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MANAGEMENT OF KANSAS PERMANENT PASTURES

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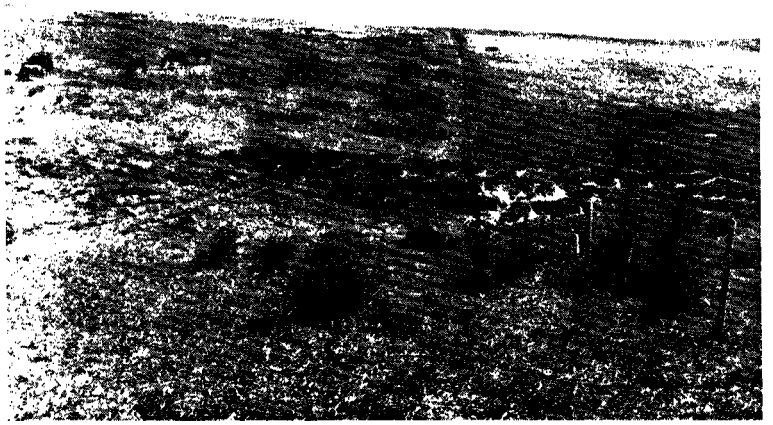


FIG. 1.—Little bluestem replaced by short grasses in central Kansas as a result of overgrazing. Area on right side of fence has been overgrazed.

FIG. 2.—Eradication of ironweed and vervain by mowing.

MANAGEMENT OF KANSAS PERMANENT PASTURES[1]

A. E. ALDOUS

PASTURE REGIONS OF KANSAS

More than one third of the total acreage of Kansas is in permanent pasture. At least 90 percent of this land is nontillable because of steep slope, excessive amounts of sand, or the thin or rocky nature of the soil. This makes it valuable only for its natural vegetative growth which provides pasturage for livestock. The present productivity of these lands varies greatly, depending upon the precipitation, type of soil, the natural vegetative covering, and the grazing management.

The Bluestem region (fig. 3) is the most important grazing area of the state. The pastures in this region, commonly known as the

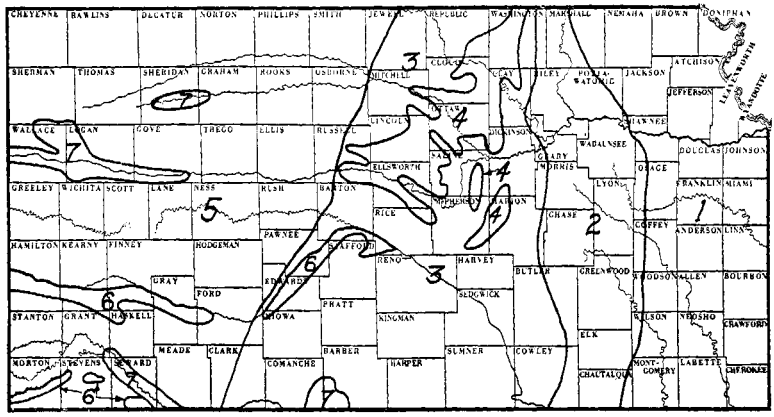


FIG. 3.—Pasture regions of Kansas. (1) Blue grass and miscellaneous pasture plants. (2) Bluestem region (bluestem grasses). (3) Mixed bluestem and short grass. (4) Dakota sandstone (bluestem grasses). (5) Short grass (buffalo and grama grasses). (6) Sand hills, bluestem grasses (mainly little bluestem). (7) Broken grazing lands (little bluestem dominant).

Flint. Hill region, are in good condition. They are vegetated with bluestem grasses, which were the original vegetative cover. These grasses are the most nutritious, most palatable, and highest-yielding native forage species in Kansas.

In the eastern part of the state the pasture lands were originally vegetated with bluestem grasses but owing to overgrazing, especially on the smaller farm pastures, the original species have been replaced mostly by blue grass, annual grasses, and weeds. Many of these pastures still have sufficient stunted bluestem plants to re-

1. Contribution No. 246 from the Department of Agronomy.

store the original stand of forage plants by conservative grazing management,.

In the central part of the state the original vegetative covering was a mixture of tall and short grasses. The tall grasses consisted mainly of little bluestem, big bluestem, side oat grama, prairie June grass, and prairie drop seed. The short grasses consisted for the most part of grama and buffalo grass. The tall grasses occupied the slopes and stream bottoms, while the short grasses grew on the uplands and the thinner, poorer soils. Little bluestem is still the dominant grass in the more broken sandstone pasture lands situated mainly in Saline and Ellsworth counties and extending northeast into Ottawa and Cloud counties. Buffalo grass, however, is now the dominant pasture grass in central Kansas. It has replaced the tall grasses because of close grazing. (Fig. 1.)

The sand hills and broken nontillable areas adjacent to the principal streams in the western third of the state were originally vegetated largely by little bluestem. The rest of this region (fig. 3) comprising the smooth hard lands supported an even stand of short grass composed of buffalo and grama. The vegetation of the sand hills is still predominantly tall grass. The short grasses have largely replaccd little bluestem in the broken, nonsandy land, wherever the vegetation has been closely grazed continuously.

ECONOMIC IMPORTANCE OF PASTURAGE

Economic studies conducted in various parts of the United States have shown that the cost of production of livestock and livestock products is reduced to a minimum when good pastures are used as a principal source of feed. In seven districts of the United States where studies of the cost of producing market milk were made, pasturage provided nearly one third of the sustenance of the cows at only one seventh of the total feed cost. At Beltsville, Md., the digestible nutrients in pasturage were produced for 48 cents per 100 pounds, while those in corn silage and alfalfa hay were produced at a cost of $1.22 per 100 pounds on the same or similar land.

A cost study made in Kansas shows that corn yielding 20 bushels per acre produced digestible nutrients at a cost of 64.3 cents per 100 pounds; barley yielding 20 bushels averaged 51.8 cents for each 100 pounds of nutrients; and oats yielding 23 bushels cost 76.3 cents per 100 pounds. Alfalfa, with an average yield of 2.5 tons per acre, produced digestible nutrients at a cost of only 25.8 cents per 100 pounds. A tame pasture mixture sown and fertilized according to the recommendations of the Department of Agronomy of the Kansas Agricultural Experiment Station, yielding 2 tons of hay per acre for a four-year period produced digestible nutrients at the low cost of 10.4 cents per 100 pounds. Included in this cost were use of the land, seeding, fertilizing, preparation of the seedbed, and cost of fencing so the area could be used for rotation grazing.

The cost of pasturage is low because it is harvested by the live-

stock, and forage from good pastures is high in palatability and feeding value.

It has generally been considered that if a pasture was depleted of its original vegetative covering, no practical method could be used to restore its productivity. Recent investigations have shown that many run-down pastures can be improved at little expense by using methods of management, that will give the desirable forage species an opportunity to make more top growth It is the purpose of this publication to outline methods that can be used to increase the productivity of these areas, representing one third of the land area of Kansas, and to suggest systems of grazing management that can be used effectively to maintain a high grazing capacity.

WHY PASTURES DETERIORATE

CLOSE GRAZING

Pastures are reduced in productivity mainly because of close grazing. This results in a gradual weakening of the plants, the amount depending upon the closeness of the grazing and weather conditions. All the carbohydrates (starch and sugars) are elaborated in the leaves of the plant while the water and mineral nutrients (calcium, phosphorus, potash, iron, etc.) are taken in through the roots. The continued close removal of the top growth reduces the food-making capacity of the plant. The leaves are essential to the growth and maintenance of the vegetation. The close cropping of the top growth also results in a proportionate decrease in the quantity of roots. The defoliation is most detrimental to plant growth at the beginning of the season. This is because the plant draws on stored food reserves to make its initial growth and this process continues until the foliage has developed sufficiently to supply its growing needs. Later in the season the food reserves used for starting growth are restored. Studies have shown that the food reserves of protected or lightly grazed bluestem grasses are not completely restored in an average year until about the middle of June. From this time until the close of the growing season the cropping of the foliage is less harmful than earlier.

Experiments in clipping vegetation have demonstrated that a very thrifty stand of bluestem grasses can be reduced two thirds in density and three fourths in annual yield by clipping to a height of 1 inch every two weeks for three successive years. This treatment is less severe than grazing the vegetation similarly close, because, in grazing, the animals pack the soil, which causes a reduction of aeration and bacterial action. This decreases nitrate development and limits growth, because available nitrogen is the principal limiting nutritive element in most of the Kansas grass lands.

DECREASE IN FERTILITY

Another factor entering into the reduced productivity of permanent pastures on this type of land is the decreased fertility. This is a major factor in humid regions, especially where the soil in its

virgin condition is low in any one of the essential elements. The continued removal of the grass cover and the subsequent leaching and erosion of the soil reduces one or more of the nutrients essential to plant growth to such a low point that they become the limiting factors in the vegetative growth.

This condition prevails to a limited extent in the southeastern part of Kansas. Here, in some soils, the calcium and phosphorus content is low or the phosphorus is low in availability. This soil condition results in a mineral deficiency that is rather common in some sections of the country, and is reflected in decreased yields. In addition the forage may be sufficiently low in one or more of the minerals to cause malnutrition of the animals grazing the pasture and fed the forage grown on adjoining farm land.

Abandoned tilled land that has been allowed to revert naturally to pasture is usually low in fertility. Most of this land was of poor quality originally and its fertility has often been decreased by erosion. The productivity of this land can be partially restored, where rapid restoration is desired, by the application of fertilizers. On most poor lands nitrogen, lime, and phosphorus are needed. The feasibility and costs of the treatment will be discussed later under fertilizers.

WEED AND BRUSH CONTROL

The abundance of weeds in many run-down pastures, especially in the eastern part of the state, makes the eradication of the worthless vegetation the first step in the logical improvement of this land. The desirable forage plants can be restored in a minimum length of time by removing the competition from the weeds or brush. This should be accompanied by grazing practices that permit the forage plants to make sufficient top growth to occupy the ground when the weeds are eradicated.

There are four direct methods that can be used to eradicate weeds and brush from pastures. They are as follows: (1) Cutting, (2) grubbing, (3) burning, and (4) the use of herbicides. Most of the experimental work at this station has been with cutting and burning.

Grubbing is an expensive method of eradication and is practical only for small areas where the entire root or enough of it can easily be removed to kill the plant. This method would not generally be feasible for the eradication of plants that propagate by running root stocks, especially after they have become well established. Its use is most practicable on shallow-rooted plants where cutting 4 or 5 inches under the surface of the crown will remove all or a sufficient amount of the root to kill the plants.

Herbicides are too expensive to justify extensive use in pastures. Their application, therefore, will be limited mainly to small areas of noxious weeds that cannot be killed by cutting or burning. Most herbicides are as detrimental to the forage species as they are to the weeds, so their use may denude entirely an area of vegetation.

Sodium chlorate has been more satisfactory than any other herbicide in eradicating weeds and brush from pastures. The greatest

efficiency of this salt can be obtaincd by making a solution consisting of 1 pound of sodium chlorate to each gallon of water, and spraying the plants when they have the least quantity of organic food reserves. Plants will absorb the greatest amount of solution in rather humid weather. Precautions should be taken when applying certain herbicides, particularly the arsenical compounds, by removing the livestock from the pasture or fencing the treated area. If given access to the treated area the livestock may be attracted by the salty taste of the vegetation and eat a sufficient quantity to cause poisoning.

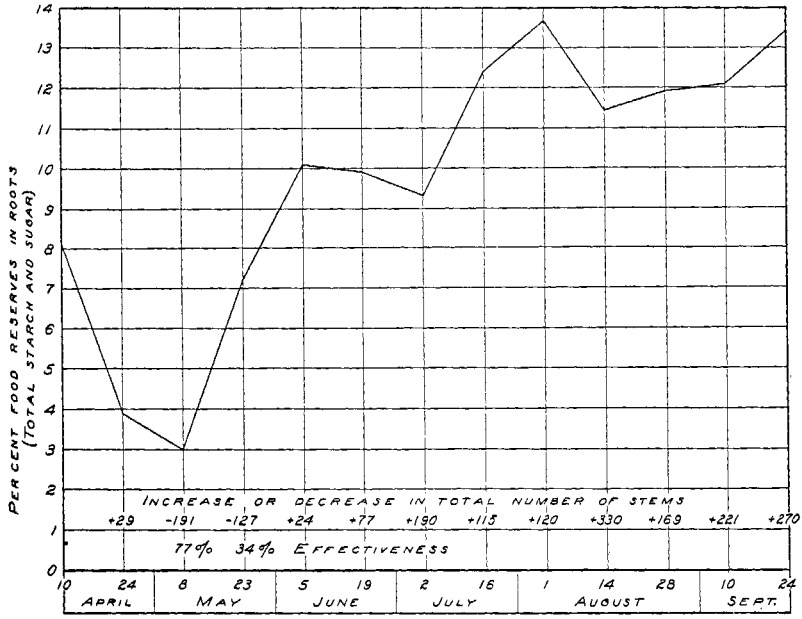


FIG. 4.—Chart showing relation of food reserves in roots to effectiveness of killing buckbrush by cutting on different dates. Each plat was cut on the same date for three consecutive years. Only the May cuttings were effective.

Mowing is the method most generally used for the eradication of weeds and brush in pastures, particularly in small farm pastures that are sufficiently smooth to permit the use of a mowing machine. Investigations at this station have shown that the effectiveness of mowing is governed to a large extent by the organic food reserves in the plants when the cuttings are made. This work was most effective when it was done at the low point in the organic food reserves. Mowing the plants when the food reserves were high had little effect. This was demonstrated in experiments conducted in the eradication of buckbrush, sumac, ironweed, and vervain. Buckbrush can be eradicated entirely in three annual cuttings made early in May. If the cuttings are delayed until July 1, few if any of the

plants will be killed Sumac, vervain, and ironweed can be eradicated most effectively by cutting during the first part of June. (Fig 2.)

Chemical analyses of the roots of these weeds and shrubs show that the food reserves of plants are rapidly restored if normal growing conditions prevail. The total starch and sugar in buckbrush roots decreased from about 13.5 percent on March 15 to 3 percent on May 10, and increased to the original amount (13.5 percent.) by August 1. (Fig. 4.) Chemical analyses of the roots of sumac show

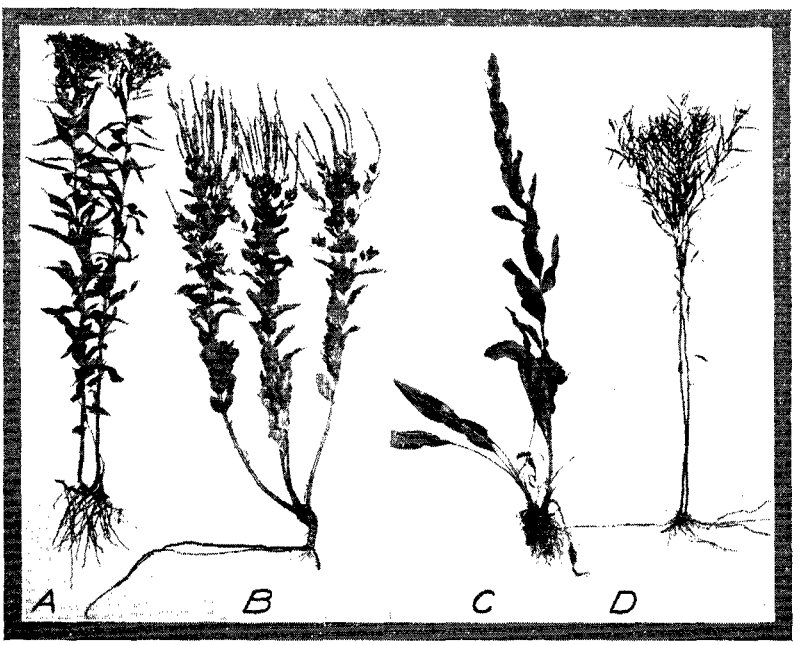


FIG. 5.—Common pasture weeds in Kansas: (a) Ironweed, (b) vervain, (c) stiff-leafed goldenrod, and (d) broomweed.

that the food reserves (total starch and sugars) of this shrub are maintained at a comparatively high level (20 to 24 percent) until about May 1, after which they decrease rather rapidly to as low as 10 percent early in June. This low point is maintained about two weeks, after which the starch and sugar are rapidly restored, reaching 18 to 20 percent, by approximately July 15. The restoration of the food reserves in most of the plants that have been studied has been equally rapid.

Some of the more vigorous pasture weeds and brush (fig. 5) are able to compete with the bluestem and other palatable pasture plants even where conservative or light grazing is practiced. This applies particularly to buckbrush and ironweed. Buckbrush propa-

gates vegetatively by runners and from seed. Growth starts early in the spring and since it grows in dense clumps all other plants are excluded by shading. The plants spread mainly by runners which grow vigorously when moisture conditions are favorable and new plants are produced at all places where these runners come in contact with the soil.

Buckbrush usually grows in the draws and other places in pastures where growing conditions are most favorable. It is increasing more rapidly throughout eastern Kansas than any other worthless pasture plant. When once established much work is necessary to

FIG. 6.—Eradication of buckbrush by mowing.

keep it from spreading or to eradicate it. Buckbrush can be cut readily with a mowing machine, and since it usually grows on the smooth land this is the most effective implement to use in killing it,. (Fig. 6.)

Ironweed is one of the most common pasture weeds in eastern Kansas. (Figs. 2 and 5.) It is first established by seed and then spreads rapidly by thrifty root stalks to form a large clump frequently containing one hundred stems. The roots of ironweed do not penetrate the soil more than 3 or 4 feet, even in deep fertile soil. Most of the roots are concentrated in the surface foot. This weed is able to grow in extremely dry conditions. It starts growth early in the spring ahead of most of the native forage plants. As in the case of buckbrush, it is necessary to eradicate ironweed from the pasture as it can compete successfully with grasses under all stages of grazing.

Vervain is another of the common perennial pasture weeds in eastern Kansas. It spreads entirely by seed and is not difficult to eradicate if cut just before the first flowers appear. (Figs. 2 and 5.) This weed produces a large amount of seed which accounts for its abundant and widespread occurrence.

Sumac presents a difficult problem of eradication owing to the fact that the stems are usually too thick to cut with a mowing machine and it frequently grows on rough broken land where farm machinery cannot be used. This shrub often invades the better pasture land as a result of overgrazing. (Fig. 7.) It frequently can be eradicated by protection or light grazing of the pasture in

FIG. 7.—Sumac (on right side of fence) in an overgrazed pasture.

order to give the grasses an opportunity to reestablish a normal ground cover.

The mature dense stands of sumac that are too heavy to cut with a mower can often be removed by breaking them down during freezing weather with a heavy drag, such as a steel rail or heavy logs. If there is enough dead grass in the area to carry a fire the top growth can be burned the following spring. It is best to do the burning on a dry day when a moderate wind is blowing. If the inflammable material is insufficient to carry a fire, straw spread thinly on the ground will aid in the burning. The removal of the large woody stems makes it possible to mow the second growth, provided the area is not too rocky or rough to permit the use of a mowing machine. The mowing should be done the season following the burning or before the stems become woody.

Since the low point in the resistance of sumac occurs in the early

part of June, cutting or any other form of eradication will be most effective at that time. Experiments conducted over a period of four years show that the common sumac can be killed in the vicinity of Manhattan by three annual cuttings made approximately the tenth of June. The most effective date would be advanced a week or 10 days in the extreme southeastern part of Kansas.

Limited experimental information indicates that stiff-leafed goldenrod, *Solidago rigida* (figs. 5c and 10d), another rather common pasture weed, can be eradicated by cutting approximately July 10, two years in succession. Rockweed, *Helianthus orgyalis,* a common

FIG. 8.—Rockweed in overgrazed pasture in southeastern Kansas.

weed in the limestone pasture lands in southeastern Kansas, should be cut about June 20. (Fig. 8.) Wild alfalfa or Psoralea, *Psoralia tenuiflora,* a deep-rooted legume, is increasing in a number of good pastures as well as in hay meadows. The low point in its food reserves is reached about May 20. The plant has made enough growth at this time to permit clipping by raising the cutter bar high enough to prevent cutting very much grass. Three annual mowings made the latter part of May should be sufficient to eradicate it.

The common prickly pear, *Opuntia humifusa,* is becoming a bad pasture weed in many areas in central and western Kansas. (Fig. 9.) This plant has invaded mainly pasture lands that have been grazed heavily. Periods of drought are favorable for its increase. While definite information is not available on the eradication of these plants, preliminary experiments indicate that the best method is to grub them out. The plants should be grubbed deeply enough to

remove completely the crown. This will require grubbing 3 or 4 inches below the surface of the soil.

The grubbed plants should be hauled to a rocky area or to some place where they are not in contact with the soil. If they are left in the pasture after grubbing, each prickly pear lobe may start a new plant, thereby spreading instead of eradicating the plants. The tops of the prickly pear may live for several seasons after the plant is grubbed, even under the most adverse conditions.

All annual weeds should be cut, or other eradication measures applied just before they flower. If they are prevented from flowering and setting seed over a peroid of about two years they can be

FIG. 9.—Cactus, or prickly pear, in a western Kansas pasture.

eradicated from pasture land. Ragweed is the most common annual weed in pastures. Annuals are frequently more abundant in pastures following dry years. This is attributed to the fact that the stand of forage plants has been reduced by the adverse climatic conditions, and the resulting rather heavy grazing makes it much easier for weed seed to geminate and grow. Weeds usually produce their seed at a period when conditions are favorable for its maturity. Weed seed may also live in the soil for several years without losing its viability.

Broomweed (fig. 5) is one of the most common annual weeds in the southern part of the Bluestem region and in southeastern Kansas. This weed is conspicuous the latter part of August,. It has numerous small yellow flowers that form a semiflat-topped type of inflorescence supported by a slender smooth stem. Broomweed, being an annual, can be eradicated by mowing before the plants set

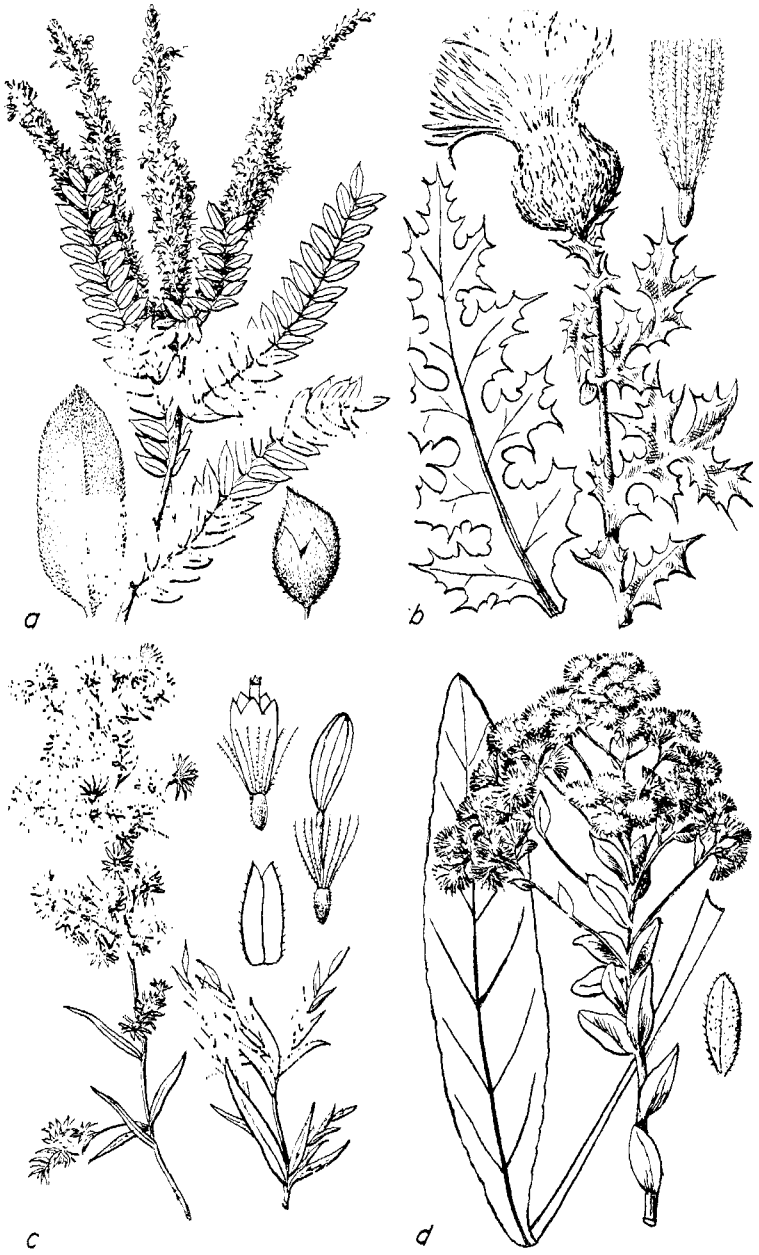


FIG. 10.—(a) Lead plant. (b) Wavy-leaved thistle. (c) Dense-flowered aster. (d) Stiff-leaved goldenrod.

seed, which in the southern part of the Bluestem region is about August 15 in an average year.

A few of the annual weedy grasses, mainly little barley, downy brome, and chess have invaded pastures in southeastern Kansas where they have increased to such an extent that they are now the dominant plants. These annual grasses usually get started around feed bunks or in corners of the pasture where most of the perennial grasses have been killed by tramping. They usually start growth in the fall, live through all but the most severe winters, and make rapid growth as soon as growing conditions are favorable in the spring. Seed is matured early, usually in May or before the native perennial grasses are well started. A large amount of seed is produced each season.

These grasses can be controlled by preventing them from maturing seed, and this may be done by mowing about the time they come into head. When they completely occupy an entire area. disking in the early spring may be effective on tillable land. If disking is practiced other forage plants should be seeded. The ones best suited for this purpose in southeastern Kansas include Korean lespedeza, orchard grass, and meadow fescue. The land should be double disked, thoroughly harrowed, seeded, and the seed covered by harrowing both ways. The seeded area should be protected from grazing during the first season to give the forage plant an opportunity to become well established

There are a number of other pasture weeds, some of which are common in local areas. In this class can be included dense-flowered aster, *Aster ericoides* (fig. 10c); daisy fleabane, *Erigeron ramosus;* perennial ragweed, *Ambrosia psilostachya;* pasture sage, *Artemesia ludoviciana;* wavy-leaved thistle, *Circsium undulatum* (fig.10b); and lead plant, *Amorpha canescens* (fig. 10a). All the experimental work with herbacious broad-leaved pasture plants has shown the low point of their food reserves and consequently their low resistance to any eradication measure to be just before the first flowers appear. It is believed this general rule can be applied with reasonable safety in determining the time that any eradication measure can be applied most effectively.

POISONOUS PLANTS

Poisonous plants do not constitute a serious pasture menace in Kansas. Livestock losses frequently occur, but, in most instances they could have been prevented by the use of precautionary measures. Under average conditions livestock will not graze poisonous plants by choice but only when forced to do so by the absence of normal pasture vegetation. Livestock shipped from distant regions where the type of pasture vegetation is different are more apt to be poisoned, particularly if they are hungry when turned in the pasture. If the grass is short and poisonous plants are present, losses are likely to occur, especially if the toxic plants are larger and more conspicuous than the grass as the livestock will eat any vegetation

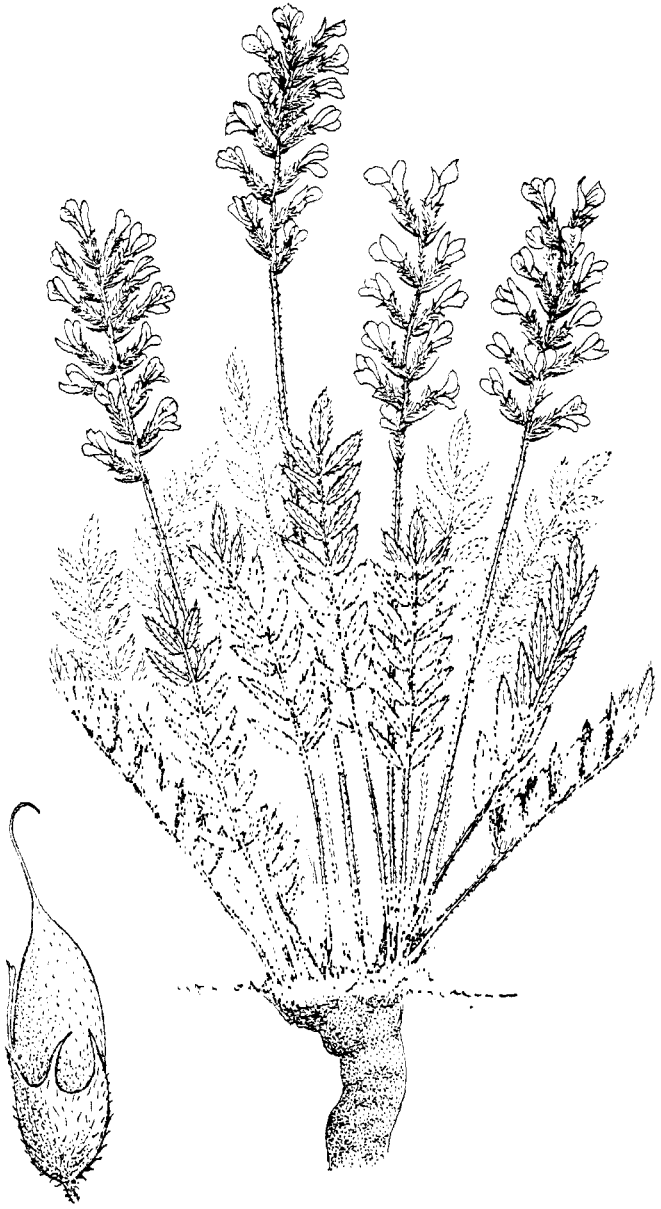


FIG. 11.—Loco weed, *Oxytropis lambertii*. A flowering plant one fifth life size, with a pod twice life size.

to satisfy their hunger. This applies particularly to livestock shipped from Texas or other distant regions to the bluestem pastures for summer grazing, and especially if they are shipped early in the season before the grass has made much growth. Losses from poisonous plants are more common during dry periods when pasture forage is scarce. Livestock that are in poor condition are also more susceptible to poisoning.

The following are some of the poisonous plants that are common in permanent pastures and from which losses have been reported: Loco,[2] false indigo, milkweeds, snow-on-the-mountain, dogbane. cockleburs, jimpson weed, spurges, water hemlock, buckeye, death camas, lupine, and larkspur.

FIG. 12.—Wooly loco in a pasture in northwestern Kansas.

Loco.—The loco weeds, of which there are two species in Kansas-white or stemless loco (fig. 11), *Oxytropis lambertii,* and purple or wooly loco (fig. 12). *Astragalus mollisimus,* are perhaps the most destructive of the poisonous plants in Kansas. The distribution of loco weeds is limited almost entirely to the western half of the state and they are most abundant in the northwestern section. The greatest danger from loco occurs early in the season as this plant starts growth much ahead of the grass, and livestock may, therefore, acquire the loco-eating habit as a result of the absence of palatable forage and the relative abundance of loco.

Loco is increasing rapidly, especially in northwestern Kansas, mainly as a result of overgrazing. Where loco occurs in scattered

2. For a description and further information concerning these and other poisonous plants see Kansas Agricultural Experiment Station Technical Bulletin 25, Principal Poisonous Plants in Kansas. 1930, 67 pp., 64 figs.

quantities over a pasture or in small local areas the most effective method of control is grubbing the plants 5 or 6 inches below the crown. This method will kill a large percentage of the plants. The pasture should be examined each spring for two or three years after the first grubbing is made and all new plants and remaining old ones taken out. This work should be accompanied by grazing methods that will allow the desirable forage plants to make more top growth and thereby decrease the possibility of the loco's coming in or spreading.

Where the loco occurs in dense stands over areas so large (fig. 12) that the cost of grubbing would be prohibitive, plowing may be the most effective method of control on areas where the land is smooth enough and the soil sufficiently deep to permit the use of a plow. This land then should be seeded to some cereal crop or sweet clover in order to provide a cover to prevent soil erosion. On some of the better lands brome grass or crested wheat grass may be seeded with moderate success in years of favorable precipitation if a good seedbed has been prepared. The seeding of these two perennial grasses is suggested only for the extreme northern part of Kansas. Small areas might be resodded to buffalo grass.

In pastures where it does not appear advisable to eradicate the loco, livestock should not be grazed during the first part of the season or until about the middle of June. By this time the loco plants will have matured, dried, and in many instances blown away so that there is little danger from them. Protection during the first part of the growing season would also give the grasses an opportunity to increase in density and vigor, which in time should have some effect in decreasing the number of loco plants.

False Indigo.—False indigo (fig. 13), *Baptisia australis*, is common in the bluestem pasture region. The plants usually occur in scattered stands through the pastures, the indigo-blue, white, or cream flowers being conspicuous during the early part of May. False indigo is not palatable to livestock and poisoning occurs early in the spring before the grass has made much growth or when the livestock have been shipped long distances and turned in to the pasture without being fed. They will then eat any available vegetation to satisfy their hunger. False indigo completes its growth during the latter part of May, drying shortly afterward and disappearing from the pastures.

Milkweeds. — Milkweeds, *Asclepias* sp., are common in the eastern part of Kansas usually in small overgrazed pastures. This weed is not palatable to livestock owing to the leathery character of the foliage and the sticky nature of the sap Milkweeds are grazed only when the forage is short and insufficlent to satisfy the hunger of the livestock. The losses usually occur during the latter part of July and in August in dry seasons.

Snow-on-the-Mountain.—Snow-on-the-mountain, *Euphorbia emarginata,* is common during the latter part of the summer in many small overgrazed pastures in the eastern part of Kansas.

FIG. 13.—(Left) *Baptisia australis*. A flowering plant and seed pods, one fourth life size. (Right) *Baptisia bracteata*. A fruiting plant, one fourth life size, with details of flowers, one half life size.

This plant, like the milkweed, is not grazed unless feed is scarce and the animals are nearly starved. The remedy is entirely one of feed supply.

Dogbane. — Dogbane (Indian hemp), *Apocynum cannabinum,* is an upright weed common in eastern Kansas pastures. It has leathery leaves and a milky juice. It is not palatable to livestock and is grazed only in the absence of normal pasture vegetation. (Fig. 14.)

Cockleburs. — Cockleburs, *Xanthium* sp., occur most commonly in recently abandoned tilled land or in feed lots. The greatest danger of cockleburs is where abandoned tilled land is joined to perennial pastures or where the livestock grazing in the pastures have access to feed lots or old corrals where cockleburs are growing. Cockleburs are poisonous in the seedling or cotyledon stage of growth. Hogs are mainly susceptible, but other livestock may also be poisoned from grazing them. Cockleburs are not palatable to livestock, especially cattle and sheep, so it is only when the regular pasture forage is absent that poisoning occurs. Care should be taken when turning strange livestock into a pasture to make certain that they do not have access to areas where cockleburs are growing, especially if the grass is short.

Jimpson Weed. — Jimpson weed, *Datura stranonium,* is generally found in feed lots and waste places. The weed is unpalatable to livestock and poisoning occurs only when stock are placed in corrals where it is growing abundantly and when other feed is not provided, thus causing the livestock to eat it because they are starved. The danger is greatest from jimpson weed in August during dry years.

Spurges. — There are several species of spurges, some of which are prostrate and some are upright. (Fig. 15.) They all have a milky sap similar to the milkweed. The spurges occur most commonly in small overgrazed pastures during August and September. Their foliage is not palatable to livestock, consequently it is grazed only when the grasses or natural pasture vegetation is short. The remedy to prevent poisoning from spurges is to provide sufficient feed to satisfy the hunger of the livestock.

Water Hemlock. — Water hemlock, *Cicuta maculata,* grows in marshy places and along streams. The roots are especially poisonous and more so at the beginning of the growing season. Since water hemlock is usually restricted to small areas the best method of control is to fence the areas. If the plants are scattered it may be more practical to pull these weeds. If the latter method is used the plants should be hauled away and placed to dry where livestock cannot get them.

Buckeye. — Buckeye, *Aesculus aryuta* and *A. glabra,* is common in wooded areas in the eastern part of Kansas. The seed and the young shoots are poisonous and poisoning usually occur in the early spring when livestock are turned in to the pastures before the grass has made sufficient growth to supply their needs.

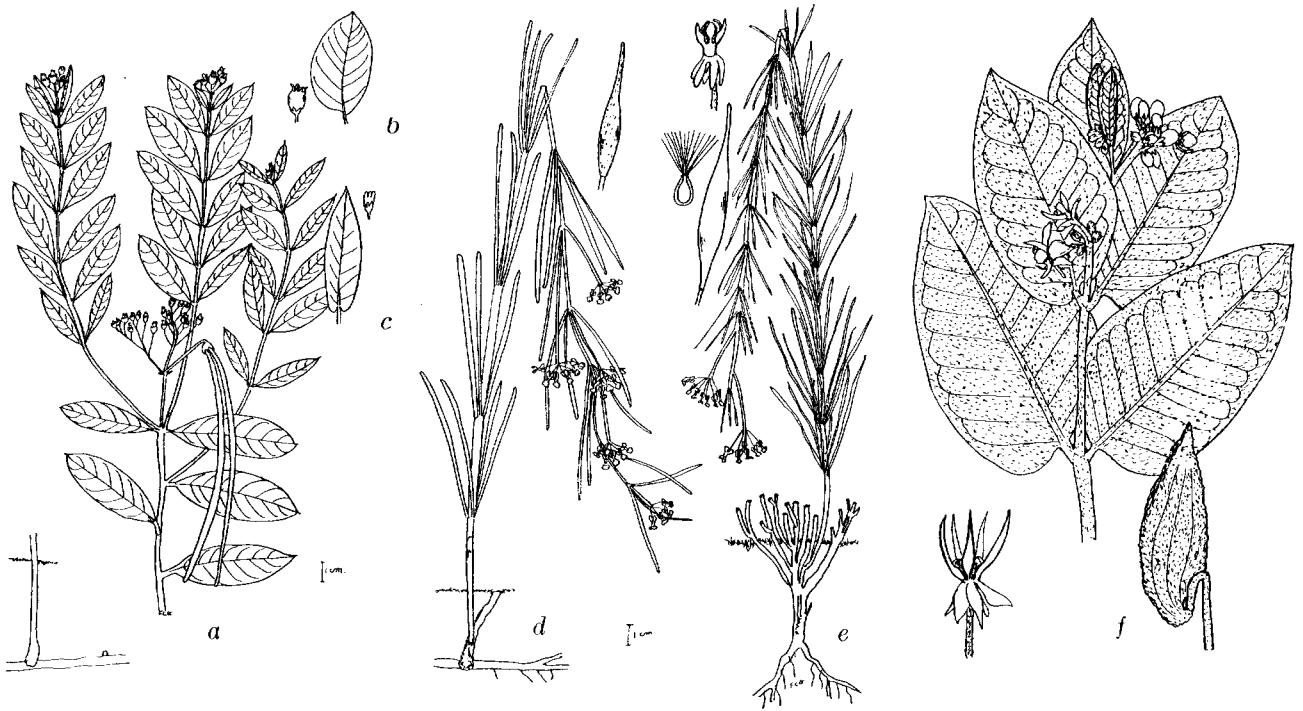


FIG. 14.—(a) *Apocynum cannabinum*. A plant, showing also a running rootstock. (b) *Apocynum androsaemifoloium*. A flower, enlarged, and a leaf, reduced. (c) *Apocynum sibiricum*. A flower, enlarged, and a leaf, reduced. (d) *Asclepias galioides*. A plant with typical fruit, one half life size. (e) *Asclepias verticillata*. A plant with detail of flower, fruit, and seed; the plant, one half life size. (f) *Asclepias speciosa*. A portion of a fruiting branch, one fourth life size, a flower, enlarged, and a fruit reduced.

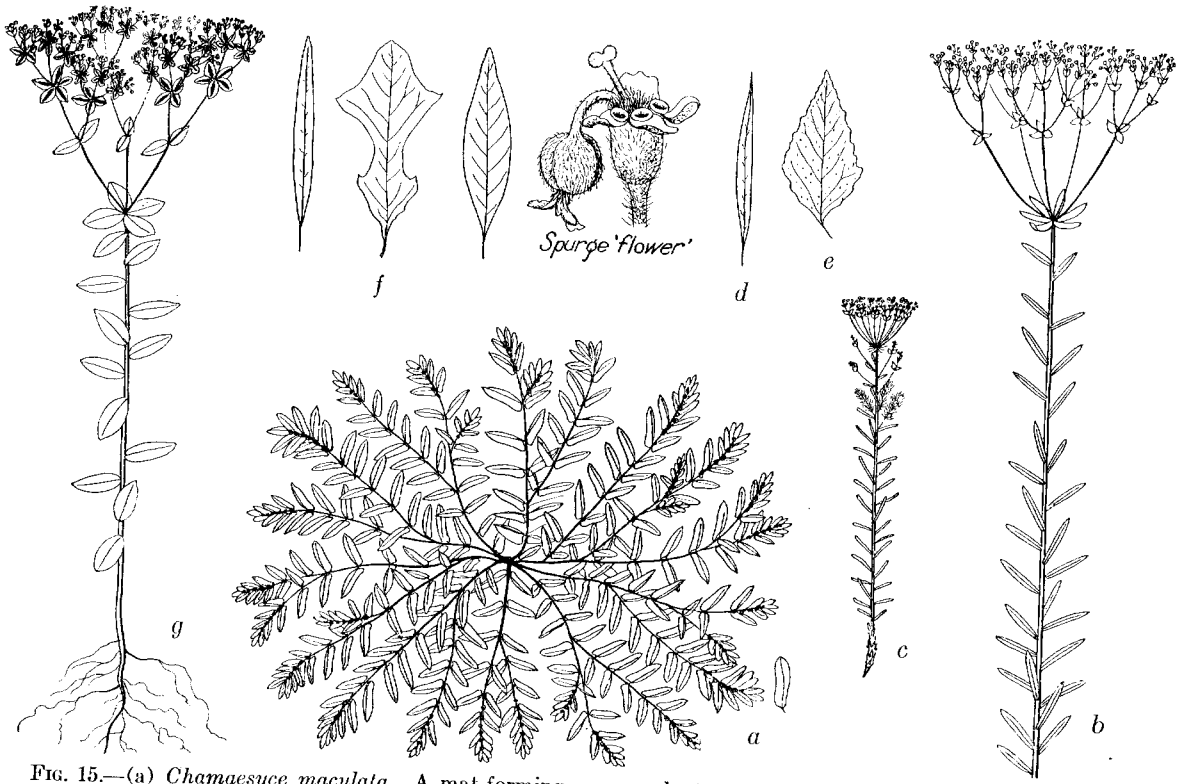


FIG. 15.—(a) *Chamaesyce maculata.* A mat-forming spurge plant somewhat reduced, with a single leaf enlarged. (b) *Tithymalopsis corollata.* A plant, reduced. (c) *Tithymalus cyparissias.* A plant, reduced. (d) *Zygophyllidium hexagonum.* A single typical leaf. (e) *Poinsettia dentata.* A typical leaf. (f) *Poinsettia heterophylla,* leaves showing three variations in leaf shapes. (g) *Dichrophyllum marginatum.* A plant considerably reduced.

Larkspur. — Two species of low larkspur, *Delphinium tricorne* and *D. vlirescens,* are rather common in Kansas, the former in the western and the latter in the eastern part. The prairie larkspur, *D. virescens,* makes its growth during April and May and the dwarf larkspur, *D. tricorne,* a month later. Plants of both species are usually too scattered to cause trouble, but since they usually start growth ahead of the grass, losses may occur when livestock are turned into the pastures too early.

Death Camas. — Death camas, *Zygadenus nuttallii,* is a lily-like plant having a small onion-like bulb. This plant is common in the eastern part of Kansas. It makes its growth early in the spring, flowers in MAY and then dries up and disappears. Death camas is most toxic to sheep but cattle may be affected. There is usually insufficient death camas in pastures to cause trouble. Where it occurs most abundantly livestock should be kept out of the pasture until the grass has made sufficient growth to satisfy them readily.

BURNING PASTURES

Burning in the spring is quite generally practiced in eastern Kansas on bluestem pastures following seasons when growing conditions were favorable and growth of the forage was high. Since it is impossible to anticipate the yield of forage in the pastures, the stocking has to be based on their grazing capacity in an average year. As a result there will be a large amount of unused vegetation at the end of a favorable season. If this dead grass is allowed to remain throughout the next grazing season, it may result in uneven grazing. Places where the livestock prefer to graze, such as the stream bottoms, ridge tops, and near water, are heavily grazed while the steeper, more rocky slopes or areas farthest from water will be undergrazed. Pastures are burned in some instances to control weeds and brush and to stimulate earlier growth of forage in the spring.

To obtain information on these and other questions that frequently arise from the practice of burning pastures, experiments have been conducted during the past seven years on two types of bluestem pastures located near Manhattan. One area is a typical flint hill type of pasture land, in which a mixture of prairie grasses composed of 60 to 70 percent big and little bluestem is growing. The other area is level, tillable upland with 50 percent of its vegetative covering little bluestem. Other less common grasses include big bluestem, Indian grass, prairie June grass, hairy grama, and Kentucky blue grass. The experimental areas were burned in the late fall or about December 1, early spring or about March 20, medium spring approximately April 10, and late spring or between May 1 and 10. One set of experimental plots was burned yearly and another set in alternate years at the above specified dates.

Burning affected the pastures mainly by decreasing the yield of vegetation the succeeding year. Burning every year in the late fall

decreased the yield about 63 percent; early spring burning, 50 percent; medium spring, 42 percent; and late spring, 14 percent. Where the burning was done in alternate years, the yields were 10 to 15 percent higher than from plots burned at the same time every year.

Burning in the early and medium spring had little effect on the succession or change in the species of vegetation with the exception of Kentucky blue grass, which was eliminated from all the plots that were burned more than three years in succession. Burning in the late fall had a tendency to increase the little bluestem and decrease big bluestem and Indian grass. Burning in the late spring caused an increase in big bluestem and Indian grass and a corresponding decrease in little bluestem. When bluestem pastures were burned between March 20 and April 10, which is the usual time to burn in the vicinity of Manhattan, little change was recorded in the vegetation. Out-of-season burning, such as early winter, which is sometimes practiced in bluestem pastures adjacent to farm land to remove cover for chinch bugs, and late spring burning which is done to control certain weeds and brush, will cause a change in the composition of the vegetation as indicated above if continued yearly for more than three years in succession.

The experiments have shown that burning stimulates early growth in the spring. This was caused mainly by an increase in soil temperatures. Where sufficient soil moisture is available to promote plant growth the increased temperature caused as a result of burning was sufficient, to increase materially the amount of vegetation. This increase is greatest where growth starts early in April, and gets progressively less as the season advances. The growth of the vegetation by April 10 on the early spring burned area averaged approximately 35 percent greater than on the unburned. When livestock were turned into the pasture about May 1 the amount of vegetation on the burned area was approximately 25 percent more than on the unburned areas. By June 15 there was little if any difference in the amount of vegetation on the two areas because at this time soil moisture rather than soil temperature was the limiting factor in plant growth. The difference in yield was most pronounced in cold wet seasons and least in warm dry ones.

Contrary to popular belief, burning did not cause any decrease in the total nitrogen or in the organic content of the soil. This may be attributed to the fact that the maintenance of the organic and total nitrogen content of the soil is due more to root development than to accumulations from the top growth. The root growth, however, is directly proportional to the amount of top growth. The data available indicate that the roots of grasses are relatively short lived, and are replaced to a large extent every two or three years. This would amount to about 2 tons of root material per acre on pasture land containing a good stand of bluestem grasses. The amount will vary from 1,000 pounds on poor pasture land to as much as 7,000 pounds on a good stand of bluestem grasses that has been moderately grazed.

Burning pastures is not effective for controlling weeds and brush unless it is done in the late spring, after April 20. To be effective the burning should not be done until after the plants which are to be eradicated have made 3 inches or more of top growth. The nearer the time of burning corresponds to the time of the lowest point in the food reserves the more effective it will be. Burning can be used effectively to eradicate buckbrush, as this shrub starts growth early in April and is fully in leaf by May 1. The main problem in eradicating buckbrush by burning is to have enough inflammable material to carry the fire over the ground. This may be accomplished by protection or by light grazing during the season previous to burning. Where the stand of brush is so heavy that the growth of the grass is excluded because of shading, straw or other inflammable material can be scattered rather lightly over the ground to carry the fire.

Sumac cannot be eradicated effectively by burning because it usually does not start growth until after May 1. Experiments have shown that burning is not harmful to sumac unless it is done the latter part of May. The grasses and other species of herbacious vegetation have made enough growth by this time to make burning almost impossible unless the season is abnormally dry, in which event it probably mould not be advisable to burn.

Nearly all the weeds starting growth early in the growing season can be controlled effectively by late spring burning. At the close of the growing season the average weed content of the plots burned in the late spring was about 2 percent on one area and about 1.5 percent on the other. The vegetation on the plots burned in late fall, early, and medium spring contained from 13 to 19 percent weeds on one area and 4 to 6 percent on the other. All the plots burned at these three periods had a greater weed content than the unburned area.

Information is frequently requested on the correct time for burning pasture. Burning for the purpose of removing the dead grass to stimulate uniform grazing should be done some time between March 20 and April 15 in the vicinity of Manhattan. These dates should be advanced about one week in the southeastern part of the state. Pastures should be burned just before the big and little bluestem grasses start growth, and if possible when the ground is wet. The latter is of much greater importance than the time of burning. In all the experiments mentioned above the burning was done when the ground was wet. Perhaps if the burning had been done when the ground was dry different results would have been obtained, particularly on the succession and density of the vegetation on the burned plots and the total nitrogen and organic content of the soil.

METHODS OF GRAZING

The aim in the management of pastures should be to obtain the greatest possible production of livestock without decreasing the productivity of the forage plants. To accomplish this necessitates the use of such grazing methods and rate of stocking as will permit

the forage plants to make enough top growth to maintain their vigor. It is especially important in the management of pastures to avoid grazing too early in the spring as this is the most critical period in the life of most perennial pasture plants. Whenever possible livestock should not be turned into the permanent pasture until the vegetation has made sufficient top growth to permit the animals to obtain a mouthful readily. This makes it possible for the plants to carry on their physiological activities adequately and for the livestock to obtain sufficient forage without continual wandering. The excess trailing is especially harmful when the soil is wet as the packing reduces the aeration and development of bacterial action, which in turn reduces the available nitrogen, the principal soil nutrient for all grasses.

In the vicinity of Manhattan in an average season the bluestem grasses do not make enough top growth to justify grazing much before the first of May. In the south central and southeastern parts of the state this date may be advanced a week or 10 days. Supplementary pasture crops, discussed later, can be used advantageously to provide forage during the early part of the growing season, thus allowing the permanent pasture to make adequate top growth to maintain the vigor of the plant and to provide ample feed when the livestock are turned on it.

Improvement and increased grazing capacity have been made in permanent pastures by applying methods of grazing that interfere as little as possible with the normal functioning of the plants. The methods most commonly used to accomplish this include deferred grazing and rotation grazing, or modified forms of these methods.

DEFERRED GRAZING

Deferred grazing consist of postponing or delaying grazing in a pasture for a part of the growing season to permit the vegetation to make sufficient top growth to maintain its vigor.

This protective period for the bluestem grasses can be applied most effectively at the beginning of the growing season, because at that time the grasses draw on their root reserves to start growth. This process continues until there is sufficient top growth to supply the growing needs of the plants. Experimental work with the bluestem grasses indicates that the food reserves of the dominant desirable grasses are restored by the middle of June under normal growing conditions. Close grazing after this time is much less injurious than earlier in the season, and the injury continues to decrease as the season advances and as the grasses make additional top growth.

A system of deferred grazing can be applied by subdividing a pasture into three units, placing all the livestock in two units until about the middle of June, then changing all or enough of them to the protected pasture to utilize the vegetation before it gets stemmy. If it is found that the deferred pasture will not carry all the stock after the excess growth has been consumed, a sufficient number can be shifted to the other two pastures so that the remaining animals

will have enough forage to meet their needs adequately. The three pastures should be managed so as to allow the grazing to be deferred in each at the beginning of the grazing season once in three years. This has been found to be sufficient to maintain the stand of desirable forage plants and to utilize them more closely than would be possible under season-long grazing.

Experiments conducted on a typical bluestem pasture near Manhattan, in cooperation with Mr. Dan Casement, have shown that the deferred system increased the grazing capacity approximately 35 percent. Livestock grazing the deferred pasture made a daily gain of 78 pounds per acre, while the pasture grazed season long made a daily gain of 65 pounds per acre. Cows and May calves were used in the experiment. The practicability of applying a deferred system of grazing will be governed by the amount of fence that is necessary for dividing the pasture, the uniformity of the pasture, and the availability of water and shade in the proposed pasture units.

It would not be advisable to apply a deferred system of grazing unless the pasture is rather uniform and water is available or can be obtained at small expense in the proposed units. The cost of additional fencing is also of major importance. The desirability of dividing the pasture will depend upon the benefits which can be expected. In most bluestem pastures the carrying capacity will not be increased much more than one third. The value of these benefits should exceed the cost involved in applying the system.

DEFERRED AND ROTATION GRAZING

A deferred and rotation system of grazing is designed primarily for pastures which contain the type of forage that requires the occasional maturity of seed to maintain its normal density. This applies mainly to the regions of lighter rainfall where the forage plants are largely replaced by seed rather than vegetatively by stolons or roots. The use of a deferred and rotation system of grazing therefore would be limited in Kansas mainly to the short grass or western part of the state. The application of this system of grazing requires the use of three pastures, each pasture to be grazed about one third of the growing season and protected the other two thirds. The pasture grazed last in the season is protected until the seed matures. Grazing after the seed matures aids in covering the seeds so that a much higher germination will be obtained. The pasture grazed last one season, will be grazed next to the last the following season in order to permit the seedlings to become well established before livestock are turned into the pasture. The third year this unit is pastured first. The same plan is used for each pasture so that once in three years the forage plants in each will be able to mature seed with part season protection the following year. This allow the seedlings to make sufficient growth to withstand grazing.

The practicability of applying a deferred and rotation system of

grazing will be governed by the comparative cost of improvements which are necessary to put the system into operation and the value of the increase in grazing capacity and improvement in the pasture. At Mandan, N. Dak., on a mixed grama and little bluestem type of vegetation, 15 head of two-year-old steers have been grazed on 70 acres divided into three pastures and the grazing deferred and rotated as described above. In a pasture similar in size and vegetative composition 10 two-year-old steers utilized all forage under a season-long system of grazing. The forage content was about equally maintained in the pastures grazed under the two methods, and the gains made by the livestock were approximately the same.

The deferred and rotation system of grazing has merit in the semiarid part of the country where the vegetation cures when it matures and retains a portion of its forage value, thereby making it possible to utilize the feed the latter part of the season. This system is not applicable to the humid or semihumid regions where the tall grasses (mainly bluestems) predominate, because these grasses lose a large percentage of their palatability and feeding value after maturity In these native grasses the protein content is very low and the crude fiber content proportionately high. The bluestem grasses maintain their stand principally by the development of roots, and reseeding is necessary only in pastures where the stand is below normal and it is desired to restore the vegetative cover in a minimum length of time.

HOHENHEIM SYSTEM OF GRAZING

The Hohenheim system of grazing management was developed in Germany during the early part of the World War for the purpose of making it possible to produce a large quantity of milk without feeding concentrates. This system is best adapted to dairy cattle and its applications involve the following steps: (1) Division of the pasture into from four to eight paddocks about equal in size; (2) applications of large quantities of fertilizers mainly nitrogenous; (3) separation of the herd into three classes, high, medium, and low or nonproducers; (4) rotating the animals in the above listed order so that the most productive cows will be turned on the forage leaving the low and nonproducers to clean up the pasture after the other two classes have taken the more palatable forage.

This system also was used in England directly after the war when milk prices were high. The Hohenheim system has been tried to a limited extent in the eastern part of the United States. It may have some value in the humid parts of this country where the moisture is sufficient to maintain a vigorous vegetative growth throughout the growing season, and where land values are high and milk or other animal products command a good price.

The system is not applicable to Kansas, because moisture is the principal limiting factor in the growth of pasturage in Kansas. The application of small amounts of fertilizers may be justified in some instances, but the addition of large amounts and the extra expense

of fencing are not justified. Investigations in this country indicate that a major part of the increased production obtained through this system comes from the use of fertilizers and only a small amount is due to the rotation grazing which causes the greatest expense incurred in applying this system.

TEMPORARY PASTURE CROPS

Temporary pasture crops provide the best source of feed to supplement the permanent pasture to permit the use of grazing methods that will maintain the productivity of the desirable forage plants. The use of temporary pasture crops is especially essential in the improvement of run-down permanent pastures where protection in

FIG. 16.—Cattle grazing winter wheat pasture.

essential in restoring the normal grazing capacity. Temporary pasture crops are not only essential in the improvement of the permanent pasture, but they make it possible to increase substantially the length of the grazing season. The crops best adapted for temporary pastures include winter wheat, rye, and barley for fall, winter, and spring pasture. Oats and sweet clover provide excellent temporary pasture crops for spring and early summer grazing. Sudan grass is the best temporary pasture crop for summer. A combination of oats and Korean lespedeza may be used profitably in eastern Kansas as a pasture crop for spring, summer, and early fall.

All the grain cereals are very palatable and nutritious to livestock. Their use makes it possible to extend the pasture season about two months in the fall and to make pasturage available a month to six weeks earlier in the spring. Owing to the high feeding

value of grain cereals for pasture, especially in the fall and early spring, the stock should have access to dry feed such as a straw stack or corn or sorghum fodder to better balance the ration and to prevent excessive scouring.

Winter wheat is the most extensively used of the grain cereals for fall, winter, and spring pasture. (Fig. 16.) Experiments conducted at the Hays station have shown that wheat can be pastured without reduction in yield of grain if growing conditions are favorable and the grain is not pastured too late in the spring. Winter wheat grown primarily for grain production should not be planted before the latter part of September because of the danger of Hessian fly. Winter wheat or any of the grain cereals grown primarily for grain are of little value as supplementary pastures for improving the permanent pasture because the stock should be taken off them about the middle of April, which is approximately the time the grass in the permanent pasture starts vigorous growth and requires protection, especially in run-down pastures. Grain cereals planted primarily for pasture will supply grazing until early in June. This provides an opportunity for protection of the permanent pasture, which will add greatly to the vigor, yield, and density of the desirable forage plants.

Winter rye makes a satisfactory pasture crop in eastern Kansas. Its use is objectionable in western Kansas owing to the danger of its becoming mixed with wheat. Winter rye can be planted as early as the middle of August if growing conditions are suitable. It is more resistant to cold and drought than wheat or barley, thus making it the best adapted grain cereal for pasture on poor soils.

Winter barley has been used to a limited extent as a pasture crop. It can be seeded early and makes a leafy growth, thus providing more pasturage in the fall and early winter than wheat or rye. Where winter barley is pastured closely it will kill in about half of the winters at Manhattan. The percentage of winterkilling will increase to the north and west and decrease to the south. This grain cereal can be profitably used for pasture in the southeastern and south cental parts of Kansas although it will winterkill occasionally in these sections. It will be advisable to plow under the barley in the spring when chinch hugs are numerous, in order to check their spread.

Oats are sometimes planted for spring pasture, but they are rarely seeded for fall pasture as they winterkill even in mild seasons, although only moderately grazed. They produce a leafy forage that is more palatable than that of other grain cereals and provide abundant forage during the fall and early part of mild winters. Oats and barley are about equal in this respect.

All the grain cereals sown for pasture should be seeded at about twice the customary rate. When sown at this rate they produce a heavy turf and leafy foliage which affords protection from tramping and reduces erosion to a minimum.

In the eastern part of Kansas a combination of oats and Korean lespedeza is used to a limited extent as a season-long temporary pasture crop. This mixture should be seeded at the rate of a bushel of oats with 8 to 10 pounds of lespedeza per acre. The seeding should be made early in the spring on a well prepared seedbed. The oats will provide pasturage during the spring and early summer and the lespedeza during the summer and early fall.

Sudan grass provides the best, summer and early fall pasture. It is very susceptible to chinch bug injury but over a series of years produces enough forage to more than justify its use.

SALTING LIVESTOCK

An adequate supply of salt (sodium chloride) is essential to the normal development and successful handling of livestock in pastures. The proper distribution of salt in larger pastures aids in securing uniform grazing by the livestock and in obtaining the most satisfactory use and maintenance of the forage. The amount of salt required by livestock varies with (1) the salt content of the feed and drinking water, (2) the presence of salt licks, (3) the salt loss by weathering, and (4) the possible differences in requirements of different animals.

The salt content of different types of feed varies enough to make significant differences in the amount of salt required by livestock. In general, green leafy forage contains less salt than mature or dry feed. Certain types of plants such as salt grass, *Distichlis stricta,* or other saline plants are high in salt content which includes not only sodium chloride but other alkali salts. Experiments conducted by this station on a bluestem pasture show that livestock will use more salt at the beginning of the grazing season than at the latter part of it. During the season of 1920 it was found that cows on bluestem pasture used an average of 2.82 pounds of salt per animal during July, 1.88 pounds in August, 1.77 in September, and 1.2 in October.

Livestock having access to natural salt licks or water containing various saline salts may use less salt, although these sources may contain salts that are injurious, such as black alkali (sodium carbonate) and white alkali (sodium sulphate). Livestock that depend upon natural salt licks often eat a large amount of soil. The soil eaten may often be detrimental to the health of the stock, and in some instances has resulted in death. It has been found in some of the western states that livestock used commercial salt even when natural salt licks were present or when the water had a high salt content.

Experiments in salting livestock show that mature stock in pastures in eastern Kansas will utilize 5 to 7 pounds of salt per animal during the average pasture season. Sheep grazing green forage will use about ½ ounce of salt per day. The requirement of goats is slightly higher.

Kinds and Grades of Salt to Use.—It is poor economy to purchase rock salt that contains a large amount of foreign material especially if this material contains compounds that are nonessential or detrimental to livestock. Stock prefer the kind of salt that will satisfy them as rapidly as possible. Experiments at this station have shown that stock ate granulated salt first, evaporated salt blocks next, and other blocks in more or less regular order according to their increasing hardness.

Losses of Salt from Weathering.—Experiments conducted near Manhattan in 1920 and 1921 show that 24 percent of granulated salt was lost cach month from weathering. Evaporated block salt and five grades of block salt subjected to 400- to 1,000-ton pressure in their manufacture lost an average of 10 percent per month. There was little difference in the weathering loss of the blocks. The use of containers for salt was found to reduce greatly the loss from weathering. In 1920 sulphur compressed blocks lost 7 percent each month when placed in containers and 13 percent when placed on the ground. The compressed blocks that were subjected to 400- to 1,000-ton pressure lost 9 percent when placed in containers and 20 percent when placed on the ground. The use of containers makes the salt more accessible to the livestock and lessens the tendency to eat soil.

The salt should be placed in the pasture so that it will meet the needs of the livestock and aid in the proper utilization of the forage. It is not generally desirable to place salt near water or other places where stock are likely to congregate. Salting in parts of the pasture which stock otherwise would not frequent may be used as a means of obtaining a more uniform utilization of the forage, provided these places are not too far removed from water. To accustom the livestock to new salt locations it may be necessary to drive them to these places a few times. Salt should not be placed on steep slopes where there is danger of soil erosion.

LIVESTOCK WATERING PLACES

A good supply of water in a pasture is essential to the most efficient use of the vegetation and to maintain the proper health and development of the livestock. In large pastures the water should be uniformly distributed, if possible, otherwise the areas nearest the water will be overgrazed while the ones farthest removed may be undergrazed. Fortunately most pastures in eastern Kansas are normally well supplied with water from streams and springs.

Wells and ponds are important sources of stock water for pastures, A geologist or other person having knowledge of the underground structure, especially with respect to its possibilities of supplying water, should be consulted before wells are drilled. Estimates on the cost of drilling should then be obtained from reliable well drillers who have equipment capable of penetrating to the water-bearing formations.

Ponds are perhaps the most important source of stock water in Kansas. They are usually constructed on drainage channels where there is a sufficient run-off to supply the livestock in the drier years. The drainage area should not be so large that the dam will be washed out when the spillway facilities are inadequate to take care of the overflow during heavy storms. The possible loss of water from seepage and evaporation should be considered and guarded against in building a pond.

The size of the water shed for supplying the water should be governed by the rainfall slope of the drainage channel, density of vegetation, type of soil, distribution and character of the precipitation, evaporation, and the number of stock to be watered.

In the eastern part of Kansas where the rainfall averages about 35 inches annually, a good Kentucky blue grass sod having a moderate slope of about 4 percent will have a run-off of approximately 12 percent. The run-off will increase as the slope increases and the density of the vegetation decreases. It also increases with overgrazing and with increased heaviness of soil texture. Heavy torrential rains increase the amount of run-off. The nature of the drainage area and the number of livestock to be supplied with water are important factors to consider in determining the size of the pond. During the summer a cow or horse will drink about 10 gallons of water per day. This may be increased to 12 gallons in extremely hot weather when forage is dry.

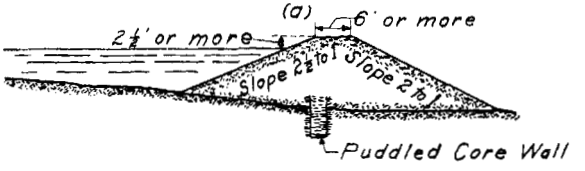
Twelve inches of rainfall on an acre of land will furnish about 320,000 gallons of water. It has been estimated that well vegetated grass land in eastern Kansas will have a run-off of approximately 40,000 gallons per acre in wet years and about one third this amount in moderately dry ones. According to this estimate a drainage area of 10 to 15 acres should supply the average sized pond in the eastern part of the state. In the western part of Kansas a much larger drainage area with a proportionately larger dam and spillway will be required. In estimating the size of the pond and the drainage area required to supply an adequate amount of stock water the loss of water from evaporation should be considered. The average yearly loss of water from this source at Manhattan is about 38 inches. This loss increases in the western part of the state, averaging about 46 inches at Hays, 40 at Colby, and 52 at Garden City.

The water-holding capacity of a pond can be roughly estimated in acre feet by multiplying its total area by one third its greatest depth. If, for example, a pond covers one acre with a maximum depth of 15 feet it would have a capacity of $1 \times 1^{5}/_{3}$ or 5 acre feet which is equivalent to approximately 1,600,000 gallons.

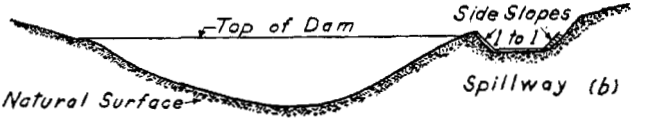
The pond should be located, if possible, where there is little erosion and where the drainage basin is well vegetated. The drainage channel should be narrow at the dam site and flat above it.

The site for the pond should have a gentle slope to furnish an easy means of access for the livestock. Earth for building the dam should be readily available. The soil selected should be of such a

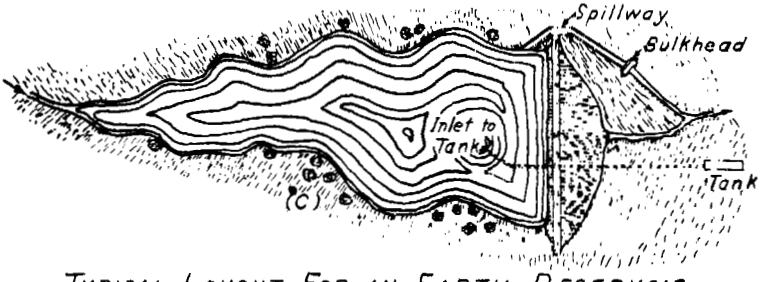
texture that it will form a watertight and stable dam. Loose open soils of coarse texture such as pure sands, gravels, or cinders and those containing a large amount of soluble salts such as gypsum should be avoided. The character of the subsoil can be learned by drilling test holes with a soil auger. Clay may be added to sandy soils to improve their water-holding ability. Heavy clay soils should be avoided as they are likely to crack when dry. An ideal soil for dam construction is one consisting of 1 part of clay to 3 or 4 parts of sand. This mixture will have the desirable characteristics of weight, stability, and water tightness.



CROSS SECTION OF DAM



ELEVATION OF DAM & SPILLWAY



TYPICAL LAYOUT FOR AN EARTH RESERVOIR

FIG. 17.—Plans for building a large livestock watering pond. (a) Crown of dam. Notice height above water, width, and slopes. (b) Spillway. Note comparative size. To prevent erosion the spillway should be lined with timber, stone, or concrete. The spillway area should equal about 17 square feet for each 80 acres of land in the drainage area. (c) The layout should be completely enclosed with hog-tight fencing. Note inlet to the tank for livestock watering below the dam and the gas pipe connection.

Adapted from plans prepared by the State Engineer, Division of College Extension, Kansas State College of Agriculture and Applied Science, Manhattan, Kansas.

The first step in building the dam should be to make a good bond between the foundation and the earth. The vegetation should be removed from the bottom of the dam as it will eventually decay and leave crevices through which seepage may start. Several furrows plowed along the bottom of the dam will seal the dam to the earth. On large dams a trench should be dug and filled with clay and thoroughly packed to build a core several feet into the dam. (Fig. 17a.)

If possible the material for the construction of the dam should be taken from the bottom of the pond above the dam. It should be taken far enough above the dam so that the dam will not cave into the excavation. The top of the dam should be level and protected by a fence or a boom of logs, to remove the force of the waves. Big dams should be faced with rock.

The dam should be provided with adcquate spillways (fig. 17b.) to carry off the overflow. During very heavy rains empty ponds may fill in 30 minutes and overflow facilities should be large enough to carry off the entire run-off from the watershed. In a cross section the floor of the spillway should be level and 3 to 6 feet below the top of the dam, the distance depending on the size of the pond or reservoir. Salt is frequently placed in the floor of the spillway so stock will tramp and pack the earth to prevent erosion. The bottom of the spillway can be sodded with buffalo grass in the western part of the state and with Kentucky blue grass, brome grass. Bermuda grass, or some other sod grass in the eastern portion. If the soil is such that the grass will not grow, the bottom should be lined with rock laid in cement or with brush weighted with rock. The latter method is good to keep the spillway floor from cutting or to prevent the formation of a waterfall in the spillway. The spillway should be so located that the overflow will not wear against and undermine the end of the dam. This should be well protected with rock, cement, or sacks of earth.

Fencing ponds, especially large ones, will help to keep the water fresh and prevent the animals from bogging. When this is done it is necessary to provide tanks for watering. These tanks should be located below the dam and connected to the water supply with an inch pipe. The flow may be controlled by a float in the tank. A convenient sized tank is one 12 feet in diameter and 4 feet deep. The tank should be set one foot in the ground. An apron of gravel or cement should be placed around the tank to prevent this place from getting wet and muddy. (Fig. 17c.)

The life of a pond from silting depends upon the amount of erosion on the watershed. In the Bluestem Region there are a number of ponds that have been in use for 30 years and still have about one half of their original water-holding capacity. When a pond has been filled with mud it is cheaper in most instances to build a new pond farther down the drainage channel than to clean the old one out. The old pond can then serve as a silting basin. To maintain a good cover of vegetation on the drainage basin and thus

greatly increase the life of a pond, it is frequently advisable to fence this area and graze it only after the vegetative cover has been restored to normal and when no injury will result from removing part of the growth.

RUN-OFF AND EROSION

Pasture plants, particularly perennial grasses, are the most effective type of vegetative growth for checking erosion throughout a major part of Kansas. This is because their fibrous roots thoroughly penetrate the soil, binding it against erosion, Grass roots often extend to a depth of 8 feet in some of the deeper soils in the eastern part of the state. Grasses also prevent erosion because they prevent the accumulation of run-off into rivulets and because the individual stems serve as dams. thereby reducing the rate of flow. The extensive fibrous root system of grasses increases the absorptive capacity of the soil.

The amount of run-off and erosion from pasture land will be governed to a large extent by the composition and density of the vegetative cover. This in turn will be controlled mainly by the intensity of grazing. Investigations conducted at the Fort Hays Branch Agricultural Experiment Station, Hays, Kan., have shown that the run-off from moderately grazed buffalo grass pasture was 1.2 percent compared with 4.95 percent from a heavily grazed area. On moderately grazed plots vegetated mainly with little bluestem the run-off was 0.52 percent compared with 3.1 percent on plots that were heavily grazed.

The amount of soil removed from all the plots was small. Only 0.049 ton per acre was removed from the heavily grazed buffalo grass plots and about one tenth of that amount from the moderately grazed plots. There was about one half as much erosion on the little bluestem as on the buffalo grass. The higher run-off and erosion on the short grass plots was due mainly to soil differences. The buffalo grass was growing in a much heavier type of soil than the little bluestem. The slope of all the plots was approximately 7 percent. The annual precipitation for the two years during which these data were obtained was approximately 19 inches.

The effectiveness of grass land in controlling erosion and run-off is strikingly shown from other experiments conducted at Hays, Kan. The data given in Table I were obtained from plots 6 feet x 72.6 feet in size with a 5 percent, slope, and are an average for the four-year period, 1930 to 1933, inclusive. The mean annual precipitation during this time was 19.73 inches.

Experiments conducted near Columbia, Mo., where the mean annual precipitation is nearly 36 inches, also show the run-off and erosion from grass land to be much less than for all types of cropped land. The run-off from a bluegrass sod was 11 percent compared to 25 percent from wheat and 49 percent from an untilled plot upon which no crop or vegetation was growing. The annual amount of soil eroded averaged 42 pounds per acre for the sod, 1,000 pounds

TABLE I. EFFECT OF THE CROP ON EROSION AND RUN-OFF (*a*).

Hays, Kan., 1930 to 1933, inclusive.

Cropping of plots. (Each plot 6 feet by 72.6 feet.)	Percentage of run-off.	Tons of soil removed per acre annually.
Wheat following wheat	8.84	2.08
Wheat on desurfaced soil	16.60	11.50
Wheat on fallow rotation	10.44	2.81
Fallow land rotation	13.06	13.64
Kafir after wheat rotation	17.68	12.22
Kafir	16.11	13.21
Buffalo grass, clipped	.59	.11
Buffalo grass, protected	.04	.004

(*a*) Data obtained from the Bureau of Chemistry and Soils, U. S. D. A.

for the wheat land, and 5,000 pounds for the bare ground. Experiments conducted in Oklahoma have shown that cultivated fields lost 84 percent more rainfall and 667 times more soil than similar fields that were under a grass sod.

USE OF COMMERCIAL FERTILIZERS AND MANURE

The productivity of pastures in humid regions is governed mostly by the fertility of the soil. Both the yield and the quality or feeding value of the forage are influenced by the soil fertility. Pastures having a thin unproductive soil will not stand so heavy usage as the ones having fertile soils. The forage plants on the thin soils will be replaced much more quickly by weeds following improper grazing practices than will those on fertile soils. In the eastern part of the United States the fertilization of pastures is one of the principal means used for increasing the amount of palatable forage plants which under proper grazing management will replace the weeds.

Pastures with a good stand of forage plants are reduced very little in fertility by properly managed grazing. This is because the run-off and erosion which are the principal causes of the rapid depletion of soil fertility are reduced to a minimum. The fine root system of the grasses also will gradually restore a desirable granular texture to soil which has run together because of continual cropping. The droppings from the cattle will aid in maintaining the fertility of pastures. There may be, however, more plant food removed from the soil in animal products and by natural causes on high-producing pastures than are replaced by the vegetative accumulations. Particularly is this true of pastures that were originally low in any of the elements essential to plant growth.

Fertilizers may be profitably applied to pastures only in the eastern third of Kansas where precipitation averages more than 30

inches annually. In the remainder of the state moisture rather than soil fertility is the limiting factor in plant growth. Throughout a major part of eastern Kansas experiments have shown that the greatest increase in yield of pasture forage can be obtained by the use of nitrogenous fertilizers. This is because nitrogen is not made available rapidly enough during May, June, and early July, when growing conditions are usually very favorable, to meet the needs of rapidly expanding grasses. The lack of available nitrogen is largely responsible for the low yield obtained from brome grass after it has been established several years and frequently attributed to a sod-bound condition of the roots. (Fig. 18.)

There are several forms in which nitrogen can be applied to pastures. Barnyard manure is the most common form. A ton of

FIG. 18.—Effect of nitrogenous fertilizer on brome grass. (Left) Nitrogenous fertilizer applied. (Right) No treatment.

good manure contains from 10 to 18 pounds of nitrogen and a smaller amount of phosphorus and potash. In experiments conducted near Manhattan, 7 tons of manure applied on rather poor sloping pasture land seeded to a mixture of brome grass, orchard grass, and Kentucky blue grass, increased the yield approximately 50 percent over a period of five years, 1927 to 1931, inclusive. The crude protein content of the grass was also increased about one third. Six tons of good barnyard manure applied on a good upland bluestem pasture, consisting mainly of little bluestem, gave a little less than 50 percent increase in yield. The application of manure also had a tendency to increase the weeds in the pasture.

The advisability of placing manure on pastures depends upon the amount of manure available and the length of the haul. Frequently, however, pasture land affords a convenient place to spread manure when it is not possible to apply it on tilled land.

Nitrogen may he applied to pasture land in various forms of commercial fertilizers. The most common ones include ammonium

sulphate and sodium nitrate. About 100 to 150 pounds per acre of either of these fertilizers should be broadcast on the pasture in the early spring to obtain the most satisfactory results. The cost of ammonium sulphate at the present time is about $2.25 per hundred pounds or $2.25 to $3.37 per acre, depending upon the rate of application. At present prices sodium nitrate will cost a little more,

Experiments conducted over a five-year period on an upland bluestem pasture containing a good stand of grass composed mostly of little bluestem, gave an increased grass yield of about 33 percent where 200 pounds of ammonium sulphate per acre was applied each year. One hundred pounds of ammonium sulphate per acre applied yearly increased the yield of grass more than 20 percent over that of the no-treatment, areas. The grass on the fertilized plots had 20 to **25** percent more protein than the nonfertilized grass. Plots receiving a complete fertilizer consisting of 100 pounds of ammonium sulphate, 200 pounds of superphosphate, and 25 pounds of potash gave little increase in yield over the plots that were fertilized with 100 pounds of ammonium sulphate. These soils, however, contained ample quantities of phosphate and potash for plant growth.

Significant, increases in yields have been obtained on acid soils in southeastern Kansas by the application of lime and phosphate. The use of these fertilizers will stimulate the growth of grass but will increase the growth of legumes to a greater extent. There are small areas in the state where the deficiency of some mineral element in the pasture forage causes nutritional disorder of the livestock when they are grazed in the pastures for extended periods. Phosphorus is generally the element which is deficient. This condition may be corrected in some instances by the application of phosphorus fertilizers, but in many cases the increases in yield or improvement in the condition of the stock may not justify the expense. The effect of the deficiency in the mineral composition of the forage can be corrected most cheaply by feeding the animals a supplement containing the minerals that are deficient in the forage.

Under existing economic conditions it is possible that the use of commercial fertilizers is justified only when a high production is desired and where the animal products can be marketed at a good price. The use of fertilizer would not be profitable in extremely dry years when the moisture content of the soil rather than the nutrient elements is the limiting factor in plant growth.

The nitrogenous fertilizers, should be applied in the spring about the time growth starts since the nitrogen is immediately available and will be lost by leaching if applied too long before it is used by the plants. When more than 100 pounds per acre is applied it should be divided into two or more applications of about 75 pounds each. At least one month should intervene between treatments. Phosphate fertilizers can be applied in the fall or early spring and little if any of the fertilizer will be lost through leaching.

REVEGETATION OF DEPLETED PERENNIAL PASTURES

The first step in the improvement of depleted perennial pastures is to correct the grazing practices that have been responsible for their condition. The poor condition of the pasture in nearly all instances is due to overgrazing. During the extremely dry hot season of 1934, however, much of the blue grass in the permanent pastures was killed. Climatic conditions rather than grazing practices were primarily responsible for the killing.

In the western two thirds of the state the restoration of the native vegetation by the application of proper grazing practices is the only satisfactory method to be used in the improvement of pastures.

FIG. 19.—Restoration of bluestem pasture by protection. Area on left side of fence has been partially protected for two years. It was similar to the other pasture previous to this time.

The restoration of the run-down pastures in the eastern third of the state will require the use of grazing methods that will give the vegetation an opportunity to make the maximum growth particularly during the first part of the growing season. Many of the run-down pastures in the eastern part of Kansas have scattering stunted bluestem plants that thicken up quickly if they are protected long enough to make normal growth. (Fig. 19.) A good stand of bluestem grass was restored on a badly run-down pasture in Labette county by three years of protection. The pasture was mowed in June of each year to control the weeds. The removal of the competition of the weeds aided greatly to increase the density of the bluestem grasses.

If bluestem grasses are growing in a pasture they should be restored if possible because they will provide more forage and will stand closer grazing than any of the tame forage plants. When the palatable forage species are so scattered that it is not advisable to protect the pasture long enough to restore the normal stand of this vegetation, the productivity of the pasture might be regained by reseeding with tame pasture plants. This method is feasible only in the eastern third of Kansas. The method of restoring a pasture located in the eastern third of Kansas that is depleted of all its desirable forage plants is to plow all the tillable land in the fall or early winter and seed it to oats, barley, or flax the following spring. The land should be plowed shortly after the crop is harvested. About the middle of August it should be worked into a level, well-prepared seedbed and planted to a well-adapted grass or pasture mixture early in September.

Where it is not advisable or not possible to plow because the land is too sloping or the soil too shallow or rocky, the surface may be loosened sufficiently by disking to cover the seed so that it will germinate and start growing. Disking may be done most effectively in the early spring because the freezing and thawing during the winter loosens the soil.

The climatic conditions in Kansas are not so favorable for spring seeding of grasses and most perennial legumes as is the late summer. If the soil is well supplied with moisture, however, and excessive hot weather does not come until July, reasonable success may be expected from spring seeding on disked pasture land.

Since all grasses and most pasture legumes require a good seedbed to obtain a good stand, the pasture land should be double disked and the sod thoroughly cut and pulverized. The stand of forage plants will be determined to a large extent by the thoroughness with which this work is done. After the land is disked it should be harrowed, then seeded. The seeding should be done with a drill if one is available, as this permits a more uniform depth of planting and covering the seed. Certain coarse chaffy grass seeds will not seed in a drill, so they require broadcasting. If the seed is broadcast, a more uniform distribution can be obtained by going over the land twice. The land should then be thoroughly harrowed. This usually requires going over the area twice, the second harrowing being done at right angles to the first. If the land is dry it is advisable to roll or cultipack it.

Climatic conditions are usually more favorable for obtaining a stand of pasture forage by seeding in early September. The advisability of seeding in the late summer will depend upon the moisture content of the soil and the possibilities of thoroughly disking it, as well as growing conditions in general. Fall seeding will frequently provide pasturage nearly as soon as spring seeding. Unless favorable growing conditions prevail the spring seeding should be protected most of the first season. The fall seeding will stand light pasturing the next spring which would be almost as soon as the

spring seeding should be grazed in most seasons. The spring seeding should permit much heavier grazing than the grasses planted in the fall, however.

Land that cannot be disked owing to topography or the rocky nature of the soil may be seeded with Korean lespedeza. The successful use of this legume is limited to the eastern third of the state. Korean lespedeza is an annual and is palatable to all classes of livestock. It should be seeded during the late winter so that the alternate freezing and thawing will cover the seed. This legume will reestablish itself from seed each spring. It will stand rather close grazing and still mature enough seed to make a good stand, the seed being produced on branches that grow close to the ground where cattle cannot graze them.

WHAT TO PLANT

There are a number of tame pasture grasses which may be used in reseeding perennial pastures. The success of reseeding will depend upon the preparation of the seedbed by plowing or disking and upon the seeding of the best adapted species. As previously stated, high moisture content of the soil and favorable growing conditions for the next few months after seeding are also of major importance in obtaining a good stand.

Figure 20 shows the tame pasture areas in the more humid parts of Kansas. The lines are arbitrarily drawn and do not, represent any sharp differences. In the northern part. of the region represented by areas 1 and 2,brome grass is the best to use in single seedings on most upland pastures representing the poorer lands in the area. In area 1 brome grass can be supplemented with orchard grass and sweet clover. After these pastures have been established two or three years, Kentucky blue grass will start to come in, especially on the better land, and it will replace the other grasses in time. Sweet clover will not last more than two or three years under average grazing management.

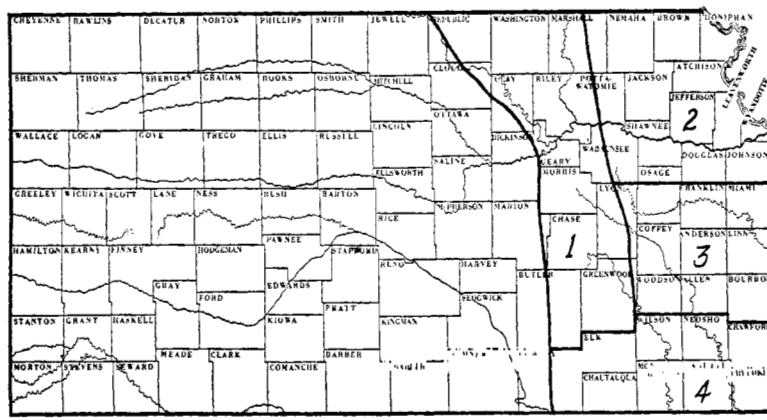


FIG. 20.—Tame pasture areas in eastern Kansas.

Brome grass when planted alone should be seeded at the rate of 16 to 18 pounds per acre. When seeded in a mixture with sweet clover, which would be advisable in the north half of area 1, 12 pounds of brome should be seeded to 6 of sweet clover. In the southern half of the area, the mixture can include orchard grass and should be planted in the following proportions: Brome grass 10 pounds; orchard grass 6; sweet clover 4 per acre.

In area 2, the grasses to be seeded in a mixture with brome grass include orchard grass, meadow fescue, Kentucky blue grass, and sweet clover. The mixture should contain from 20 to 24 pounds of seed per acre composed of the following: Brome grass 8 pounds; orchard 6; meadow fescue 4; Kentucky blue grass 4; sweet clover 4 per acre. If the land is acid, Korean lespedeza should be substituted for the sweet clover.

Orchard grass should constitute the base grass for areas 3 and 4. In area 3, the mixture should be composed of orchard grass 8 pounds; brome 4; meadow fescue 4; and Korean lespedeza 6 per acre. On the poorer land the mixture should contain red top in place of the brome grass. The seeding in area 4 should include orchard grass 6 pounds; meadow fescue 6; red top 4; and Korean lespedeza 6 per acre.

All the above seedings are suggested for an average pasture and may be changed to meet local conditions and changing prices of seed. In southeastern Kansas, orchard grass has given the best results of any of the grasses planted on disked pasture land.