d. _Pheidole dentata_ Mayr. Range: general; collected in bermuda grass.

e. _Ponera_ sp. Range: general; collected in bermuda grass.

** Classifications proposed by J. H. Young.

H. ORTHOPTERA*

(1) Gryllidae:

a. *Gryllus assimilis* Fab. Range: general; collected in all three areas.

(2) Locustidae:

a. *Melanopus differentialis* (Thomas) Range: general; collected in bermuda grass.

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