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DEPARTMENT OF AGRICULTURE

Miscellaneous Publication No. 194

Washington, D.C.

Issued April 1934
Slightly revised May 1940

A PASTURE HANDBOOK

By

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With a Foreword by

HENRY A. WALLACE
Secretary of Agriculture

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By A. T. Semple, formerly *associate animal husbandman, Bureau of Animal Industry;* H. N. Vinall,* *senior agronomist,* and C. R. Enlow, formerly *associate agronomist, Bureau of Plant Industry;* and T. E. Woodward, *senior dairy husbandman, Bureau of Dairy Industry*

With a foreword by Henry A. Wallace, *Secretary of Agriculture*

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FOREWORD

Encouraging the conservation and building of the Nation's soil productivity has become a definite and important national policy. Preservation of the resources of the land upon which the Nation depends, now and in the future, for its food and clothing prompts such

*Mr. Vinall died February 1937.

a policy. Greater security and a better living standard for the dwellers on the land who produce the Nation's food and clothing are other considerations leading toward the same objective of general public welfare.

Advancement in the management of pastures, meadows, and ranges, and realization that these crops contribute to soil conservation and to efficient farming, have been salutary developments in the farm program of recent years. The right use of pasture and of roughage crops is of basic importance in a national program of efficient farming, in the control of erosion, and in the building of soil fertility.

Under the encouragement of the agricultural-adjustment program that was in effect from 1933 to 1935, the greater part of more than 30 million acres of land was shifted from the growing of basic commodity crops that had been produced in excess of domestic and foreign requirements, and was planted to grasses and legumes for pasture and hay or was devoted to other soil-conserving uses.

The programs developed under the Soil Conservation and Domestic Allotment Act, beginning in 1936 have more directly encouraged the planting of soil-conserving grasses and legumes, and the improvement of pastures and meadows.

Farmers' experiences in recent times of severe drought have emphasized the importance of established pastures and meadows and of emergency forage crops in more effectively meeting the shock of severe drought, preventing damage from wind erosion, and combating damage from floods which often follow severe droughts.

Each farmer should examine for himself the possibility of devoting more of his land to pasture and meadow crops. Many farmers will thus be able to reduce production costs and thereby increase the net gains from their farms. Experiments by the Soil Conservation Service and the State agricultural experiment stations have shown the need for increased use of grasses and legumes in rotations carefully planned to protect soil that is subject to erosion. Such rotations, together with the shifting to permanent pasture of land that is not suited to cultivation, help to maintain and improve productivity and to reduce the cost of producing milk and meat.

We are revising some of our thinking about pastures. We usually find them on the poorest parts of our farms. Compared to the pastures of other countries they are, as a rule, of low productivity. We must make them more productive, eventually, in order to justify our going further into a grassland agriculture. Marked improvement in methods of pasture management has already been made, but this field offers opportunity for further development.

Farmers who wish to make their pastures and meadows more productive by growing adapted grasses and legumes, by properly fitting seedbeds, and by liming, inoculating, and fertilizing, will find helpful information in this handbook. Additional help may be obtained from the State agricultural experiment stations and the State agricultural extension services.

H. A. Wallace,
Secretary of Agriculture.

ESTABLISHMENT, MAINTENANCE, AND IMPROVEMENT OF PASTURES

By H. N. Vinall, *senior agronomist,* and C. R. Enlow, formerly *associate agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry*

CONSIDERATIONS IN ESTABLISHING PASTURES

In planning for pastures on the average farm a number of things should be taken into consideration. The principal object, of course, is to provide feed for livestock, and most of the following discussion is centered on this phase of the subject. However, there are other advantages to be derived from pastures, some of which are of special importance under present agricultural conditions, as indicated in the foreword. The importance of pastures in livestock production, including their effect in reducing the cost of feed and promoting the

Figure 1.—An example of good land practically ruined by the long continuation of improper methods of management. Such conditions can be prevented by proper cultural methods or by keeping the land in pasture and avoiding overgrazing.

health of the animals, is discussed elsewhere in this publication (see pp. 44–47). It is desirable to point out here briefly some of the favorable reactions on the soil which accrue from pastures, all of which have a direct bearing on the question of what and how much land should be seeded down to grass.

Recent activities of the United States Department of Agriculture and the State experiment stations have provided some very significant data in regard to the losses of soil on land in cultivated crops as compared with that on similar land protected by a cover of grasses or legumes. It has been found that land planted to cotton on a 7 percent slope in Oklahoma or Texas (fig. 1) loses annually from 14 to 17 tons per acre of the best topsoil. Where this land is in grass, the annual loss is only 0.04 to 0.5 ton per acre. The run-off (rainfall loss) on the cotton land is 13 percent, while on land in Bermuda grass it is less than 2 percent. The decaying grass roots keep the soil porous and create a favorable condition for the absorption of moisture.

Land planted to corn on an 8- to 10-percent slope in Missouri and North Carolina loses 15 to 17 tons per acre of soil annually, while

that growing bluegrass or lespedeza loses less than a ton per acre. Similar results were obtained in a comparison of the native-grass sod and clean-tilled kafir in central Kansas. The loss from the land growing kafir was 21 tons per acre of soil and 12 percent of the rainfall. On natural-grass sod the loss was 5 pounds per acre of soil and 0.5 percent of the rainfall (fig. 2).

These results, obtained by actual measurements in different sections of the United States, indicate the usefulness of grasslands not only in preserving soil resources but also in protecting storage reservoirs from destruction through the gradual accumulation of silt. Many such reservoirs have been constructed for irrigation purposes and power development. The capacity and consequent usefulness of these expensive public utilities is lessened each year by the move-

FIGURE 2.—Steep hillsides in southwestern Virginia, showing perfect control of soil erosion by pasture. Where phosphate has been applied, clover is abundant.

ment of soil from the surrounding watershed. Any increase in pasture acreage will tend to extend the period during which these reservoirs will fulfill their purpose.

In addition to losing less soil by erosion than cultivated land, well-managed grazing land loses less fertility because less is taken from the soil by pasture plants and part of that which is removed is restored directly through the excrement of grazing animals. Theoretically, the soil should lose only the fertilizing constituents contained in the carcass or in the milk that has been produced. However, if the grazing is not well managed the losses of fertility on grazed land may be much greater than is at first apparent. Observations show that on good pasture cattle spend only about one third of their time grazing. Therefore, if most of the remainder of the time is spent in barns, in lots, at watering places, in lanes, under trees along streams, or in brush or wooded places, as much as two thirds of the manure may never be returned to the pasture.

In producing 100 pounds of beef per acre annually, approximately 3 pounds of nitrogen, 0.94 pound of phosphorus, and 0.17 pound of potassium are taken from the soil and are retained in the carcass. Estimating that only half of the manure is returned to benefit the pasture, there is an additional loss of 12 pounds of nitrogen, 0.87 pound of phosphorus, and 9.96 pounds of potassium. If about 35 percent of pasturage is legumes, the nitrogen content of the soil, under ordinary conditions, would be maintained. To maintain the phosphorus and potash in the soil by applying superphosphate and muriate of potash once in 10 years would cost $6.60 per acre, or 66 cents per year, at 1932 prices in the eastern part of the United States. If it were necessary to replace all the nitrogen lost there would be an additional cost of $1.90, or a total cost of $2.56 per acre per year.

The amount of soil nutrients removed by pasturing is small in comparison with the amount removed in growing some of the common cultivated crops. According to Warington[1] a 30-bushel-per-acre crop of wheat removes 48 pounds of nitrogen, 9.22 pounds of phosphorus, and 23.91 pounds of potassium; a 30-bushel corn crop, 43 pounds of nitrogen, 7.86 pounds of phosphorus, and 30.13 pounds of potassium; and a mixed-hay crop of 1½ tons per acre, 49 pounds of nitrogen, 5.37 pounds of phosphorus, and 42.25 pounds of potassium.

Forests are even more effective than grasslands in controlling soil erosion and conserving the rainfall. Trees are also able to grow on soils that will not support the grasses. This is particularly true of the conifers. Most of the land that has been under cultivation is sufficiently fertile, however, to grow pasture plants, and under such conditions grass is preferable to trees. This is true because it is less expensive to establish grass and easier to return the land to cultivation if later that is found desirable. Trees should be planted only on land which it seems reasonably sure ought never to be used again for cultivated crops. There is, however, some land that experience has shown cannot be cropped profitably even under more favorable marketing conditions than those prevailing at this time, and other lands once cropped profitably that have been ruined by erosion. The latter can be redeemed, if at all, only by being planted with the hardiest kind of trees.

The proper use of land as between crops, pasture, and forest depends on several factors, such as climate, topography, productiveness of the soil, distance from market, the cost and abundance of farm labor, and prevailing economic conditions.

In the following pages the various kinds of pastures are discussed, together with the type of pasture plants best suited to each kind in the various sections of the country. The discussion is confined chiefly to tame pastures, and as such is concerned almost entirely with cultivable lands.

KINDS OF PASTURES

TAME PASTURES

Tame pastures are lands once cultivated that have been seeded with and are now occupied largely by domesticated pasture plants and used chiefly or entirely for grazing livestock. They include the following main types.

[1] WARINGTON, R. THE CHEMISTRY OF THE FARM, pp. 64–65. London. 1894.

Permanent pastures.—Grazing land occupied by perennial pasture plants or by self-seeding annuals, usually both, which remains unplowed for long periods (5 years or more).

Rotation pastures.—A field used for grazing which is seeded to perennials and (or) self-seeding annuals, but which forms a unit in the crop-rotation plan and is plowed within a 5-year or shorter interval.

Supplemental or temporary pastures.—Fields used for grazing when the permanent or rotation pastures are unproductive and do not supply enough feed for the livestock kept on the farm. Supplemental pasture may be provided by the aftermath of meadows, small-grain stubble, seedling small grains, annuals like Sudan grass, lespedeza, and crimson clover, or biennials like sweetclover.

FIGURE 3.—Natural bluestem pasture in eastern Kansas. Such pastures are among the most productive native-grass pastures in the United States.

Annual pastures.—The term "annual pastures" is usually applied to pastures that are seeded each year to take the place wholly or in part of permanent pasture. Such pastures may include a series of crops like winter rye, Sudan grass, soybeans, and rape, which combined will furnish pasturage nearly all of the year.

NATURAL OR NATIVE PASTURES

Natural or native pastures are uncultivated lands occupied wholly or mainly by native or naturally distributed introduced plants useful for grazing (fig. 3). They include the following main types.

Range.—A very extensive natural pasture.

Brush pastures.—Pastures covered largely with brush and shrubs, where a considerable portion of the feed obtained by the livestock comes from browsing woody plants.

Woodland pastures.—Wooded areas with grass and other grazing plants growing in open spaces and among the trees.

Cut-over or stump pastures.—Land from which the trees have been removed but on which there are stumps and new growth.

PERMANENT PASTURES

CLIMATIC ADAPTATION OF PASTURE PLANTS

The United States is divided naturally into five main pasture regions (fig. 4), in accordance with the varying climatic relations of pasture plants. The larger regions have been subdivided into sections (shown by dotted lines) in order to indicate more definitely under what conditions each of the tame grasses or legumes is useful in pastures. There is, of course, some overlapping of the types of pasture plants at the boundaries of the different regions and sections. Bermuda grass is found in the southern part of section 1–b, and redtop, Kentucky bluegrass, and orchard grass are grown successfully in some localities, especially at the higher altitudes, south of the 60°

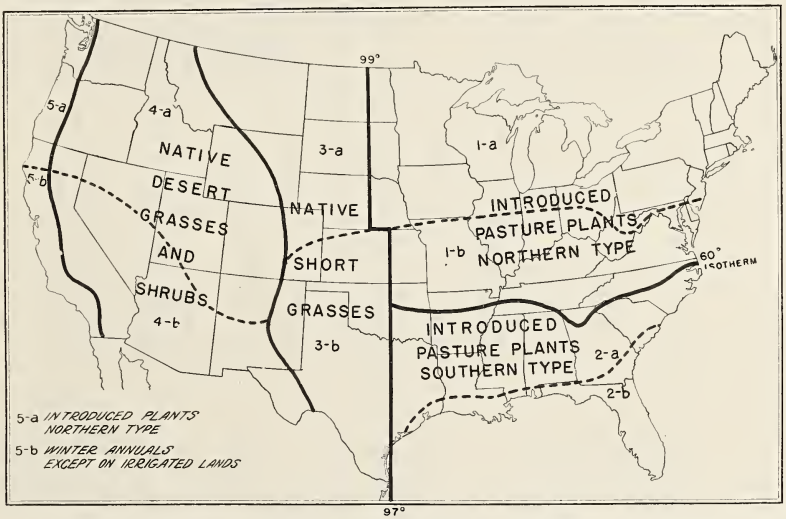

FIGURE 4.—Map showing types of pasture plants that provide the majority of the pasturage in each part of the United States.

isotherm, which, however, most nearly approximates the line of separation between the winter-hardy and the nonhardy perennial plants. Region 5, the narrow strip along the Pacific coast, is humid, with a winter rainfall in section 5–a. The pasture plants recommended for region 1 can be grown successfully in section 5–a, and in addition, because of the mild winter climate, certain of the winter annuals which are valuable in region 2 succeed there. In section 5–b, which includes the interior San Joaquin and Sacramento Valleys and the western foothills of the Sierra Nevada Mountains up to an altitude of 1,500 feet, winter rains are less abundant than in section 5–a, and the summers are too dry for all but the most drought-resistant perennials. Here most of the pasturage is supplied by winter annuals of Mediterranean origin, except on irrigated land.

GRASSES DESIRABLE IN PERMANENT PASTURES

The more important tame grasses which occur in our productive and permanent pastures are listed in table 1 and are discussed in the text that follows. The table also gives information on the climatic and soil adaptations of these grasses, their palatability, time and rate of

TABLE 1.—*Information regarding grasses for permanent pastures*

Name	Climatic adaptation [1]	Degree of palatibility	Season for grazing	Time and rate of seeding per acre	Soil adaptation [2]	Remarks
Bahia grass (*Paspalum notatum*).	Section 2-b	High	Early spring to late fall.	Early spring, 10 to 15 pounds	Sandy loam to sand.	Seed expensive and of low germination.
Bermuda grass (*Cynodon dactylon*).	Region 2 and sections 3-b and 4-b.	Medium	Late spring to early fall.	Early spring, 5 to 8 pounds	Loams, clays, and silts.	Propagated to a large extent vegetatively.
Bromegrass or smooth brome (*Bromus inermis*).	Western part of section 1-a and sections 3-a and 4-a.	High	Very early spring to late fall.	Early spring or early fall, 15 to 20 pounds.	Practically any type.	Becomes sod-bound quickly.
Canada bluegrass (*Poa compressa*).	Region 1-a and sections 3-a and 4-a.	do	Early spring to late fall.	Early spring or fall, 15 to 20 pounds.	Almost any type	Succeeds on poor soils.
Carpet grass (*Axonopus compressus*).	Region 2	Medium	Spring to fall	Early spring, 8 to 12 pounds	Moist sands or sandy loam.	Makes a very tight turf.
Centipede grass (*Eremochloa ophiuroides*).	Southern half of region 2	do	do	Early spring; use sod or stolons; no seed available.	Almost any type	Makes a close turf and is very aggressive, when once established, crowding out weeds, legumes, and other grasses.
Crested wheatgrass (*Agropyron cristatum*).	Sections 3-a and 4-a	High	Very early spring to late fall.	Early spring, 12 to 15 pounds	do	Drought resistant; easy to get a stand.
Dallis grass (*Paspalum dilatatum*).	Region 2 and sections 3-b, 4-b, and 5-b where irrigated.	do	Early spring to late fall.	Early spring or fall, 8 to 12 pounds.	Any fairly productive soil.	Seed expensive and often of low germination; difficult to get a stand.
Johnson grass (*Sorghum halepense*).	Region 2 and section 3-b; also 4-b and 5-b where irrigated.	do	Spring to fall	Early spring, 20 to 25 pounds	Loams and clays	Productiveness decreases rapidly when grazed; very difficult to eradicate.
Kentucky bluegrass (*Poa pratensis*).	Region 1 and section 5-a; also 3-a and 4-a where moisture is plentiful.	do	Spring to late fall	Early fall, 15 to 20 pounds	Sandy loams to clays of high productivity.	The leading pasture grass on good soils in the North.
Meadow fescue (*Festuca elatior*).	Region 1 and section 5-a; also 3-a and 4-a where moisture is plentiful.	do	Early spring to late fall.	Early fall, 20 to 25 pounds	Loams to heavy clays.	Valuable in section 5-a; of limited value elsewhere, disappearing rather quickly except on heavy, moist clays.
Meadow foxtail (*Alopecurus pratensis*).	Sections 1-a and 5-a; also 4-a at high altitudes.	do	do	do	Moist sandy loams to clay.	Very useful in pasture mixtures on wet soils, especially in 5-a.
Orchard grass (*Dactylis glomerata*).	Region 1; also sections 3-a, 4-a, and 5-a where moisture is plentiful.	Medium to high.	Early spring to fall.	Early fall or early spring, 20 to 25 pounds.	Any soil type except sand, if not too wet.	Inclined to grow in bunches unless seeded thickly.
Para grass (*Panicum purpurascens*).	Section 2-b	High	Spring to fall	Early spring, no seed available	Wet soils	Propagated by planting pieces of stem or sod.
Perennial ryegrass (*Lolium perenne*).	Southern half of region 1 and in section 5-a.	do	Early spring to late fall; winter grazing in section 2-a to limited extent.	Very early fall (or spring in the North), 20 to 25 pounds.	Sandy loams to clays of medium to good fertility.	Used but little in pasture except in section 5-a.

Redtop (*Agrostis alba*)	Regions 1, 2, and section 5–a; also under irrigation and in mountain meadows, sections 3–a and 4–a.	Medium	Early spring to late fall.	Early fall best, early spring fair, 10 to 12 pounds.	Grows on majority of soil types; prefers moist soils.	Of most value on poorly drained soils too wet for other grasses.
Reed canary grass (*Phalaris arundinacea*).	Sections 1–a and 5–a; also 3–a and 4–a where moisture is plentiful.	do	Spring to fall	Very early spring, 8 to 12 pounds	Loams to heavy clays.	Very good for wet lands, will endure submergence.
Rescue grass (*Bromus catharticus*).	Region 2, and where moisture is sufficient in sections 3–b and 4–b.	do	Fall to spring (winter pasture).	Early fall, 20 to 25 pounds	Sandy loam to clay loam.	An annual, used in some localities for winter and spring grazing.
Rhodes grass (*Chloris gayana*).	Section 2–b; also southern parts of 3–b and 4–b.	do	Spring to fall	Spring, 10 to 12 pounds	Loams to clays	Found most useful in the dry sections of southern Texas where other grasses fail.
Slender wheatgrass (*Agropyron pauciflorum*).	Northern parts of sections 3–a and 4–a.	High	Early spring to late fall.	Early spring, 15 pounds	Practically any type, except sand.	Better for hay than pasture; inclined to be stemmy.
Tall oatgrass (*Arrhenatherum elatius*).	Sections 1–b and 5–a	Medium	do	Early fall, 20 to 25 pounds	do	Better in hay mixtures than for pasture; stemmy; used most for pasture in section 5–a.
Timothy (*Phleum pratense*).	Region 1 and section 5–a; also 3–a and 4–a where moisture is sufficient.	High	do	Early fall (or early spring), 12 to 15 pounds.	do	Comes quickly and furnishes much pasturage at first, but is not permanent.

[1] The region and section numbers refer to those in fig. 4.
[2] Specifications of soil types in this and the following tables are necessarily very general because of space limitations.

seeding, the season of the year when they may be expected to furnish grazing, and other pertinent facts affecting their grazing value. No attempt has been made to include native grasses the seed of which is not available commercially.

NORTHERN PASTURE GRASSES

There are a great many grasses to choose from in planning pasture mixtures for the humid areas of the Northern States. The ones more commonly used are timothy, Kentucky bluegrass, redtop, orchard grass, perennial ryegrass, tall oatgrass, meadow fescue, Canada bluegrass, and bromegrass. In the more arid regions, crested wheatgrass, bromegrass, and slender wheatgrass are most useful in establishing tame pastures.

Perennial ryegrass is fairly common in section 5–a, where it is quite well adapted. This grass gives good grazing and makes good hay but is not sufficiently winter-hardy to be used in the most northern States. The abundance of short-lived plants that are present in a planting from commercial seed causes the stand to thin out in 2 or 3 years.

Tall oatgrass is valued for the early grazing it affords in the spring. The grass is useful only in mixed seedings. It is best adapted in sections 5–a and 1–b.

Meadow fescue is a desirable pasture and hay plant in section 5–a, in the mountain meadows of section 4–a, and in the western part of section 1–b. It can be grown almost anywhere in region 1, but seedings east of Missouri, Iowa, and Minnesota are generally short-lived.

Reed canary grass is an excellent grass for wet lands, especially those subject to overflow. It is a northern grass and probably will be of most value in sections 1–a and 5–a. Formerly the high cost of seed prevented the extensive use of this grass. Present seed prices justify a wider use of it in the improvement of wet-land pastures.

Canada bluegrass is particularly well adapted to the poorer soils of section 1–a, where it constitutes a valuable addition to pasture mixtures for such soils. It makes a thin, wiry growth, but is readily grazed and appears to be very nutritious.

Bromegrass is very palatable and should be more widely used than at present. Its chief weakness is that it becomes sod-bound within 3 or 4 years after being seeded and steadily declines in productivity unless the turf is loosened up by disking or plowing.

Kentucky bluegrass is the most important of all the introduced grasses from a pasture standpoint; and, because of its use on lawns, it is most widely distributed. In many sections of the Northern States it appears spontaneously in fields that are not cultivated for several years. Advantage may be taken of this characteristic to omit seed of it from pasture mixtures in natural bluegrass areas, and it will gradually invade the field and finally become the dominant grass if soil conditions are favorable for its growth.

Meadow foxtail is not so well known as the other grasses recommended for pasture seeding. It has been found most useful on wet soils in section 5–a, but is also much at home in the high mountain meadows of section 4–a. A more extensive use of meadow foxtail on wet soils in region 1 is justified.

Orchard grass unless closely grazed is not so palatable as several of the well-known grasses, but contributes materially to pasturage because it endures shade better than most grasses and is more productive on soils of low or moderate fertility. It begins growth early in the spring, and the excess growth in the fall provides considerable winter grazing.

Redtop is not relished especially by livestock, but is generally included in pasture mixtures because of its ability to grow on poorly drained acid soils.

Slender wheatgrass is perhaps better suited for use as a hay plant than for pasture. However, until the introduction of crested wheatgrass, slender wheatgrass and bromegrass were the only grasses available that could be grown successfully under the unfavorable climatic conditions prevailing in the northern Great Plains and adjacent areas in Canada. Mixtures of slender wheatgrass and sweetclover are usually preferable for grazing to pure stands of either.

Timothy is distinctly a hay grass, and from the time of its introduction until recently, when automobiles supplanted horses and mules in the cities, timothy was the leading tame hay on the markets. Its use in pasture mixtures is warranted, however, because it grows rapidly from seed and is leafy and palatable, providing abundant, excellent pasturage while the slower growing turf grasses are becoming established.

Colonial (*Rhode Island*) **bentgrass** and **creeping bentgrass** are found in many pastures in the New England States, and a form of creeping bent known as "seaside" bent is abundant on moist soils in section 5–a. These are all more valuable in lawns than in pastures.

Quackgrass or **couch grass** (*Agropyron repens*) is common in section 1–a, where it occurs as a persistent weed in cultivated and abandoned fields. It is difficult to eradicate because of its rootstocks, but it may be grazed and is both palatable and nutritious.

Red fescue (*Festuca rubra*) is a fine-leaved, persistent, turf-forming grass which is of little value in pasture mixtures because cattle do not find it palatable. It grows best in the shade and is valuable in lawn mixtures.

Sheep fescue (*Festuca ovina*) is a near relative of red fescue, but is a small bunch grass very drought resistant and of some value on sheep ranges.

Crested wheatgrass shows much promise for regrassing land in the northern Great Plains that has been put in cultivation.

SOUTHERN PASTURE GRASSES

The southern grasses that contribute most to pastures are Bermuda, carpet, and Dallis grasses. Those less commonly found in pastures are Johnson, centipede, Rhodes, Napier, rescue, and Vasey grasses. Para, Bahia, Guinea, and molasses grasses are hardy only in the subtropical belt along the Gulf coast, indicated on the map as section 2–b. They can also be grown on irrigated lands along the Mexican border in sections 3–b and 4–b.

Carpet grass is persistent and aggressive on moist sandy soils and often appears spontaneously in region 2 when the land has been cleared and grazed heavily. It endures close grazing very well, but is not very productive, is only fairly nutritious, and makes such a close turf that it is very difficult to keep legumes in it.

Bermuda grass has spread naturally on loam, clay, and silt soils over most of the Cotton Belt and even a little north of the 60° isotherm. It is late in starting in the spring and ceases growth at the first light frost in the fall. In the irrigated sections of 4–b and 5–b Bermuda grass produces viable seed and spreads out into the cultivated fields, where it is a nuisance. In region 2 it is propagated mostly by planting pieces of sod.

Dallis grass, a long-lived perennial, while less abundant than carpet and Bermuda grass, is becoming increasingly important as a grazing plant in region 2. It is a bunch grass, and the turf is more open than that of the other two. The growth of basal leaves is luxuriant, and Dallis-grass pastures are both productive and nutritious. The chief drawback is the difficulty of obtaining a good stand. The presence of a fungus (*Claviceps paspali*) in the seed heads, which if eaten in any quantity by cattle causes a disease, characterized by nervous symptoms (p. 64), may be controlled by preventing the production of seed heads by heavy grazing or mowing the pasture. It is best adapted to clay, loam, and silt soils.

Johnson grass is best known as a pest in cultivated fields, but is also found in pure stands, where it is utilized as a hay crop and to a lesser extent as pasture. When grazed closely and continuously it gradually becomes unproductive and is not very desirable in pastures.

Centipede grass, a rather recent introduction from China, is an aggressive stoloniferous grass much like carpet grass in its tendency to form a very compact turf, which gradually excludes other grasses and legumes, leaving pure stands of centipede grass. Such centipede-grass pastures are low in productivity, and their nutritive qualities are questionable. Centipede grass will grow on most soil types but appears to best advantage on sandy soils of the Norfolk series. It is propagated by scattering pieces of sod or stolons and for this reason is rather expensive to establish.

Rhodes grass has been tested in most parts of region 2 and sections 3–b and 4–b but has achieved importance only on some of the large ranches in southern Texas, where a drought-resistant plant is required. It will grow on moderately alkali soils but is less palatable under such conditions. Seed is expensive and difficult to obtain in quantity.

Vasey grass resembles Dallis grass very much but has fewer basal leaves and is less valuable for pastures. It comes in spontaneously on the rice and sugarcane lands of southern Louisiana.

Rescue or **arctic grass** is a winter annual which often reseeds naturally in southern Texas. It appears usually at the end of the dry summer season and provides grazing after Bermuda grass has become dormant.

Para grass is characterized by its long trailing stems and very rapid growth under favorable conditions. It is very sensitive to low temperatures and is of most value on wet lands. No seed is available, therefore it must be propagated vegetatively.

Bahia grass is not grown to any extent except in Florida. It is of most value on poor sandy soils. Seed is expensive and usually of low germination.

Guinea grass (*Panicum maximum*) is a large, coarse bunch grass which is very drought resistant and one of the most dependable pasture grasses of the West Indies. In the United States it has never become popular, but it should be valuable in southern Texas where Rhodes grass has succeeded.

Molasses grass (*Melinis minutiflora*) is one of the most productive pasture grasses in Brazil and Colombia, South America, where it is known as Gordura. It has fine stems and makes a very dense leafy growth about 2 feet deep over the ground. The leaves and stems exude a sticky sweetish fluid which gives the grass an odor. Cattle dislike the grass at first, but later appear to relish it and thrive on it to a remarkable degree. It can be grown only in practically frost-free localities, such as the southern half of Florida.

Natal grass (*Tricholaena rosea*), introduced from South Africa, has become naturalized in southern Florida and has spread to citrus groves and uncultivated land including the roadsides. It appears well adapted to the climate and the sandy soil of this part of Florida, but it is not relished by livestock and contributes little to the pasturage resources of the United States.

LEGUMES DESIRABLE IN PERMANENT PASTURES

The legumes which alone or in mixture with the grasses (table 1) previously described contribute most to the productiveness of our permanent pastures are listed in table 2 and are discussed in the text that follows The table supplies information respecting the climatic and soil adaptations of these legumes, their palatability, the time and rate of seeding, the season of the year when they are available for grazing, and other facts affecting their grazing value. No attempt has been made to include the native legumes the seed of which is not available commercially, nor introduced species that are of only minor importance in pastures.

TABLE 2.—*Information regarding legumes for permanent pastures*

Name	Climatic adaptation [1]	Degree of palatability	Season for grazing	Time and rate of seeding per acre	Soil adaptation [2]	Remarks
Alfalfa (*Medicago sativa*)	All regions where moisture is sufficient, but only locally in region 2.	Very high	Spring to early fall. Winter grazing in Southwest when irrigated.	Depends on location; consult State experiment station.	Practically any fertile soil not wet or acid.	Good pasture, but danger of bloat. Use locally adapted seed.
Alsike clover (*Trifolium hybridum*).	Chiefly region 1 and section 5–a. In sections 3–a and 4–a if moisture is sufficient. Winter crop in region 2.	do	Early spring and fall.	Early spring, 8 to 10 pounds.	Practically any soil type except sands. Will stand slight acidity also will tolerate some inadequate drainage.	Especially suited for wet land.
Red clover (*Trifolium pratense*).	do	do	Early spring to fall	Early spring, 10 to 15 pounds.	Practically any well-drained soil if not acid.	Use locally adapted seed.
Mammoth red clover (*Trifolium pratense* var.).	Region 1, chiefly section 1–a	High	do	Early spring, 10 to 12 pounds.	Practically any well-drained soil not more than slightly acid.	Will endure slightly more soil acidity than common red.
White clover (*Trifolium repens*).	All regions where moisture is sufficient.	Very high	Early spring and fall.	Very early spring, 5 to 10 pounds.	Practically any soil type	Everywhere in the North. In region 2, winter and spring crop.
Ladino clover (*Trifolium repens* var.).	Sections 4–a, 5–a, and 5–b	do	Spring to fall	Early spring, 5 to 10 pounds.	Practically any well-drained, well-watered soil.	Injured by heavy continuous grazing.
Least hop clover (*Trifolium dubium*).	Sections 2–a and 5–a and parts of section 1–b.	High	Spring	Late summer, 4 to 5 pounds.	Good soil	Annual; disappears in June; volunteers.
Low hop clover (*Trifolium procumbens*).	Section 2–a and southern part of section 1–b.	do	do	do	Practically any well-drained soil.	Annual; usually disappears in June but volunteers.
Strawberry clover (*Trifolium fragiferum*).	Locally in sections 3–a, 4–a, and 5–a.	do	Spring to fall	Early spring, 5 to 10 pounds.	Wet alkali soil	Grown only locally; domestic seed produced in Oregon.
Sour clover or annual melilot (*Melilotus indica*).	Region 2 and sections 3–b, 4–b, and 5–b.	Medium	Winter and early spring.	Late summer	Sweet well-drained soils	Annual; volunteers; no value north of region 2.
Yellow trefoil or black medic (*Medicago lupulina*).	Region 2 and section 1–b	Very high	Early spring to late fall.	Very early spring, 8 to 12 pounds.	do	Not prominent, except on black land in Alabama and Mississippi.
California bur-clover (*Medicago hispida*).	Sections 3–b, 4–b, and 5–b, if sufficient moisture, also eastern Texas and Oklahoma.	High	Fall to spring	Late summer, 15 to 20 pounds hulled seed.	Well-drained soil of practically any type.	A winter annual; volunteers.
Southern bur-clover (*Medicago arabica*).	Region 2 and section 3–b	do	do	Late summer, 10 to 15 pounds hulled seed.	Well-drained soil	Annual, but reseeds.
Common lespedeza (*Lespedeza striata*).[3]	Region 2 and section 1–b	do	Early summer to fall	Early spring, 20 to 25 pounds.	do	Annual, but is usually permanent in pastures because of volunteer seeding.
Korean lespedeza (*Lespedeza stipulacea*).	Section 1–b	do	do	do	Practically any well-drained soil.	Annual, but volunteers.

[1] Region and section numbers refer to fig. 4.
[2] See footnote 2, table 1.
[3] Kobe and Tennessee 76 are heavy-yielding strains of common lespedeza which should be used in region 2 and the southern part of section 1–b.

CHARACTERISTICS OF VARIOUS LEGUMES

Alfalfa.—While alfalfa has been used extensively for grazing in California, it has not been much used in the Eastern States because of frequent losses of livestock by bloating and because of the injurious effect of grazing on the stand. If the crop is allowed to become quite mature before being grazed, both troubles are avoided to a large extent, but the full feed value of the crop is not realized by such a practice. The most profitable practice appears to be to cut the first crop for hay and to graze during the rest of the season. Apparently the stand of alfalfa may be maintained if not grazed too severely and if the animals are removed sufficiently early in the fall to allow the alfalfa to restore the exhausted food reserves in the root system.

Alsike, red, and white clovers are too well known and commonly used for grazing to need discussion. The first two are included in the majority of pasture mixtures recommended in those sections where adapted, but generally they do not last more than 2 years. White clover seldom provides much grazing until the second season, but if the pastures are kept fairly well grazed it is quite permanent, although it is much more prevalent some years than others. All are very responsive to phosphatic fertilizers, and red clover in particular requires neutral or only slightly acid soils. On strongly acid soils red clover should be omitted from seed mixtures for pastures, and from central Indiana south lespedeza should be substituted for the clovers on such soils. Ladino is a large, highly productive variety of white clover which has proved its value under irrigation but has so far not shown permanence under grazing in regions 1 and 2.

Bur-clover is used mostly for winter pasture in the South and the far West. In Arizona and California the burs and dry herbage are eaten in summer. In the South it succeeds very well with Bermuda grass or Dallis grass, as it furnishes grazing in the fall, winter, and spring, while Bermuda grass furnishes summer grazing. It is advisable to graze bur-clover lightly in May in order to allow it to reseed. New seedings of bur-clover should be inoculated if hulled seed is used, but generally sufficient soil adheres to the burs to carry inoculation if seeded in the bur.

The low and least hop clovers are important in some parts of the South and the northern Pacific slope. They furnish early grazing but disappear in June. They combine well with carpet, Dallis, and Bermuda grasses, and with lespedeza in the South; also with bluegrass and redtop in section 1–b. Seed of *Trifolium dubium* is available in quantity and that of *T. procumbens* in limited amounts in Tennessee.

Cluster clover (*Trifolium glomeratum*) is a winter annual which has done well at McNeill, Miss., where it is called McNeill clover. The seeds germinate in the fall, and the plants grow rapidly in early spring so that grazing can begin in late February and lasts till June. Cluster clover fits in well, therefore, with Bermuda and carpet grasses and materially lengthens the grazing season.

While experimental data are incomplete, there is reason to believe that cluster clover is not reliably hardy much farther north than the cut-over pine area in the Coastal Plains and that its chief place will be on such lands in the southern half of region 2.

Persian clover (*Trifolium resupinatum*) is a winter annual suited to moist rich land wherever winters are mild. Its value is still much in doubt, since where it thrives best white clover also does well as a winter and early-spring grazing crop, and Persian clover has not shown any superiority over white clover. Persian clover makes its greatest growth about May, at which time it is high enough to cut for hay; soon after that it matures seed and dies.

Ladino clover is a giant strain of white clover which has achieved its greatest success in the irrigated sections of the Northwestern States. Where soil moisture is abundant Ladino clover is one of the most productive pastures known, but it should not be grazed continuously, and there is considerable danger of bloating. It prefers a rich soil and on the poorer soils responds markedly to applications of phosphate fertilizer.

Sour clover or **annual melilot** is an annual legume which, like lespedeza, reseeds in pastures each year and thus becomes more or less permanent. It is very sensitive to soil acidity and therefore is found growing only on soils of limestone origin or those but slightly acid. Its distribution is confined to the southernmost States, and it is of no value in the North.

Strawberry clover is a perennial legume with about the same habit of growth as white Dutch clover. It is reported to be grown as a regular farm crop in Australia and New Zealand, where it apparently thrives on excessively wet soils and yet is able to resist drought. In the United States it is grown only locally in sections 3–a, 4–a, and 5–a, and so far has not proved useful in the humid Eastern States. Its chief recommendation is its ability to grow on alkali soils.

Yellow trefoil or **black medic** is a winter annual like the hop clovers but more widely distributed and usually making a larger growth. It is most abundant on the black prairie soils of Alabama and Mississippi, where it occasionally furnishes a considerable part of the pasturage in early spring. Its abundance varies greatly from year to year, and it cannot therefore be depended upon for grazing.

Common or **Japanese lespedeza**, a self-seeding annual, is the most widely distributed of all lespedezas, being naturalized as far north as southern Iowa. Because of its ability to reseed under most conditions, it is useful in pastures from southern Indiana and Illinois south to the Gulf of Mexico. It is a standard hay and pasture plant everywhere in section 1–b and region 2 except on very sandy lands, and even on sands it does fairly well unless they are quite dry.

Kobe lespedeza is a variety similar to Common lespedeza, but it makes a larger growth of stems and leaves than Common and has larger seed. It has about the same range of distribution as Common, but sometimes fails to reseed in the northern part of section 1–b. It is preferable to the Common in region 2 on account of its higher yields of hay and pasture. Like Common, its growth is low and spreading except in thick stands.

Tennessee 76 lespedeza is a selected strain of Common lespedeza originated by the Tennessee Agricultural Experiment Station. It is characterized by an erect growth, heavy yields of hay, and rather late maturity. It is most popular in western Tennessee and parts of North Carolina. It should succeed throughout region 2 also, but authentic seed of Tennessee 76 is rather difficult to obtain in quantity. The seed is not distinguishable from that of Common lespedeza.

Korean lespedeza is an annual also, but belongs to a different species from Common. It is earlier, coarser, and usually a heavier producer than Common, but its production is ordinarily less than that of Kobe or Tennessee 76 in localities where these two varieties are grown successfully. Korean is of most value in section 1–b but has promise in some parts of 1–a as far north as southern Michigan. In the southern part of section 1–b its early maturity is of some disadvantage, as there are usually 30 days or more of grazing weather after Korean matures. An early strain of Korean advertised under the name Harbin lespedeza may have value still farther north than the original Korean, but this has not yet been determined.

All the annual lespedezas are valuable in permanent pastures because they reseed each year. They may also be used as supplemental pasture and are discussed under that topic (p. 36). They begin growth late in the spring, and it is usually May 15 to July 1, depending upon the latitude, before they are ready to graze. The season for grazing ends for Korean about September 30, but that of Common, Kobe, and Tennessee 76 may last until frost comes.

Inoculation is not necessary in the South, but in the northern part of section 1–b and in 1–a inoculation is advisable unless lespedeza has been grown on the land previously. Except on poor soils the application of lime and fertilizers is seldom profitable. Applications of phosphate are the most profitable.

The prospective planter should consult State authorities in regard to source of seed. This is especially important in the case of alfalfa and red clover.

There are other possible permanent legumes, such as *Lespedeza sericea*, but their value has not been sufficiently established to warrant general recommendation.

PLANT MIXTURES FOR DIFFERENT SECTIONS OF THE UNITED STATES

It is seldom advisable to seed land intended for a permanent pasture to one grazing plant. A mixture of several kinds, especially of grasses and legumes, has many advantages, among which may be mentioned the following:

(1) Legumes in pasture mixtures help to maintain the nitrogen content of the soil and reduce the need of nitrogen fertilizers.

(2) Mixtures result in a more uniform stand and higher production, because several soil conditions are often represented in a pasture, and in a mixture plants adapted to each soil condition are likely to be found.

(3) Mixtures provide a more uniform seasonal production because the periods of flush growth and dormancy vary in different plants.

(4) Mixtures of grasses and legumes provide a better balanced ration, since legumes are richer than grasses in both protein and minerals.

The following mixtures are recommended for each section of the United States (fig. 4) where permanent pastures of the highest productivity are desired. The cost of the necessary seed may seem an extravagance, but this investment is usually returned within the first 2 years because of the higher productivity of pastures thus seeded.

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NORTHEASTERN STATES (SECTION 1–a)

Good, well-drained soils

Mixture:	*Pounds per acre*
Kentucky bluegrass	5 or 6
Orchard grass	4 or 5
Timothy	4 or 5
Redtop	2 or 3
Alsike clover	2 or 2
Red clover	2 or 2
White clover	1 or 2
Total	20 or 25

Poor, well-drained soils

Mixture:	*Pounds per acre*
Orchard grass	8 or 10
Canada bluegrass	5 or 6
Redtop	4 or 5
Alsike clover	2 or 3
White clover	1 or 1
Total	20 or 25

In Iowa, Minnesota, and the Dakotas, bromegrass may be substituted for orchard grass in these mixtures.

Wet, poorly-drained soils

Mixture:	*Pounds per acre*
Timothy	4 or 6
Redtop	8 or 10
Alsike clover	3 or 4
Total	15 or 20

Mixture:	*Pounds per acre*
Reed canary grass	5 or 8
Redtop	4 or 4
Alsike clover	1 or 3
Total	10 or 15

Reed canary grass may be sown alone at the rate of 8 to 12 pounds per acre on land likely to be submerged for a part of the year, and excellent pasture obtained thus from land otherwise unproductive.

EAST CENTRAL STATES (SECTION 1–b)

Good, well-drained soils

Mixture:	*Pounds per acre*
Kentucky bluegrass	5 or 6
Orchard grass	4 or 5
Timothy	2 or 3
Redtop	2 or 2
Lespedeza	6 or 7
White clover	1 or 2
Total	20 or 25

Poor, well-drained soils

Mixture:	*Pounds per acre*
Orchard grass	5 or 6
Tall oatgrass	4 or 5
Redtop	4 or 5
Lespedeza	7 or 9
Total	20 or 25

Wet, poorly drained soils

Mixture:	Pounds per acre	Mixture:	Pounds per acre
Timothy	5 or 6	Meadow foxtail	4 or 5
Redtop	8 or 10	Redtop	8 or 10
Alsike clover	3 or 4	Alsike clover	4 or 5
Total	16 or 20	Total	16 or 20

In the northern part of this section the Korean lespedeza should be used; in the southern part, Common, Kobe, or Tennessee 76 are best. The latter two varieties are usually more productive than the Common, but good results are obtained from a mixture of Common and Korean in Tennessee and North Carolina.

SOUTHEASTERN STATES (REGION 2)

Moist, sandy soils

Mixture:	Pounds per acre
Carpet grass	5 or 6
Dallis grass	3 or 4
Lespedeza	12 or 15
Total	20 or 25

Clay, loam, or clay or silt loam soils

Mixture:	Pounds per acre
Bermuda grass	5 or 6
Dallis grass	3 or 4
Lespedeza	10 or 12
White clover	2 or 3
Total	20 or 25

Common, Kobe, and Tennessee 76 lespedezas are the varieties to use in region 2. Bermuda grass is usually started by planting pieces of sod rather than seed.

GREAT PLAINS AND INTERMOUNTAIN REGIONS (REGIONS 3 AND 4)

In the Great Plains (region 3) and in the Intermountain regions (region 4) the climate varies from semiarid to arid or desert conditions, and pastures are chiefly extensive areas or ranges occupied by native grasses, legumes, woody shrubs, and other plants of some value for grazing. This is true with two exceptions, the irrigated districts and the mountain valleys at high altitudes. In the Great Plains the herbage consists mostly of "short grasses" such as the gramas, buffalo, and mesquite grasses, while in the Intermountain region bunch grasses and desert shrubs predominate at the lower altitudes. This native flora is the main source of pasturage, and proper methods of grazing designed to protect and encourage the most valuable grazing plants are more important than the improvement of grazing conditions by seeding tame or introduced plants (fig. 5).

In the northern parts of these areas (sections 3–a and 4–a), when it is desired to restore to grazing condition land that has been cultivated, crested wheatgrass, bromegrass, or slender wheatgrass may be seeded in localities that are favorably situated as to rainfall. All are drought-resistant, nutritious, and palatable. Their value for grazing is about in the order named. Mixtures of slender wheatgrass and sweetclover are also recommended.

The productiveness of pastures in the high mountain valleys may be increased by seeding timothy, redtop, Kentucky or Canada bluegrass, meadow foxtail, and red, alsike, and white clovers, alone or in

FIGURE 5.—Sheep grazing on a mountain slope in the Humboldt National Forest (Nev.). This region, besides producing wool, provides feeders for finishing in the Corn Belt.

mixtures. Crested wheatgrass, bromegrass, and slender wheatgrass will also thrive under these conditions.

NORTHERN PART OF REGIONS 3 AND 4

For irrigated lands

Morton's mixture (modified):	*Pounds per acre*
Smooth bromegrass	9
Orchard grass	9
Timothy	4
Meadow fescue	5
Yellow sweetclover	3
Total	30

Montana mixture:	*Pounds per acre*
Smooth bromegrass	3 or 4
Kentucky bluegrass	4 or 6
Orchard grass	4 or 6
Meadow fescue	3 or 4
White clover	1 or 2
Alsike clover	1 or 2
Total	16 or 24

Alfalfa or sweetclover seeded alone at the rate of 12 to 15 pounds per acre is used by many farmers on the irrigation projects with good results where care is observed to prevent bloating. The mixtures and also the legume pastures on well-drained soils ordinarily have a carrying capacity of two or more animal units per acre for 4 to 6 months, depending upon the latitude.

On wet or poorly drained soils a mixture consisting of redtop 10 pounds, timothy 6 pounds, and alsike clover 4 pounds ordinarily gives the best results.

In the South (sections 3–b and 4–b) the pastures on irrigated lands are largely either Bermuda grass or alfalfa. Dallis grass, another perennial, is adapted to these two sections and makes a more productive pasture on irrigated lands than Bermuda grass.

NORTHERN PACIFIC SLOPE (SECTION 5–A)

On the Pacific slope in section 5–a where rainfall is fairly abundant, especially during the winter season, the ryegrasses and bents thrive, and rather complicated mixtures are recommended.

For moist bottom land

Mixture:	Pounds per acre
Italian ryegrass	3
Perennial ryegrass	3
Meadow fescue	4
Kentucky bluegrass	4
White clover	2
Red clover	2
Alsike clover	2
Total	20

For fertile uplands

Mixture:	Pounds per acre
Italian ryegrass	4
Tall oatgrass	4
Orchard grass	4
Kentucky bluegrass	4
White clover	2
Red clover	2
Alsike clover	2
Total	22

For land subject to flooding for short periods

Mixture:	Pounds per acre
Seaside bent	5
Meadow foxtail	5
Italian ryegrass	4
Alsike clover	4
Total	18

For land subject to flooding for long periods

	Pounds per acre
Reed canary grass	8 to 12
or	
Seaside bent	8 to 10

The principal disadvantage in using seaside bent and meadow foxtail is in the excessive cost of the seed.

On irrigated lands in section 5–a the mixture recommended for moist bottomland is perhaps the best pasture for irrigated lands. Both alfalfa and Ladino clover seeded alone have been found to make unusually productive pastures for dairy cattle. There is, however, grave danger of losing some of the animals from bloating when either of these legumes are grazed.

In the southern part of the Pacific slope in section 5–b the summers are quite dry and the rainfall during the winter is light so that natural pastures consist largely of winter annuals which reseed each year. On the irrigated lands a large part of the pasturage is obtained from alfalfa fields. Ladino clover, Bermuda grass, and Dallis grass also do well here.

SOUTHERN PACIFIC SLOPE (SECTION 5–B)

Irrigated lands [2]

Mixture:	Pounds per acre
Dallis grass	5
Italian ryegrass	5
Alfalfa	5
Ladino clover	6

[2] GARTHWAITE, E. L. A SURVEY OF MADERA COUNTY PASTURES. Pacific Rural Press 125:256. 1933.

This mixture, requiring a total of 21 pounds per acre, is seeded in the spring. Such a pasture is much less likely to cause bloating than alfalfa or Ladino clover alone; it provides a longer grazing season and a better balanced ration, makes better use of the irrigation water, and is less expensive to maintain. Harding grass, sweetclover, and orchard grass are sometimes added to this mixture, but the simpler one as given, is on the whole more satisfactory.

ESTABLISHING PERMANENT PASTURES

Many permanent pastures are simply worn-out or unproductive meadows. Others are the result of the occupation of uncultivated fields by certain pasture plants that are sufficiently aggressive so that they spread without the help of man, as Kentucky bluegrass and white clover do in some sections of the humid Northern States, and as Bermuda grass, carpet grass, and lespedeza have spread in the Cotton Belt. This undirected and unaided establishment of improved pastures requires many years for its full development and thus results in immeasurable waste of potential resources. The low production of average pastures in the United States at the present time is due to lack of planning and the prevailing disposition to avoid as far as possible any initial expense for labor, seed, and fertilizer in starting the pasture. The increased expense of thorough preparation is usually balanced by an increased production the first 2 years.

SEED-BED PREPARATION AND SEEDING

Most of the plants recommended for permanent pastures have small seeds, and the young seedlings are weak. It is necessary, therefore, to prepare a good, firm seed bed and to cover the seed lightly. A general practice is to seed the grasses and legumes in small grain, which is considered a nurse crop. In defense of this practice it is claimed that the wheat, oats, rye, or barley takes the place of weeds and is less harmful to the pasture plants than are weeds, and in addition there is a crop of grain or hay which pays for the labor expended. Numerous experiments have shown that pasture mixtures like those recommended (pp. 17–21), if sown in the fall or early spring without a nurse crop, will be highly productive the first year, and if grazed properly will provide a larger net return than the grain crop.

The land to be seeded should be plowed long enough before seeding time so that it will become settled and firm. Just before seeding it is profitable, except on especially productive soil, to apply 400 to 600 pounds per acre of a complete fertilizer that is known to be successful on small-grain crops in that vicinity. Fertilizers having approximately a 4–12–4 formula are generally effective. A light disking after the fertilizer application will put the soil in condition for seeding, which is usually accomplished by broadcasting. If a cultipacker is available, running this over the land after seeding is the best method of covering the seed. If there is no cultipacker available, then an ordinary spike-tooth or drag harrow with the teeth sloping slightly backward should be used. Where the seed is such as will flow through a drill the seeding and covering may be accomplished in one operation, and usually a better, more uniform stand results if the seed is drilled than if it is broadcast. It is best to sow grasses, except a few like carpet and Bermuda, in the fall, and seed the legumes on the surface in the spring.

Early spring seedings are frequently successful, but often it is difficult to get on the fields sufficiently early in the spring in the Northern States. Much earlier grazing is possible from fall seeding, which is very desirable. In the Southern States, where the permanent grasses are distinctly summer grasses, early spring seeding is advisable. This is also true in the Northern States on extremely heavy soils where heaving causes a severe loss of seedlings during the winter.

Clovers and other legumes should be broadcast on the grass seedings in late winter or very early spring. This is particularly desirable on heavy clay soils, as generally the loss of legumes from heaving is much more severe than that of the grasses, if seeded in the fall.

SOIL AND WATER CONSERVATION MEASURES

The amount and distribution of rainfall are often limiting factors in the establishment and maintenance of pastures. Before a good sod is formed, the loss of rainfall by run-off may be so great that the soil moisture becomes deficient for growth during periods of drought. Even on old pastures drought effects are first apparent on the slopes where a considerable part of the rainfall is lost as run-off. To conserve the rainfall by reducing the run-off and thus provide better conditions for seed germination and subsequent plant growth, small contour ridges may be used.

To establish contour structures on land that is being prepared for seeding to pasture, one should first establish contour lines with a level or a surveying instrument. A satisfactory method of constructing contour ridges consists in making a series of backfurrows with a gang plow or some other breaking plow, leaving strips (fig. 6) about 6 to 12 inches wide to be cut with a disk. The crests of the ridges or centers of the backfurrows should be the width of a double disk apart or wider depending on the slope of the land. The narrow ridges and broad, shallow, flat-bottom furrows resulting from this method of seedbed preparation do not interfere with mowing. Such plowing, disking, and rolling in preparing the land for seeding can be done ordinarily at the rate of 1 acre in 2 to 3 hours and cost but little more than the ordinary methods of seedbed preparation. Following the first heavy rain some hand work may be necessary to repair breaks in the low places. After the grass becomes better established, damage from overtopping during heavy rains will diminish. During the first year there may be some shifting of soil from the crests of the ridges to the troughs between them but with a complete sod the second year, this shifting should be almost entirely stopped.

TREATMENT OF NEWLY SEEDED PASTURES

Considerable care should be exercised in grazing a new seeding. The young seedlings must have time to develop a good root system in order to withstand drought, freezing weather, and the strain of being cropped by cattle. If many weeds appear in spring seedings it may be necessary to clip the weeds 4 to 6 inches high before grazing is begun. At all events the grazing should be rather light the first year. On heavy soils, rolling early in the spring compacts the ground

FIGURE 6.—Small, closely spaced ridges following contour lines. Such ridges on hilly or rolling pastures hold the rainfall until it soaks into the ground, thereby checking erosion and storing more water to carry the pasture through dry spells.

and tends to reset plants that may have been heaved by frost. Moderate grazing is usually beneficial after the grass is well started.

MAINTENANCE AND IMPROVEMENT OF PASTURES

CAUSES OF UNPRODUCTIVE PASTURES

After a permanent pasture has become firmly established, proper methods of management and control of grazing, with an occasional application of fertilizers to replace the plant food removed from the land in the form of animal products, will keep the pasture in good condition and productive for a long period. In many instances, however, the productivity of a pasture is much lower than is warranted when the soil and climate are considered. The cause of this poor condition may be due to one or all of the following reasons: Poor stand of desirable pasture plants; low fertility of the soil; poor drainage; the presence of undesirable plants such as weeds and brush; and the lack of proper provision for shade during the summer season. Measures useful in overcoming these faults are described in the following sections.

CULTIVATION AND RESEEDING

Cultivation of old pastures to secure improved grazing is of no value unless accompanied by reseeding or the application of fertilizer or both. Lack of desirable grazing plants in a pasture that formerly produced well is due generally to either a decrease in soil fertility or improper grazing. Cultivation alone cannot overcome either of these conditions, but cultivation in connection with fertilizing and reseeding has given excellent results in Vermont and Iowa by eliminating weeds, covering the seed, and mixing the fertilizer with the soil. Quick-growing grasses and clovers seeded on old-pasture sod that has been well disked and fertilized will give grazing in surprisingly short time, and will continue to give it while slower growing, more permanent grasses are becoming established.

Reseeding alone may be desirable in some instances in connection with the improvement of old pastures, but it is not often a complete remedy. If legumes are scarce in the stand of grass, broadcasting seed on the surface in late winter or early spring is advisable. Such seeding cannot be expected to succeed, however, until fertilizers have been applied.

USE OF LIME, COMMERCIAL FERTILIZERS, AND BARNYARD MANURE

The majority of pasture soils in humid sections of the country are deficient in calcium, phosphorus, and nitrogen, and many are deficient in potassium. Very little work has been done in determining to what extent these elements can be added to pastures on a paying basis, but it has been definitely shown that all are valuable in increasing the stand and production of desirable grazing plants when not present in the soil in sufficient quantity. The minerals—calcium (lime), phosphorus, and potassium—must be supplied before much response can be expected from the application of commercial nitrogen. Barnyard manure has given good increases in the production of pasture plants; and, where available, it can well be used on pastures.

It is folly to expect fertilizers to produce a good growth of grass on extremely poor soils or soils that have never been productive. Such land had better be returned to timber production. On soils of fair natural fertility, much can be expected from fertilizing, particularly where the land has never been fertilized, or has been neglected for several years. Applications of superphosphate alone are usually the most profitable, because it costs less than other mineral fertilizers and, by encouraging the legumes, supplies through them nitrogen for the grasses.

If a fair stand of desirable pasture plants is present, the fertilizer treatment shown in table 3 is sure to result not only in a larger growth of these plants but also in an inprovement of the stand, especially of stoloniferous plants, thereby enabling them better to compete with weeds.

TABLE 3.—*Fertilizer treatment for growth promotion and improvement of stand*

Element	Carrier	Rate per acre
Calcium	Ground limestone	1 ton.
Phosphorus	Superphosphate	300 to 500 pounds.
Potassium	Muriate or sulphate of potash	100 pounds.
Nitrogen	Nitrate of soda	100 to 200 pounds.
	or	
	Sulphate of ammonia	75 to 150 pounds.
	or	
	Barnyard manure	5 to 10 tons.

In case of calcium deficiency, an acidity test should be made to determine the requirements of ground limestone. Where an excessive amount is required, such as 2 or 3 tons, however, a lighter application will probably give greater returns on the investment. Applications of ground limestone are often expensive, and since the principal effect desired is to encourage the growth and abundance of legumes, this effect may often be obtained by increasing the quantity of phosphate. In sections where lespedezas thrive (p. 36), these legumes, which are not sensitive to acid soils, may well replace the clovers and make the application of lime unnecessary. Both lime and phosphate are believed to be more effective when they are worked into the soil rather than applied on the surface.

In case of a deficiency of nitrogen, barnyard manure will furnish considerable nitrogen if applied at the rate of 5 to 10 tons per acre,

FIGURE 7.—Shade trees properly located at the top of a slope in a pasture.

and the effect of such applications continues for several years. The effect of applications of commercial nitrogen is soon exhausted, and they are of doubtful value for improvement of pasture grazed with beef cattle or sheep at present prices. Many dairy farmers are using commercial nitrogen and applying small quantities from 1 to 3 times a season. Some prefer, however, to make one heavy application of nitrogen in the spring and rely on supplementary grazing crops for midsummer. This system seems much more practical. Frequent or heavy applications of nitrogen usually result in a gradual disappearance of the legumes.

The mineral fertilizers, limestone, and barnyard manure can be applied in the fall, winter, or very early spring. Commercial nitrogen should be applied about 2 weeks before increased growth is desired, as it results in a quick stimulation of the growth and is lost rapidly from the soil by leaching. Early applications may make it possible

to begin grazing about 2 weeks earlier than could be done on unfertilized pastures. Applications of nitrogen are rarely effective, except in the presence of adequate soil moisture. Hence the returns from midsummer applications are often unsatisfactory.

When barnyard manure is used for pastures it should be spread lightly and uniformly on the whole pasture, preferably in the fall. Spreading some phosphatic fertilizer with each load of manure is a good practice.

Shade trees and shelters (p. 54) should be set on the higher portions of the field, and not along the banks of running streams, as they so often are (fig. 7). With good grass, the animals do not graze more than one third of the time; the rest of the time is spent lying down or standing in the shade fighting flies. Hence, much of the manure of grazing animals is not voided on the land that produced the grass. If the manure produced while the animals are not grazing is deposited on the tops of the hills, its beneficial effects on the grass may be noted for several rods down the hillsides.

On old pastures where there are relatively few desirable pasture plants it is often better to plow, fertilize, and reseed the land than to attempt to renovate the pastures by applying fertilizers alone.

USE OF CONTOUR FURROWS

On established pastures single contour furrows may be made with a lister or plow, preferably a two-way plow, throwing the sod down the slope. The furrows should be approximately 4 to 5 inches deep. Shallow furrows closely spaced produce grass more quickly, distribute the rainfall more evenly, and interfere less with mowing than large contour ridges or terraces. Such furrows have proved to be very effective and valuable in reducing run-off and increasing forage production in many parts of the Great Plains.

Contour bedding or furrowing has another important use in hill pastures where annual legumes such as lespedeza and hop clover are used as a part of the pasture mixture. Lespedeza especially has a light seed, and on hill slopes the seed is washed by hard rains into depressions so that it is a problem to maintain even stands on the slopes. Closely spaced furrows reduce the velocity of the surface water, and moving seeds may be stopped in the furrows instead of being washed away.

CONTROL OF WEEDS AND BRUSH

The application of fertilizers is one of the best means of weed control, as generally grasses will dominate when they have favorable soil conditions. Mowing weeds at the proper time is another good means of control. In general, this is when the weeds are starting to bloom and before the seed has formed. It is necessary to mow twice during the year to eradicate some weeds.

Sheep and goats are very efficient in keeping down many troublesome weeds, and many farmers have found it profitable to keep a few sheep in their cattle pastures because of their tendency to eat weeds.

Shrubs and tree sprouts can best be controlled by being cut at the proper time. Buckbrush and sumac can be eradicated if cut while they are in flower. Work at the Connecticut Agricultural Experi-

ment Station shows that July is the most effective time to mow brush such as soft maples, alders, birch, and blackberries. In the Northern States apparently the "critical period" for brush is when the roots contain the smallest amount of starch. Generally, this is at time of blooming.

The eradication of sprouts and shrubs in the Southern States appears to be much more difficult than in the North. Grubbing them out or killing them with chemicals has so far seemed the only sure way to eradicate them. Both these methods are expensive unless labor is very cheap.

FIGURE 8.—Arrangement for feeding cattle on pasture in New York State. Supplemental feed given on the pasture conserves fertility.

EFFECT OF METHODS AND INTENSITY OF GRAZING

It should be borne in mind that there are striking differences in methods of grazing. Where beef cattle or sheep are grazed, much of the manure is left on the pastures, and the land is enriched if the animals are given additional feed on the pasture during the winter (fig. 8). This is usually not the case on dairy farms, where the cattle spend much of the time in yards or stables. It is often remarked that "the pastures are robbed to keep up the fertility of the plowed fields."

Pastures should not be grazed too early in the spring in the Northern States. At this time the soil is usually soft because the snow and frost have so recently disappeared, and in many localities rains are frequent at this time. In addition, the plants must have an opportunity to produce leaves and strengthen their root systems, otherwise their subsequent growth will be reduced. In the South early grazing is not so harmful. Grazing pastures closely in the late fall, thus preventing any surplus growth of the plants before they enter their dormant period, is harmful also, because they require some food reserves in the

roots and a fair cover of foliage to protect them from injury when their vitality is low and conditions are unfavorable.

In the humid parts of the United States forests are the climax type of vegetation and trees will dominate over grass if not interfered with by man. In such regions fairly close grazing is helpful in maintaining a grass cover. Trampling as well as grazing by cattle and sheep assists in the production of a good turf. Sheep are believed to be especially beneficial in compacting the soil, and goats help by browsing to prevent brush and trees from occupying grazing lands. In general, reasonably heavy grazing favors plants that require light and that grow best on a compact soil. Most stoloniferous plants like bluegrass, redtop, bentgrass, and white clover are of this type.

On the other hand, in arid and semiarid country, where grasses are the climax form of vegetation and may even conquer such hardy plants as sagebrush, continuous heavy grazing is destructive rather than helpful. The plants have a short period of growth, on account of the brief rainy spells and the lack of soil moisture during a greater part of the year; thus they cannot perpetuate themselves by seeding or storing plant food in their subterranean parts if they are closely cropped throughout their growing period each year.

Cattle alone graze more uniformly and will keep a pasture in better condition than horses or sheep alone, but mixed grazing frequently provides a more uniform utilization of the forage. In the case of any class of livestock, the inclusion of some good pasturage and some poor pasturage within the same boundary usually results in poor utilization because the stock will overgraze the good pasture and undergraze the poor pasture. Consequently, improving a part of the pasture and neglecting the rest may eventually result in reduced rather than increased carrying capacity.

The bad effects of understocking a pasture may occur when animals are fed heavily with supplemental feeds and do not have to rely much on the pasture for feed. Therefore, they may graze very selectively, avoiding the plants that have become too mature and allowing the less desirable plants to grow and crowd out the more palatable and closely grazed plants. In such cases young stock and breeding animals that are not receiving supplemental feed should follow to clean up what has been left.

Where grazing is confined to one kind of animals it is likely to affect the quality of the pasture adversely on account of the selectivity of their grazing. Horses are quite likely to graze certain areas very closely and to leave other areas wholly untouched. On the other hand, they may be used to graze down a pasture that has rather completely grown up to coarse herbage. Such rough herbage as they will not eat can be removed by mowing late in the summer. Sheep, too, are much inclined to select the more tender grass and the tender tips of weeds and bushy plants. One of the rules for maintaining a uniform turf is to graze it all down close at least once a year. In England it has been found that rolling is the most effective means of eradicating moss from old pastures.

EFFECT OF BURNING PASTURES

No general statement can be made regarding the advisability of burning over pastures or ranges, except that indiscriminate, uncon-

trolled burning is usually harmful. Much depends upon the kind of vegetation, the time of the year, and the soil and weather conditions when burning takes place. Pastures and ranges are burned over for various reasons such as: To destroy dead herbage which was unconsumed the previous season and remains to interfere with the grazing of new growth; to control weeds and brush which otherwise might replace the desirable pasture plants; and to destroy pine needles and other forest litter which tend to smother out the forage plants on cut-over timber land. When fire is so used, much care should be exercised to prevent its spread to adjacent fields, forests, and farmsteads where the flames might destroy timber or other valuable property.

Experimental evidence indicates that good tame pastures of introduced grasses are usually injured by burning at any time of the year. At the Wisconsin Agricultural Experiment Station a bluegrass pasture burned over March 9 when the soil was frozen produced 52 percent less forage the following summer than unburned areas, and an adjacent area burned May 11, when the soil was thawed out, produced 71 percent less. Weeds were much more abundant on the burned than on unburned areas.

Native grasses apparently are not injured as much by fire as the introduced grasses. Annual burning of the native bluestem pastures of Kansas, March 20, reduced the yield of grass about 32.5 percent, but when burned in alternate years the reduction in yield was only 3.5 percent. Burning in late spring was also effective in destroying the herbaceous weeds and the coralberry or buckbrush. These experiments of the Kansas Agricultural Experiment Station indicate that burning bluestem pastures in alternate years or less often may result in more uniform grazing, especially on rough land, by removing the dead grass, weeds, and brush.

The Colorado Agricultural Experiment Station found burning an effective and economical method of clearing range lands of sagebrush. Land thus cleared of sagebrush increased its production of forage grasses 238 to 336 percent in two years. That the grazing value of cut-over lands in the Gulf Coast region, especially longleaf pinelands, is increased by burning at the proper time of the year has been demonstrated in both Florida and Mississippi. At McNeill, Miss., the average seasonal gains for an 11-year period of cattle grazing about 8 months of the year were 46 percent larger on burned than on unburned pastures.

DRAINAGE

Unless pasture land is exceptionally productive, the expense of tile drainage over any considerable area is rarely warranted. There are, however, many instances where seepage from the higher land renders unproductive small areas on the slope above water courses or ditches. In such areas sedges, rushes, and other undesirable grazing plants predominate. Short lines of tile laid above this wet spot and opening into the ditch below may be justified in the increased productiveness that results. Often open ditches may be constructed to catch the subsurface water as it comes down the hill. Such ditches, however, are more or less unsatisfactory because of their danger to the grazing animals and the possibility of their developing into gullies.

DAMAGE BY RODENTS AND INSECTS

On range lands of the Western States prairie dogs, ground squirrels, jack rabbits, and other rodents sometimes become a serious problem. In years of severe drought, especially, some control of rodents may be necessary to lessen their competition with livestock for the little range forage produced. Pocket gophers sometimes damage pastures by covering the forage with numerous mounds of earth thrown out in the excavation of their underground tunnels, and their burrows may interfere with the proper distribution of water in irrigated pastures. The Bureau of Biological Survey, United States Department of the Interior has developed and demonstrated methods of controlling rodents.[3]

In some sections insect pests, notably those of subterranean habit, cause considerable injury to permanent pastures. In Iowa, Wisconsin, and northern Illinois, especially, white grubs have in some years done great damage to pastures. Seeding legumes, such as sweetclover or alfalfa, in such pastures has been found to be an effective way to restore their productiveness. The sod webworms and some kinds of wireworms may be partially controlled by similar measures. Leafhoppers are apt to do considerable damage to pure legume pastures, but are of no great importance on pastures which contain a considerable percentage of grass. Close grazing or clipping the pasture at the time when the hoppers are immature will reduce their numbers. This benefits the turf by compacting the sod as well as by crushing many of the larvae. Chinch bugs sometimes cause damage to supplemental pastures such as Sudan grass but rarely trouble permanent pastures. A full discussion of methods of control for various possible insect pests of pastures is not warranted in this publication. Individual cases are best handled by reference to the Bureau of Entomology, United States Department of Agriculture, or the entomological department of the State experiment station.

SUPPLEMENTAL PASTURES

While the hardy perennial grasses and legumes have a value that cannot be denied for seeding pastures to provide a turf that will keep animals out of the mud and require but little attention after it is once established, their inclination to be unproductive when it is too hot or too cold makes it desirable to grow annual or biennial crops suitable for grazing. Such crops as rye, wheat, barley, oats, Sudan grass, rape, ryegrass, sweetclover, or soybeans are recommended because they have 2 to 4 times the carrying capacity in early spring, midsummer, and late fall of the average permanent pasture on soils of equal productivity. Larger yields, together with the advantage of having pasturage to replace barn feeds when permanent pastures are unproductive, offset the expense of preparing the ground and seeding such crops each season.

For a temporary pasture it is important to have level or nearly level land and a soil that will not erode badly, as the plowing and seeding require that the ground be bare for short periods each year. The seasonal production of permanent pastures in the North and in the South is shown in figure 9.

[3] Further information may be obtained from the Bureau of Biological Survey, Washington, D. C., or from the representatives of that Bureau in your State.

Information regarding plants useful for supplemental pastures is given in table 4 and in the text following. In the North it is usually

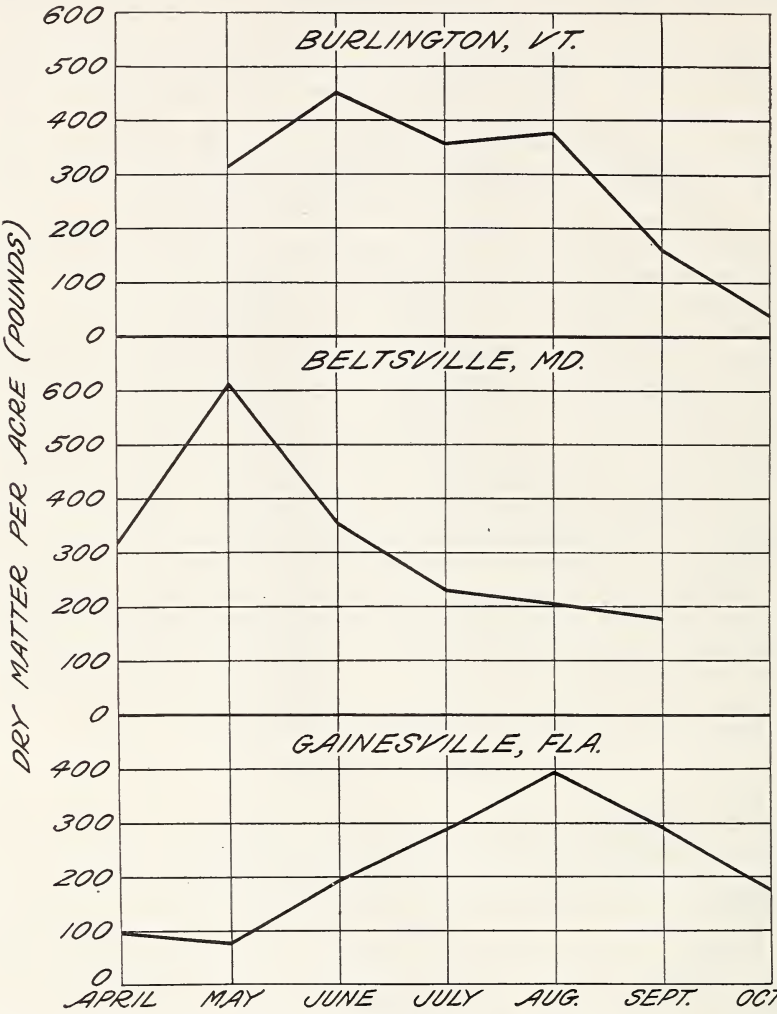

FIGURE 9.—Monthly yields of pastures in Vermont, Maryland, and northern Florida. (Vermont data are the average of 17 pasture records in 1925–26 from table 5, Vermont Experiment Station Bulletin 295; Maryland data are average yields for 1929, 1931–33 by T. E. Woodward, Bureau of Dairy Industry; Florida data are for 1928–32 from annual reports by G. E. Ritchey of the Bureau of Plant Industry.)

impractical to graze supplemental pastures with dairy cows in the early spring or late fall on account of weather conditions. This is not true, however, in the Southern States.

TABLE 4.—*Information regarding plants useful for supplemental pastures*

Name	Climatic adaptation [1]	Degree of palatability	Season for grazing	Time and rate of seeding per acre	Soil adaptation	Remarks
Barley	Wherever enough moisture is available.	High	Spring in North, fall and spring in South.	Fall in South; spring in North; 1 to 2 bushels.	Well-drained soils of moderate fertility.	Use seed of a locally successful variety.
Cowpeas (*Vigna sinensis*).	Region 2 and section 1-b	do	Late summer and fall	Spring to early summer; 30 pounds in rows, 15 pounds alternate rows in corn.	Almost any well-drained soil.	When intended for grazing, usually planted with corn and grazed when seed matures.
Crimson clover (*Trifolium incarnatum*).	Mainly sections 5-a and 2-a, and the southern and eastern part of section 1-b.	do	Fall to spring	Late summer; 12 to 15 pounds.	Well-drained fertile	Prefers fertile sandy loams; best used in mixture with rye.
Italian ryegrass (*Lolium multiflorum*).	Regions 1 and 2, and section 5-a.	do	Early fall to midsummer.	Early fall or very early spring in North, 20 to 25 pounds.	Sandy loams to clays of medium to good fertility.	Probably the best grass for late-fall and early-spring grazing.
Kudzu (*Pueraria thunbergiana*).	Region 2 and favorable locations in the southern part of section 1-b.	Medium	Spring to fall	Early spring rooted plants are set 6 to 8 feet apart; seed is available.	Practically any well-drained soil.	Difficult to establish from seed; plants should be set before spring growth begins; can readily be overgrazed.
Napier grass (*Pennisetum purpureum*).	Region 2, southern part of sections 3-b, 4-b, and 5-b if irrigated.	High	Late spring to fall	Early spring; no seed available.	Sandy loams to clays	Propagated by seed canes, like sugarcane.
Oats	Wherever enough moisture is available.	do	Spring in North; fall and winter and spring in South.	Fall in South, spring in North; 2 to 3 bushels.	Well-drained soils of moderate fertility.	Use seed of a locally successful variety.
Rape (*Brassica napus*).	Sections 1-a, 1-b, and 5-a, locally 3-a and 4-a, winter crop in region 2.	do	Early summer, late fall, and winter according to the climate.	Early spring, later if desired; early fall in South; in rows 3 pounds, broadcast 8 pounds.	Prefers rich, good, moist, loamy soil.	Especially good for sheep and hogs. Some danger of bloating in sheep.
Soybeans (*Soja max*).	Regions 1 and 2 except northern part of section 1-a.	Very high	Midsummer to fall	Spring to early summer; 42-inch rows 30 pounds, 30-inch rows 45 pounds.	Practically any well-drained soil.	Varieties differ in respect to their ability to renew growth after defoliation.
Sudan grass (*Sorghum vulgare* var. *sudanense*).	All regions except extreme north.	High	Early summer until frost.	Middle spring to early summer; 15 to 25 pounds.	do	One of the most productive and palatable of all annual pasture grasses for summer grazing.
Sweetclover (*Melilotus alba* and *M. officinalis*).	Regions 1, 2, and 3; also section 4-a where moisture is sufficient.	Medium	Very early spring (second year) to late fall (first year).	Winter and very early spring; 15 to 20 pounds.	Any well-drained non-acid soil.	Provides much nutritious pasture, but its success often requires applications of lime.
Velvetbeans [2]	Section 2-b and southern part of 2-a.	High	Fall and winter	Spring, with corn	Any well-drained soil	Usually grazed after the corn has been harvested.

[1] Region and section numbers refer to fig. 4.

[2] Usually seeded with corn.

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TABLE 4.—*Information regarding plants useful for supplemental pastures*—Continued

Name	Climatic adaptation	Degree of palatability	Season for grazing	Time and rate of seeding per acre	Soil adaptation	Remarks
Vetch [3]	Regions 1 and 2; also region 5 where moisture is available.	High	Early spring; some fall and winter in South.	Early fall; 30 to 50 pounds, depending on size of seed.	Well-drained soils of fair fertility.	Several species. Use locally adapted kinds.
Wheat and rye	Wherever enough moisture is available.	Wheat high; rye medium to high.	Fall and spring	Early fall; 1 to 2 bushels	Well-drained soils of moderate fertility.	Use seed of a locally successful variety.
Winter peas [3]	Regions 2 and 5 where moisture is available.	Very high	Early spring; some fall and winter in South.	Early fall; 30 to 50 pounds	Well-drained soils of fair fertility.	Sometimes suffer from disease; often injured by trampling.

[3] Best for grazing when seeded with small grain.

CROPS FOR SUMMER AND EARLY FALL GRAZING

SUDAN GRASS

Sudan grass leads the list of crops suitable for supplemental pasture in the summer months. Although not introduced into the United States until 1909, it is now grown in almost every State in the Union. Sudan grass can be seeded any time after the ground is warm in the spring until midsummer; and if the soil has a fair amount of moisture at seeding time, grazing may begin within 4 or 5 weeks and continue until frost. Sudan grass also makes a very palatable hay and will yield several tons per acre. The crop may be seeded with an ordinary

FIGURE 10.—A sweetclover field used as pasture for dairy cattle in Michigan. Such a field properly managed makes excellent supplemental pasture.

grain drill. The seed is inexpensive, and failures to get a good stand are rare.

Sudan grass has one weakness that occasionally mars its excellent record. After very severe drought or after frost, livestock grazing on it may suffer from prussic-acid poisoning. It is advisable to refrain from grazing Sudan grass that has been noticeably injured by drought or frost. The grass so injured can be fed as hay without any cause for worry, since curing seems to remove the danger.

SWEETCLOVER

Sweetclover is more truly a rotation pasture than a supplemental pasture. Its greatest use is in the Corn Belt and the Great Plains as far south as Oklahoma and as far north as Saskatchewan, Canada. It is a biennial. The first year's growth furnishes grazing in the late summer and fall, except where the summers are too dry to permit adequate growth. The second year's growth develops rapidly in the early spring and may be heavily grazed till about July (fig. 10).

Sweetclover will tolerate a reasonable amount of salt or alkali in the soil.

There may be a few weeks between the time the old growth becomes too woody to graze and the time the new crop is large enough to graze, but under favorable conditions stock can go from one field to the other. Since the first year's growth has only half the carrying capacity of the second year's growth, twice as many acres should be seeded each year as are contained in the 2-year-old field. The excess acreage is commonly turned under for corn the following spring.

Bloating may occur, but there is not so great danger of it as with red or alsike clover or alfalfa. Allowing the animals access to a stack of hay or of straw will go far toward solving this difficulty.

Sweetclover is commonly seeded on winter grain or with spring grain. Unhulled seed may be used if sown in winter; for spring seedings scarified seed should be used. In Kansas the best stands are obtained following Sudan grass or sorghum.

Sweetclover is so important as a grazing crop in the Great Plains that special combinations of rape and sweetclover have been recommended by the Nebraska Agricultural Experiment Station, and a rotation pasture including rye, Sudan grass, and bluegrass has also been suggested for eastern Nebraska wherever sweetclover is not desired.

LESPEDEZA

In addition to its value in permanent pastures (pp. 16–17), lespedeza has great possibilities as supplemental pasture when grown in rotation with one of the small grains. This use has been demonstrated on many farms in Missouri, Kentucky, Tennessee, Virginia, and North Carolina. Korean, Kobe, and Tennessee 76 are used more in this way than the Common. Wheat, oats, or barley are seeded in the fall at the customary seeding date, and in the spring one of these varieties of lespedeza is broadcast on the surface. The small grain may be grazed or harvested either for hay or as a grain crop, after which the lespedeza grows rapidly, and within 2 weeks, generally less, it is ready to be grazed. From the middle of July to the middle of October, depending upon the variety and the latitude, the lespedeza will provide grazing for from one to two mature cattle per acre. When seeding time for the small grain arrives, a seed bed is prepared, usually by merely disking the land. In some cases a subsoil plow is run through the field, at intervals of 3 or 4 feet, prior to the disking. By this method the lespedeza reseeds yearly, and no further expense for seed of lespedeza is entailed. Ordinarily the yield of grain is increased by this double cropping with lespedeza. This plan of growing lespedeza with grain as described here is successful only with varieties of lespedeza that will mature seed before the seeding time of the fall grain. Kobe and Tennessee 76 should be used only in region 2 and the extreme southern part of section 1–b. North of that, Korean lespedeza is the only variety that can be depended upon to reseed yearly in such a cropping system.

Lespedeza is commonly seeded on winter grain, but may follow such crops as corn and cotton. Use 25 to 30 pounds per acre if a full stand is wanted the first season. If a light stand for reseeding is wanted, use 5 to 10 pounds. It may be seeded on a thin grass

pasture very early in the spring, without preparation, or the pasture may be lightly disked. Korean lespedeza used in this way has given good results as far west as eastern Kansas. North of the Ohio River, too few trials have been made to determine whether such practice will prove successful. In laying down new pastures, a few pounds of lespedeza seed per acre in the mixture will increase the grazing in midsummer.

SOYBEANS

Soybeans make excellent supplemental grazing, either seeded alone or in combination with Sudan grass. The best time for seeding in region 1 is immediately after corn-planting time, but the grazing season may be extended in region 2 by making successive seedings at intervals of 1 month from March 15 to June 15.

Less waste in grazing occurs when soybeans are grown in cultivated rows than when they are drilled or broadcast. An excellent method of using soybeans for grazing is to seed them in rows, and after the first cultivation of the soybeans, seed a row of Sudan grass between the rows of soybeans. Such a combination supplies more grazing than the soybeans alone.

In order to obtain the full value of soybean pasture the field must be divided into sections by temporary fences, and these sections grazed in rotation in order to allow the beans time to recover between grazing periods. Much more grazing can be obtained in this manner than by continuous grazing. If dry weather intervenes the soybeans will not recover if heavily grazed, but under favorable soil and rainfall conditions the Biloxi variety has been grazed three times during the season. This variety is said to be especially successful in producing a new crop of leaves after having been partially defoliated by grazing. Soybeans are recommended particularly for dairy cows and sheep. However, the animals should be left on the soybeans for only a few hours in the forenoon and for a like period in the afternoon, being removed after each grazing period to a grass turf on which they can lie down.

Soybeans are usually ready to be grazed 60 days after being seeded. At that time they should be 12 to 18 inches tall and will not have begun to bloom. Grazing may continue until late fall, because they are less susceptible than Sudan grass to injury from light frosts. The Biloxi is a late-maturing variety and other varieties would be preferable in section 1–a and the northern half of 1–b. Locally adapted varieties recommended by the State agricultural experiment station or extension service should be used.

COWPEAS

Cowpeas are best suited for use as hay or green manure, but in the Cotton Belt they are often seeded in alternate rows with corn and grazed in the same manner as velvetbeans after the corn has been harvested. Some farmers prefer the cowpea to the velvetbean for interplanting with corn because the vines are not so heavy and interfere less in gathering the corn. For young hogs especially cowpeas are an excellent grazing crop, and but little additional grain is needed to bring them to market weight if the cowpeas are grazed when the majority of pods are mature. The hogs feed mostly on the pods and leave the vines and leaves, which may be grazed off by cattle or sheep after the hogs have been removed.

When cowpeas are grown alone the best time to begin grazing with cattle or sheep is when the first pods are mature. There is some danger from bloating, but this danger is much less than in grazing alfalfa or clover. Gains of 2 pounds per head per day for 90 days have been obtained by grazing cowpeas with steers and giving them a light ration of cottonseed meal.

NAPIER GRASS

Napier grass is an imported plant, known in the West Indies and in Africa, its original home, as elephant grass because of its large size. In habit of growth and the method of planting, it resembles sugarcane very much. It is a perennial, but will not endure continuous grazing, and is therefore most useful as a supplemental pasture and for silage. It is more or less tropical in its climatic adaptations, being grown principally in the Gulf States and in irrigated districts of New Mexico, Arizona, and southern California.

The stems of Napier grass are coarse, and the leaves are long and harsh. Notwithstanding this, cattle appear to relish the grass, and because of its vigorous growth and adaptability to a wide variety of soil types it excels most plants in the quantity of feed produced during the summer months. The stems grow to a height of 10 to 12 feet in clumps of 30 or more. After it has been grazed heavily for a few weeks the animals should be removed so that the Napier grass may renew its growth. The best method of propagation is planting seed canes 3 feet apart in furrows about 6 feet apart. The cuttings or seed canes may also be pushed into freshly prepared land in rows at the intervals indicated.

KUDZU

Kudzu is a perennial leguminous vine suitable to the South. The vines make an annual growth of 30 to 50 feet but are commonly killed by the first freeze, except where they have rooted at the nodes. The foliage is palatable, and kudzu may readily be overgrazed. Unless the plants are allowed to store reserved food in the roots they will decline in productivity and finally die. Kudzu is therefore especially suitable for supplemental pastures on to which cattle may be turned for several days at a time. Constant grazing is sure to kill it. Hogs will destroy kudzu by feeding on the roots.

CROPS FOR LATE FALL, WINTER, AND EARLY SPRING GRAZING

ITALIAN RYEGRASS

Italian ryegrass is a leafy, short-lived grass, usually an annual. When seeded in the spring, late summer, or early fall it makes rapid growth and furnishes grazing in a remarkably short time. It is tender, very palatable to livestock, and has excellent carrying capacity; the plants grow from 2 to 3 feet in height and make excellent hay. When not seeded too thick, it makes an excellent nurse crop for spring-seeded permanent pastures and lawns. In the South, Italian ryegrass is used extensively for fall-seeded winter pastures. It is not so winter-hardy as many other grasses, including timothy and orchard grass, and is grown principally in sections 5–a, 1–b, 2–a, and 2–b. Heavy pasturing is quite desirable, as it keeps the grass in a succulent condition and utilizes all the forage produced during its short period of growth.

SMALL GRAINS

Small grains such as rye, oats, barley, and wheat, are relished by all kinds of livestock, and since seed is usually available on the farm it is convenient and inexpensive to provide additional pasturage in this way. In the winter-wheat belt a month of excellent grazing is often afforded in late fall or early winter by the regular wheat seedings. In many cases where the fall growth is abundant a reasonable amount of grazing often increases rather than diminishes the grain yield. The double cropping of land to lespedeza and some small grain has been explained under lespedeza. This small grain may be grazed if pasture rather than a grain crop is needed. Grazing results in no injury to the lespedeza unless the animals are allowed on the field when the ground is too wet. It may be necessary to remove the animals for a short time in the spring after the grain crop has been consumed, to allow the lespedeza to get started.

Locally adapted varieties of these small grains should be used in all cases. In the southern half of section 1-b and in region 2 Abruzzes rye is much preferred to the ordinary kinds. Barley, although not grazed as much as oats and rye, is well suited for use as a grazing crop. Heavy seeding of all these small grains at a rate at least twice that customary in seeding for grain production is a profitable practice. A thick stand produces a heavy turf which protects the soil better from trampling in wet weather and also provides a greater quantity of feed. Outside of the spring-wheat belt early-fall seeding is recommended to provide fall grazing.

CRIMSON CLOVER

Crimson clover is especially valuable for supplemental grazing in late winter and early spring. Under favorable conditions it may be grazed more or less all winter and by March can be heavily grazed. Crimson clover is commonly seeded for soil improvement, but a great deal of early grazing can be taken without loss of its value as a green-manure crop. It is most successful along the Atlantic seaboard from New Jersey south, but also does fairly well in many places south of the Ohio River and as far west as Kansas.

RAPE

Rape, a plant closely related to kale, is useful as a supplementary pasture, being almost equal to alfalfa as a grazing crop for hogs. Cattle and sheep also make good gains on rape pasture, though there is some danger of bloating. Dwarf Essex is the variety usually sown.

Rape is not adapted to poor land. It should be sown on productive soil from late March to the middle of July in the North and from August 15 to October 15 in the South. It is ordinarily ready to graze in 7 to 10 weeks or when 12 inches high. The seed may be broadcast and covered lightly with a harrow, or it may be sown with a grain drill. Four to eight pounds of seed per acre are recommended. It is sometimes sown at the rate of 2 to 3 pounds per acre in rows 18 to 40 inches apart to permit cultivation.

In pasturing rape, it is advisable to divide the field with temporary fences to permit of moving the animals progressively to ungrazed portions or to graze two fields alternately.

VELVETBEANS

Velvetbeans are legumes which at one time occupied several million acres in the Cotton Belt and are still being grown on many southern farms, almost invariably as a companion crop with corn. This is due to the fact that the most productive varieties are vining types which require an upright support of some kind to keep the pod clusters off the ground. While very resistant to fungus and insect attacks, the pods and beans often become moldy if they are in constant contact with damp soil. The beans are usually seeded in alternate rows with corn, the corn rows being from 4 to 6 feet apart, according to the productivity of the land. Some prefer to seed the beans in the same row with the corn, thus having the corn rows the customary distance apart. Bush types of velvetbeans are being developed which will not require support and may be grown without a companion crop. At present the vining types are more dependable and better yielders than the bush type.

The grazing value of the velvetbean is confined largely to the mature beans, which are grazed off by cattle or hogs after the corn crop has been harvested. Both the corn and the beans may be "hogged off" and thus the labor of gathering the corn avoided. Velvetbeans are of no importance except in region 2.

PEANUTS

The principal value of peanuts as pasturage is for hogs, because they will root out the peanuts, which grow underground. While hogs make rapid and generally cheaper gains on peanuts, where they grow well, than on other feeds, the fat is so soft and oily that hogs so fed sell at a considerable discount. Peanuts should not be grazed until they are nearly mature because the trampling reduces the yield. As there is more foliage than hogs will use to advantage, part of it should be grazed by other livestock or cut for hay before the hogs are turned in. As the peanuts will spoil or sprout if they are left too long in moist ground, they should be grazed within 1 to 3 months after they mature, depending upon the variety, the water-holding capacity of the soil, and the climate. Good yields vary from 30 to 40 bushels per acre. With the foliage, 10 to 12 bushels should make 100 pounds of gain on thrifty shotes.

In order to obtain carcasses of satisfactory firmness from hogs fed or pastured on peanuts it is necessary subsequently to make them gain about three times as much on a ration such as 7 parts of corn and 1 part of cottonseed meal as they have gained on peanuts.

VETCHES

Vetches (*Vicia* spp) of numerous varieties and species are grown principally as green manure for soil improvement purposes, but in case of need they may be grazed in the early spring with good results. Their use as a grazing crop is confined chiefly to region 2 and section 5–a, and the kinds best suited to this purpose in region 2 are hairy vetch and smooth vetch (*V. villosa*), wooly pod vetch (*V. dasycarpa*), and Monantha vetch (*V. monantha*). These and in addition purple vetch (*V. atropurpurea*) and common vetch (*V. sativa*), are grown successfully in section 5–a. When intended for hay or grazing, vetch is usually sown at the rate of 30 to 40 pounds per acre from September

15 to October 15, with a nurse crop of winter rye, oats, or barley. Grazing may begin in late February or early March and lasts ordinarily till about May 15 or June 1. Vetch is not relished as much as most legumes, and the injury from trampling is considerable, but it is nutritious and provides pasturage in region 2 before growth begins on the permanent pastures.

WINTER PEAS

The gray winter pea, or Austrian winter pea as it is commonly known, is grown for the same purposes and in the same way as the vetches in region 2. Section 5–a is the principal source of domestic seed of this variety of field pea, and most of the acreage in that section of the Pacific slope is harvested for seed, very little being grazed. The winter pea is more palatable than vetch, but the vines are very tender and the injury from trampling greater. The grazing season is the same as that of vetch.

RESCUE GRASS

Rescue grass, also known as arctic grass, is a winter annual which ordinarily begins its growth at the end of the hot summer season and thrives only during the cool weather of late fall, winter, and early spring, at which time it produces seed and ceases growth for the year. This grass is not well known or much used, perhaps because the winter small grains are available for grazing at practically the same season of the year and are much more productive. It is grown most in eastern Texas, where some sow it on Bermuda turf in the late summer with little or no cultivation and thus provide some winter pasture after the Bermuda grass and lespedeza become unproductive. It normally produces abundant seed crops, and under favorable conditions will reseed naturally after becoming established.

Rescue grass is useful only in sections which have mild winters, such as those along the Gulf coast and in southern California. It is fairly palatable and perhaps deserves more consideration than it receives.

AFTERMATH OF MEADOWS

On the ordinary farm there are usually some fields devoted to the production of hay. In the Northeast and in the Corn Belt these meadows consist largely of timothy and clover or alfalfa; in the central West there are many meadows of native grasses and of alfalfa. In most hay meadows there is a considerable growth after the hay crop is removed, and except in the case of alfalfa these meadows are not injured by a reasonable amount of grazing. There is usually a considerable proportion of clovers in the aftermath of timothy-and-clover meadows; thus the animals are supplied with a diet rich in protein and minerals. The carrying capacity of these hay lands is high for the short periods in which they are utilized as pasture, and much feed that would otherwise be wasted is put to excellent use.

When meadows, especially alfalfa fields, are grazed in this way it is unwise to allow the animals to remain on them late in the fall. They must be removed in time to allow a sufficient growth to restore root reserves and produce enough foliage to protect the plants during the winter; otherwise the yield of hay the following year will be lessened and the productive life of the meadow shortened.

ANNUAL PASTURES

A succession of annual crops chosen from those described under supplemental pastures may be so managed that they will provide pasturage for all 12 months of the year in region 2, and for a considerable part of this period in region 1 and the irrigated districts of the Western States. Such pastures are of special value to the dairy farmer and the producer of sheep and swine. The expense of preparing the land and seeding these crops is in most cases more than offset by the greater productiveness of such pastures and certain favorable reactions upon the animal, such as a greater degree of freedom from internal parasites and the more adequate supply of mineral nutrients.

Some of the advantages of annual pastures are a greater production per acre, so that less land is required; a longer grazing season, which reduces the feed cost; less trouble from internal parasites; better maintenance of the productivity of the soil; and less danger from obnoxious weeds.

There are also certain disadvantages which cannot be overlooked, such as a much larger labor requirement; more expense for seed, fences, and machinery; greater danger of erosion; the impracticability of grazing such crops on clay soils in wet weather; and the frequent impossibility of obtaining good stands of necessary crops.

CALENDAR OF SEEDINGS

Advice as to a sequence of annual crops that are suited to the climate and soil of a particular locality as well as to the kind of animals that are to graze them can usually be obtained from the State agricultural experiment station or the county agricultural agent. An effective arrangement of annuals used successfully in southeastern North Carolina to provide pasturage for dairy herds is given as an example:

> Abruzzes rye, sown in September and grazed from November 15 to March 15; crimson clover and hairy vetch, sown August 15 to September 1, and grazed from March 1 to May 15; Sudan grass, sown April 1 and grazed from May 15 to November 15; and Biloxi soybeans, sown March 15 and grazed from June 1 to November 15. Several progressively later sowings of soybeans, or soybeans and Sudan grass in alternate rows, usually furnish pasturage for the entire herd during the season indicated, thus leaving the pure Sudan grass for night grazing or to be cut for hay as circumstances demand.

Similar combinations of annual crops have been devised for other sections of the United States, not only for dairy cattle, but also for hogs and sheep. While the possibility of having grazing available for each month of the year decreases as one goes northward, a proper combination of annuals usually results in a longer grazing season than is possible on permanent pastures. Advice regarding desirable crop combinations for any particular locality should be obtained from the local county agricultural agent or the State agricultural experiment station.

VITALITY OF SEEDS OF PASTURE PLANTS

There is always a question as to whether seed of grasses or legumes that has been in storage for several years is in condition to germinate and produce a good stand when properly seeded. This question is answered for the most important of the pasture plants in table 5,

which shows how much the germination of the seed of each decreases yearly and how many years elapse before the seed ceases to be viable. Lespedeza seed, not included in the table, may safely be used the second spring after harvest. In subsequent years the germination is likely to decrease seriously.

TABLE 5.—*Percentage of germination in relation to the age of the seeds of certain pasture plants*

[From South Australia Dept. Agri., Bull. 261.]

Pasture plant	Percentage of germination each year														
	First year	Second year	Third year	Fourth year	Fifth year	Sixth year	Seventh year	Eighth year	Ninth year	Tenth year	Eleventh year	Twelfth year	Thirteenth year	Fourteenth year	Fifteenth year
White clover [1]	98	99	90	91	87	61	31	26	21	18	14	13	10	10	8
Alsike clover [1]	99	99	98	96	70	33	23	19	20	15	17	19	16	15	13
Alfalfa [1]	99	95	96	87	82	68	63	55	42	38	18	12	12	7	4
Red clover [1]	100	100	100	91	52	10	4	2	1	3	1	4	3	----	----
Bentgrass	91	96	93	92	92	91	80	50	44	32	17	4	1	----	----
Italian ryegrass	83	79	79	65	57	40	22	15	6	2	----	----	----	----	----
Orchard grass	90	85	88	88	77	71	59	27	16	1	----	----	----	----	----
Kentucky bluegrass	78	94	87	85	72	44	32	12	10	1	----	----	----	----	----
Perennial ryegrass	92	89	89	87	67	41	24	10	----	----	----	----	----	----	----
Timothy grass	98	95	91	79	53	12	4	1	----	----	----	----	----	----	----
Meadow foxtail	89	84	66	56	30	10	4	1	----	----	----	----	----	----	----
Oatgrass (probably tall)	98	94	88	83	50	16	6	----	----	----	----	----	----	----	----
Meadow fescue	98	94	96	81	42	66	----	----	----	----	----	----	----	----	----
Reed canary grass	49	29	20	2	----	----	----	----	----	----	----	----	----	----	----

[1] Seed stored at 64° F. at Danish State Seed Testing Station. The germination percentages include viable hard seed. These results are reported in the following publication: DORPH-PETERSEN, K. HOW LONG DO THE VARIOUS SEED SPECIES RETAIN THEIR GERMINATION POWER. Internatl. Rev. Sci. and Pract. Agr. (n.s.) 2 (2): [283]-301. 1924.

UTILIZATION OF PASTURES

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PASTURES COMPARED WITH HARVESTED CROPS IN COST OF FEED

After the establishment of permanent pastures the labor requirement is small. In a number of typical cases it varied from 1 to 3

FIGURE 11.—A good pasture of mixed grasses and legumes. Such a pasture lessens or eliminates the need for supplemental feeds.

hours of man labor and less than 1 hour of horse labor per acre per year for fence repair and replacement. The principal other labor requirements are for occasional jobs such as the application of fertilizers and weed and brush cutting. On many pastures, however, the use of more labor would pay well. Other charges are interest and taxes which are fully as low as on any similar acres of the farm. Although annual and other temporary pastures may cost as much to produce as grain crops, they are harvested by livestock with practically no labor cost.

In seven districts where studies were made by the United States Department of Agriculture concerning requirements for the production of market milk, pasturage furnished nearly one third of the total

sustenance for the cows. On these same farms the pasture cost was only one seventh of the total feed cost.

Records obtained on 478 Corn Belt farms which produced beef calves showed that the breeding cows obtained practically their entire living from pasture for 200 days and from roughage and concentrates for 165 days. The pastures which were furnishing a little more than half of the total sustenance were credited with only one third of the feed bill.

A survey on typical farms in southern Indiana shows that those with half of their farmed area in pasture and half in crops made more profit than those which devoted one fourth to pasture and three fourths to crops. Thirty-six percent of the total feed for dairy herds on those farms was obtained from pasture, and such feed furnished nutrients at one fourth the cost of nutrients in harvested feeds.

PASTURES COMPARED WITH HARVESTED CROPS IN YIELD OF NUTRIENTS

In general, fair comparisons of the quantities of feed produced by pastures and by harvested crops are difficult to obtain on farms, because the poorer lands are used for pastures and because there is no practicable means of determining the quantity or composition of the pasturage consumed.

According to calculations based on census data (table 6), lands in harvested grain crops, as they are produced generally on farms of the United States, supply fully 50 percent more nutrients for livestock than similar land in pasture. A comparison of yields of harvested crops with calculated yields of pasturage on good Corn Belt land, where grain yields are usually higher than elsewhere, shows that a 5-year rotation of corn, corn, oats, wheat, and red clover produces practically twice as much nutrients as pasturage on the same land. As previously shown, however, pasturage is commonly produced and utilized at a much lower cost, particularly of labor. (fig. 11).

In general, closely grazed pasture produces about two thirds as much dry matter as the same plants would produce if they were allowed to grow nearly to maturity and then cut for hay. However, as the dry matter of immature grass is more digestible than the dry matter of hays made from mature grass, the pasturage produces about three fourths as much digestible nutrients as the hay.

Table 6 shows a comparison of the quantities of digestible nutrients produced from various harvested crops and pasturage.

TABLE 6.—*Comparison of the quantities of digestible nutrients produced from harvested crops and pasturage at the yields indicated*

Crop	Yields per acre of—		Total digestible nutrients [1] when—	
	Concentrates	Roughage	Harvested	Grazed
Cereals:	*Bushels*	*Tons*	*Pounds*	*Pounds*
Corn ears	28.2		1,396	
Corn stover		0.84	852	
Corn, whole plant as silage		5.60	2,273	
Barley	22.8	.82	1,522	
Oats	29.6	.88	1,359	
Wheat	14.1	.63	1,092	
Forage plants:				
Alfalfa		2.61	2,793	2,067
Clover, red, alsike, and crimson		1.46	1,504	1,113
Sweetclover		1.82	1,867	1,382
Lespedeza		1.82	1,170	866
Clover and timothy mixed		1.40	1,393	1,030
Timothy		1.26	1,210	895
Grains cut green		1.31	1,292	956
Annual legumes [2]		1.02	1,102	815
Millet, Johnson grass, and Sudan grass		1.23	1,225	906

[1] Based on analyses of feeds and their coefficients of digestibility for crude protein, fiber, fat (ether extract), starch and sugar (nitrogen-free extract), compiled by G. L. Bidwell and A. T. Semple of the U.S. Department of Agriculture.
[2] Principally cowpeas and soybeans.

QUALITY OF MEAT FROM LIVESTOCK FATTENED ON GRASS

Results of studies on the effects of grass in the ration, on meat quality, point strongly to the possibility of cheapening production costs by making greater use of pastures in the fattening of livestock.

A summary of 10 experiments conducted for several years in cooperation with the Louisiana, Virginia, and West Virginia Agricultural Experiment Stations showed that beef from 2- and 3-year-old cattle fattened on good pasture alone was very similar in palatability to beef from cattle fed grain while on grass. The greatest differences were in aroma, flavor of fat, and in richness and quantity of juice, the beef from the grain-fed animals being superior, but the differences were small. The grain-fed cattle had a higher dressing percentage and were somewhat fatter. The similarity in tenderness and general palatability of the beef from the two methods of feeding indicated that grass as a feed does not necessarily produce beef of low grade. It appears that lack of finish or gain due to poor or insufficient pasture is often the cause of the low quality that is sometimes attributed to the use of grass.

The meat of suckling lambs produced on good pasture has been found as satisfactory from the standpoint of both fatness and palatability as that from suckling lambs which received a supplement of grain on pasture.

INFLUENCE OF PASTURES ON HEALTH OF LIVESTOCK

Fresh green pasturage grown on fertile soil provides in a palatable form most of the substances required for perfect nutrition. Pasturage is rich in protein, minerals, and vitamins. It is valuable therefore in maintaining the health and productivity of livestock. Pasturage permits the animals to replace the stores of minerals or vitamins which may have been used up during the winter and also

enables them to lay up a supply for use during a period of inadequate nutrition. Good pasturage appears to be a perfect feed for all herbivorous animals except those doing hard work, giving very large quantities of milk, or being fattened rapidly. On the other hand, long-continued feeding of herbivorous animals on poorly cured roughages is injurious to both production and reproduction. Among other reasons, such feeds are deficient in carotene from which vitamin A is made in the animal body.

Although certain parasites and diseases may be largely avoided by keeping livestock in dry lots or barns, animals generally are better off on pastures. A clean pasture not only provides natural conditions but it reduces the labor of caring for stock and also the danger of mineral and vitamin deficiencies.

Naturally the benefits of pastures over dry lots or barns are much greater in the case of breeding animals than of fattening animals because breeding animals need plenty of exercise and fattening animals should have no more exercise than is necessary in obtaining and consuming the feeds on which they are being fattened. In the case of work stock pastures give opportunity for light exercise which keeps the animals from getting soft when not working.

FEED VALUE OF IMMATURE PASTURAGE

Immature pasturage, including both grasses and legumes, has feeding properties similar to those of high-protein concentrates, such as the oil-mill byproducts. It is especially well supplied with protein, minerals, and vitamins. About 100 pounds of young leafy grass, when grazed, containing 25 pounds of dry matter, will provide enough carbohydrate to produce about 50 pounds of milk and enough protein to produce about 70 pounds, not including the carbohydrate and protein required for maintenance. Therefore, if young grass is to be supplemented it should be with a feed rich in carbohydrates, such as the grains.

The grass from high-yielding pastures generally contains more water than the grass from low-yielding pastures. The minimum quantity of dry matter contained in pasture grasses is approximately 15 percent and occurs early in the season. Grass from an irrigated pasture clipped four times in the season of 1929 at Huntley, Mont., averaged 23.8 percent of dry matter. The dry-matter content of grass from six pasture plots at Beltsville, Md., clipped 7 or 8 times from the early part of May to the early part of October, varied on an average from 24 percent in May to about 44 percent in August. The variations in the average dry-matter content are shown in table 7, together with the variations in the nutrients in both the green and dry material. Although the samples gathered for analysis during the latter part of the grazing season contained some mature plants, the pastures were so closely grazed that most of the forage was immature and hence the percentages of crude protein and crude fiber were fairly constant.

TABLE 7.—*Average composition, in percentage, of pasture clippings at intervals throughout the growing seasons of 1929, 1931, and 1932 at the United States Dairy Experiment Station, Beltsville, Md.*[1]

GREEN MATERIAL

Approximate date	Dry matter	Ash	Crude protein	Crude fiber	Starch and sugar (Nitrogen-free extract)	Fat (ether extract)	Calcium	Phosphorus
May 6	25.8	1.9	4.8	6.1	11.9	1.1	0.15	0.08
May 19	23.7	1.9	4.0	6.9	10.0	.9	.12	.11
June 2	26.8	2.2	4.8	7.2	11.5	1.1	.13	.11
June 28	28.8	2.6	5.0	7.7	12.2	1.3	.17	.13
July 14	30.5	2.8	5.7	8.1	12.4	1.5	.18	.16
Aug. 13	36.4	3.5	5.7	9.4	15.8	2.0	.25	.18
Aug. 30	43.5	3.5	7.1	11.8	18.7	2.4	.31	.17
Oct. 3	34.0	2.9	6.3	8.1	14.8	1.9	.23	.15
DRY MATERIAL								
May 6		7.4	18.6	23.7	46.3	4.0	0.58	0.33
May 19		7.9	17.0	29.2	42.1	3.8	.43	.39
June 2		8.3	17.9	27.0	42.7	4.1	.50	.40
June 28		9.1	17.2	26.7	42.5	4.5	.58	.44
July 14		9.3	18.6	26.4	40.9	4.8	.61	.52
Aug. 13		9.5	15.8	25.8	43.4	5.5	.69	.50
Aug. 30		8.0	16.4	27.0	43.0	5.6	.71	.39
Oct. 3		8.5	18.6	23.9	43.4	5.6	.67	.45

[1] This table is an average of the grass from 6 plots—1 in 1929, 2 in 1931, and 3 in 1932. The plots were located in good well-established pastures in which the predominating plants were Kentucky bluegrass, orchard grass, and white clover.

PRESERVING IMMATURE PASTURAGE

Since immature pasturage is richer in protein and more digestible than the best mature hay, there has been much interest in developing methods to preserve it for use in winter and other periods of shortage. By an English method, as yet little used in the United States, the grass is dried by artificial heat and either stored as hay or pressed into small cakes which facilitate handling and shipment. In either case, the grass usually maintains its green color and agreeable odor. When used in the rations of cattle and sheep, such dried grass has proved to be a satisfactory substitute for oil-mill byproducts.

Immature pasturage may be preserved also by making it into silage. On account of its low content of readily fermentable carbohydrates, some precaution may be necessary to secure a desirable form of fermentation; otherwise, an ill-smelling silage may result. If the grass has a high content of water, some wilting or partial curing of the green material before it is placed in the silo will prevent leakage of juices and may increase the palatability of the silage. Or instead of wilting, molasses or phosphoric acid may be used to bring about a desirable fermentation. A product of good quality has been made by ensiling whole Italian ryegrass as early as the last of April. At that time even with clear and windy weather it was not possible to cure the grass satisfactorily for hay. A more palatable silage was obtained in this experiment by adding 1 part of molasses diluted in 2 parts of water at the rate of 40 pounds of molasses per ton of green grass.

CHANGES IN FEED VALUE AS PLANTS MATURE

In the spring, when the new grass is beginning to grow, the water content may be as much as 85 percent. Therefore, a 1,000-pound animal would have to eat 100 pounds of such fresh green forage to obtain 15 pounds of dry matter, and of this 15 pounds, 11 pounds

would be required for maintenance, which would leave but little to be applied to the production of meat or milk.

As pasture plants mature the percentages of protein and minerals decrease. Air-dried bromegrass in North Dakota cut on May 10 contained 18.5 percent of crude protein, whereas that cut on July 25 contained only 9.2 percent. Within the same time the ash content decreased from 11.9 to 5.7 percent.

Samples of Nevada bluegrass, violet wheatgrass, and Letterman needlegrass from Utah contained in the dry matter 25 percent of protein on June 24, 11 percent on August 9, 10 percent on August 29, 6 percent on September 18, and 5 percent on October 7. If such forage is cut about the time the seed matures, the plants contain only about 40 percent of water. With so much greater growth and lower moisture content, the grazing animals can readily get not only enough dry matter for maintenance but also plenty for fattening. Forty pounds of such forage would contain 24 pounds of dry matter, which is practically a full feed for a 1,000-pound animal. If the same forage is cut twice during the season, the water content of the fresh forage would be about 54 percent. When cut four times a season the average water content is about 79 percent.

Mature forages lose a considerable part of their nutritive value by exposure to wet weather. As the more soluble and digestible nutrients are leached out by rain, the less valuable part for feeding therefore remains. The greatest loss is the soluble mineral matter or salt. Such losses may exceed 60 percent. Consequently, it is very important that a mineral supplement be supplied to livestock fed chiefly on leached roughage.

The effect of the leaching action of rain, accompanied by the loss of leaves, is illustrated by bur-clover in California. When it is ripe cattle prefer it to the green feed that is available and fatten rapidly. But if much rain falls on the ripe clover it loses its leaves and the feeding value is not even sufficient for maintenance in many cases.

In the arid and semiarid sections of the West, where the pasture and range grasses cure in their natural state with little or no loss of leaves, these grasses have nearly the same feeding value as hay made from the same plants and ordinarily carry cattle, horses, and sheep through the winter in good condition, if a plentiful supply is available.

MINERAL CONTENT OF PASTURAGE

Green, immature grasses are much better sources of minerals than hay or mature plants from the same land. Immature grass is generally about twice as rich in phosphates as mature freshly cured grass, and may be from 4 to 5 times as rich in them as grass that has matured and been exposed to the weather for several months. The dry matter of immature grass contains practically 4 times as much mineral as the average cereal grain, and as much as the average legume hay. Furthermore, pasturage produced on fertile land contains more of the important minerals than that produced on poor soil.

Although pasturage is ordinarily the best source of minerals, there are important instances of mineral deficiencies in the grazing of livestock in the United States. Such mineral deficiencies are responsible for many cases of malnutrition and some cases of actual disease. In cases where there is no disease there may be low fertility, a high death rate in young animals, stunted growth, and meager milk yields.

Pasture grasses, like other crops, are deficient in those elements that are deficient in the soil. Such deficiencies are especially common on

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acid soils resulting from the leaching out of soluble minerals by heavy rainfall. The scant growth on arid land has been found to contain about twice as much soluble calcium and phosphorus as the luxuriant growth of coarse vegetation on well-watered but acid soil. The absence or scarcity of legumes in a pasture which has not been severely overgrazed is an indication of insufficient phosphorus. The content of phosphorus in pasturage is greatest in the spring and decreases as the plants become mature. Phosphorus deficiency is also more severe during droughts than during times of adequate moisture supply, regardless of the stage of maturity of the plants. On the other hand, the lime content of grasses is usually lowest in the spring and increases as the season progresses.

In southern United States, particularly in the Gulf coast region, such so-called diseases as creeps, stiffs, sweeny, and loin disease of cattle are the result of phosphorus deficiency. The first symptoms of a phosphorus deficiency are usually manifested by a perverted or depraved appetite on the part of the animal, as evidenced by the chewing of wood, bones, and dirt. This condition can usually be prevented and, with the exception of advanced stages, may be cured by feeding from 5 to 10 grams of phosphorus per head daily to mature beef cattle grazed on a phosphorus-deficient range. Lactating cows will usually require from 12 to 15 grams of phosphorus per head daily on a similar range. Sterilized bone meal, spent bone black, and dicalcium and disodium phosphates are good sources of phosphorus. The latter two are not palatable and accordingly should be mixed with common salt or some palatable feed. Disodium phosphate is soluble in water and may be supplied through the drinking water. Mature beef cattle will consume from 1 to 3 pounds of salt per head a month, depending somewhat on the locality and type of feeds and vegetation available.

The Florida Agricultural Experiment Station has found that certain soils of Florida are deficient in iron and copper, and that cattle grazing the vegetation on such soils suffer from a nutritional anemia known locally as "salt sick." It was found that this condition could be corrected by allowing the cattle access to a mineral mixture consisting of 100 pounds of common salt, 25 pounds of red oxide of iron, and 1 pound of finely ground copper sulphate, mixed thoroughly to overcome the poisonous effects of the copper sulphate.

Many areas of the upper Mississippi Valley and some sections of the Rocky Mountain region are deficient in iodine, which results in goiter. Extremely small quantities of iodine compounds are given to overcome this condition. A suitable formula for a particular locality may be obtained from the agricultural experiment station of the State in which it is located.

Under natural conditions, where there is a mineral deficiency the animals have become adapted to the condition. They do not reproduce until they are mature and have stored enough minerals to withstand the drain of rearing young. Then 2 or 3 years may pass before the female is ready for producing young again. When animals of improved breeds, developed on fertile soils, are moved to poor soils and bred to reproduce before maturity and regularly each year thereafter, various physiological disturbances are likely to result.

Both lime and phosphorus can be supplied to the animals, either by applying lime and some phosphate fertilizer to the pasture soil or by giving the animals a mineral supplement such as bone meal. Bone meal is commonly mixed with salt, equal parts by weight. Other

combinations are: 2 parts bone meal and 1 part salt; and 1 part each of bone meal, finely ground limestone, and salt.

PROTEINS AND OTHER NUTRIENTS

Samples of bluegrass, gathered at intervals of from 2 to 6 weeks from May to September at Beltsville, Md., had a crude-protein content of 17.5 percent on a dry matter basis. This is about double that of ear corn and slightly higher than that of wheat bran or middlings (table 8). The protein of pasturage is also high in quality as well as in quantity. This applies particularly to the protein in the leaves, which are valuable for supplementing the protein deficiencies of the cereal grains. Typical analyses of immature grass and some common feeds are given in table 8.

TABLE 8.—*Analyses of typical immature grass (percentage), calculated at a 10-percent water content, and of some common dry feeds*

Feed	Water	Ash	Crude protein (Nx6.25)	Crude fiber	Starch and sugar (nitrogen-free extract)	Fat (ether extract)
Pasturage:						
Bluegrass	10.0	8.0	15.9	23.1	39.1	3.9
Pasture mixture	10.0	10.2	16.1	16.9	44.0	2.8
Sudan grass	10.0	12.1	12.1	23.4	40.4	1.9
Sweet vernal	10.0	5.5	9.7	28.1	44.5	2.2
White clover	10.0	12.2	23.4	13.3	38.1	3.0
Cereals and cereal products:						
Corn (shelled)	12.9	1.3	9.3	1.9	70.2	4.3
Corn (corn-and-cob meal)	15.6	1.5	8.3	6.8	64.4	3.4
Oats	7.7	3.5	12.5	11.2	60.7	4.4
Wheat bran	9.6	5.9	16.2	8.5	55.6	4.2
Wheat middlings or shorts	10.1	3.5	16.3	4.3	61.6	4.2
Grass hays:						
Johnson grass	9.0	7.0	8.2	29.7	43.4	2.7
Sudan grass	5.3	8.1	9.7	27.9	47.3	1.7
Timothy	12.5	5.4	6.8	28.3	44.3	2.7
Legume hays:						
Alfalfa	8.3	8.9	16.0	27.1	37.1	2.6
Lespedeza	7.9	6.2	11.9	28.5	42.7	2.8
Red clover	12.9	6.9	13.6	24.1	39.1	3.4
Oil-mill products:						
Cottonseed meal (choice)	7.1	5.7	41.7	10.0	28.4	7.1
Linseed meal (old process)	8.9	5.4	34.5	7.7	36.7	6.8
Stover and straws:						
Corn stover	10.7	6.1	5.7	30.3	45.7	1.5
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3

The crude-fiber content, on the basis of the dry matter, is higher in immature grass than in most concentrates, but digestion experiments have shown that the fiber of immature grass is as digestible as its other nutrients and those of concentrates in general. It is only after the toughening of grass begins, which happens at about the flowering stage, that the crude fiber of pasturage becomes difficult to digest and hinders the digestion of its other nutrients. The average digestibility of the dry matter of immature grass is approximately 71 percent, whereas that of hay from similar plants at a more mature stage is about 59 percent.

VITAMIN CONTENT OF PASTURAGE

An adequate supply of vitamins is necessary for proper growth and reproduction in livestock and to keep them thrifty and resistant to diseases. When animals are grazing on green, immature pasturage they are better supplied with vitamins than is practical by any other

method. Such feed is especially rich in carotene from which vitamin A is made in the animal body. Vitamin A promotes growth and increases resistance to disease. Good pasture produces milk with a high content of vitamin A. Ripe pasturage bleached by exposure or hay bleached in curing contains little or no carotene.

Pasturage, like most natural feeds of farm animals, is also well supplied with vitamins B, E, and G. Although pasture plants are usually well supplied with vitamin C, it is not known to be needed in the nutrition of farm animals.

Green vegetation contains little or no vitamin D, which gives protection against rickets, but being in the direct sunlight enables animals to get along without this vitamin in their feed. Cutting the pasturage and curing it in the sunlight build up a supply of this vitamin. Although green vegetation is deficient in vitamin D, it does contain some substance or property which promotes the assimilation of calcium by dairy cattle.

In general, approved feeding methods, such as providing good green pasturage throughout the growing season, plenty of sunlight, and liberal feeding of well-cured leafy hay and yellow corn during the winter will take care of all the vitamin requirements of farm animals. Some of the benefits of pasture feeding are carried into the winter months. Hence, for well-fed and well-cared-for animals there is little need of purchasing commercial sources of vitamins. For poultry kept largely indoors and as an emergency measure for unthrifty animals, cod-liver oil or some similar oil may be given to supply both vitamins A and D.

PALATABILITY A FACTOR IN PASTURE MANAGEMENT

The palatability of pasturage depends on the kind of plants, their tenderness, stage of maturity, density of the plants, and climatic and soil conditions. Different kinds of livestock also vary in their likes and dislikes. In addition, livestock are able to select plants which contain relatively high percentages of minerals in preference to those having a low percentage of the same minerals.

In general, animals prefer legumes to grasses though there are some exceptions to this preference. At the Massachusetts Agricultural Experiment Station, on a series of plots containing various grasses and forage crops, the cows preferred seedings with a high proportion of timothy. Bromegrass ranks high in palatability, heading the list of grasses at the United States Animal Husbandry Experiment Station, Beltsville, Md. At the same station Italian and perennial ryegrass, meadow fescue, and a pasture mixture of grasses and clovers ranked next in the order stated. The palatability of Kentucky bluegrass and orchard grass was greatly reduced by seed-head formation. Hence, mowing or close grazing at heading time is important for keeping the forage palatable.

When one kind of livestock is given a pasture much larger than the animals graze down, they may eat only the most palatable plants, leaving the less palatable ones to mature and become still less palatable. Under such conditions animals also avoid the vegetation near their droppings. Rather than eat the less palatable forage, the stock may keep on eating the more palatable plants down to the very roots. Consequently, it is generally best to turn several kinds of livestock on a pasture and to give them only as large an area as they

need. When they have too large an area they not only waste feed but travel too far in getting what they eat.

GRAZING PRACTICES

A common farm practice is to use whatever pasture is available or can be most readily supplied for the kind of livestock to be kept. Usually the pasture supplements other feed. But in cases where grazing is the chief source of feed for livestock, as in the South or on the western ranges, or wherever the bulk of the farm or ranch area is in pasture, the problem of major importance is to choose the kind or kinds of livestock best suited to the pasture. In most cases, greatest returns will be obtained from the forage available and the pasture will be kept most productive if two or more kinds of livestock are grazed, either at the same time or at different times during the season (fig. 12). Where large areas of several kinds of pasturage are available, such as are common in the West and in the South and East on cut-over land, or where so few animals are kept that it does not pay to provide separate pasture, all kinds may be turned on the same area.

FIGURE 12.—Good grazing on a rocky hillside. This pasture is so steep that the animals have formed parallel ledges by tramping from side to side year after year. Cattle and sheep together make better use of such land than either alone.

On farms where considerable numbers of several kinds of livestock are kept and the pastures require intensive grazing, it is much better to have several pastures and separate the various kinds of livestock and oftentimes the various ages of livestock. Young horses and mules are most likely to disturb and injure other livestock. Then moving the different kinds from one pasture to another several times a year may reduce the danger from certain parasites and make possible a more complete utilization of the feed available.

More uniform grazing is obtained if the droppings are scattered several times during the season. This practice is most important on pastures of high carrying capacity, such as those supporting one head of cattle to an acre. A chain-type harrow is a good implement for the

purpose. It is desirable usually to have hogs running with cattle that are fed whole grain, as they pick out the grain in the droppings and also scatter them.

Certain peculiar soil conditions, such as in the bluegrass region of Kentucky and the Genesee Valley of New York, are especially well adapted to the production of race horses. The conditions include limestone soils rich in available calcium and phosphorus, and the vegetation growing there contains these and other minerals in the proper proportion and adequate quantities.

Some localities are particularly well adapted for fattening cattle, such as parts of southwestern Wisconsin, east-central Kansas, central Kentucky, West Virginia, and southwestern Virginia. There appear to be marked differences in the fat-producing qualities of

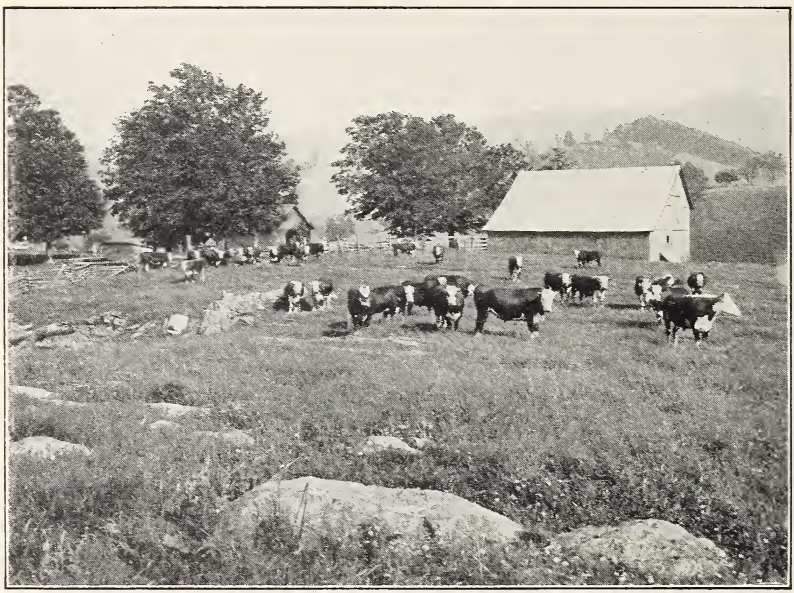

FIGURE 13.—A rich limestone pasture of southwestern Virginia. Mature steers fatten here on grass alone, producing Good to Choice beef.

grass, depending apparently on the character of the soil on which it is grown. Practically all the grass-fattened cattle are produced on fertile limestone soils (fig. 13). Other kinds of soil may produce luxuriant grass, but the cattle fail to finish properly.

In some cases, the kind of forage and the soil determine not only the kind of livestock but also the breed which is favored in a certain locality. For instance, in southern Ohio the fine-wool breeds, such as the Delaine Merinos, have persisted because they graze the unusually steep hillsides better than other breeds.

SHADE, SHELTER, AND WATER

As farm animals may suffer from the heat of summer days, some sort of shade should be provided (fig. 14). If there are not sufficient trees or brush, sheds or other shelters should be built. If they are for summer use only, all sides should be left open. Poles, brush, and

straw may be used to make the roof. About 15 square feet of roof surface will be required per head of mature cattle. For protection against cold, rains, and sleet livestock should have more shelter, such as sheds open only on the south. Where there is little rainfall but much cold wind a windbreak such as a tight fence, rows of trees, or bluffs are needed.

As streams may be polluted or have banks which are dangerously steep, wells and springs are usually the safest source of water. Moreover, water from underground sources is more likely to be adequately supplied with minerals than surface water, especially in areas of heavy rainfall where the soluble material of the surface soil is quite thoroughly leached out. If dependence must be placed on ponds, it is important to keep the area draining into the pond as clean as possible (fig. 15). Carcasses and droppings may cause the water to be a source of disease. Such water may cause poisoning, on account of having passed through moldy or decayed vegetation.

ROTATION GRAZING

The practice of rotation grazing consists in grazing two or more pastures in regular order with definite rest periods for the pastures. When only two pastures are involved this type of grazing is sometimes known as alternate grazing. Results from several experiments conducted in Maryland, Missouri, Virginia, and Washington on typical pastures of the better type, and in South Dakota on native range, were inconclusive in some cases, but in others the rotation plan increased the carrying capacity from 8 to 12 percent. They indicate that there is not usually justification in going to much expense to divide pastures that are already established especially when it is also necessary to provide shade and water in each division.

Another form of rotation is that of using several different kinds of pasture. This requires careful planning in order to have the animals on each pasture when they can get the most from it without reducing its productive capacity later on. An example is the use of rye in April, bluegrass in May and June, Sudan grass in July and August, lespedeza in September, and bluegrass in October and November. The choice of pasture crops will vary with different regions. On the western range, the rotation is important chiefly in connection with deferment of grazing on certain areas every 2 or 3 years in order that the desirable grasses may reseed and strengthen their root systems.

HOHENHEIM SYSTEM OF PASTURE MANAGEMENT

The Hohenheim system of grassland management was developed at Hohenheim, near Stuttgart, Germany, in 1916. It was the result of an effort to produce milk without the feeding of concentrates, which were difficult to obtain in Germany during the latter part of the World War period. The system is designed to supply a luxuriant growth of grass rich in protein, thereby making it possible for the animals, at least during the summer months, to obtain from pasture all the feed necessary.

The Hohenheim system is best adapted to dairy cattle and is distinguished from the usual methods of grazing by the following features: (1) Division of the pasture into from 4 to 8 paddocks, about

FIGURE 14.—Plenty of shade well located on pasture. Such conditions cause the fertilizing elements in manure to be returned directly to the pastures thereby conserving fertility. When shade for livestock is along streams and lanes, pasture fertility tends to decrease.

FIGURE 15.—Ponds and reservoirs should be fenced to avoid pollution of the water. Usually it is possible to pipe the water to a trough equipped with a float valve. If the land is too level for that, a windmill may be used.

equal in size; (2) heavy applications of fertilizers, especially nitrogen; (3) separation of the herd into 2 groups—producers and nonproducers, or into 3 groups—high, low, and nonproducers; and (4) rotation grazing with the groups following each other in the order named so that the most productive animals get the "cream" of the grazing.

In this system of pasture management the herbage is to be grazed when it is young and tender and has a high protein content. If the animals available for grazing are not sufficient to keep the grasses and legumes short during the flush growth of early summer, then 1 or 2 paddocks are mowed for hay.

The number of days that each group remains on a pasture depends on the growth of the grass and may vary from 2 to 4 days, sometimes more. The faster the growth the fewer the days that each group remains on a pasture. After the last group has been moved from the pasture it is a good practice to scatter the droppings.

The original Hohenheim plan called for four applications of nitrogen during the year; one half to go on in February and the remainder in May, June, and July. Ammonium sulphate or nitrate of soda was used for the February application but urea, a concentrated nitrogenous fertilizer, appeared to be more effective during the summer months. In addition to the nitrogen, phosphate and potash were applied late in the fall and lime was added once in 6 years. The total annual application of fertilizer at the beginning was equivalent to 500 pounds of sulphate of ammonia, 260 pounds of superphosphate, and 200 pounds of 40-percent potash salts. Later the phosphate and potash applications were reduced but the nitrogen remained the same.

It is obvious that an intensive system of pasture management like the Hohenheim is better adapted to European countries where the rainfall is well distributed and the summers are cool; both of these factors contribute to a uniform level of production during the grazing season. Applications of nitrogen are not utilized effectively except in the presence of soil moisture.

The Hohenheim system was under investigation from 1928 to 1935 at the Beltsville Research Center, Beltsville, Md.

This work showed an increase of 10.4 percent in feed production due to rotation grazing and a further increase of 16.4 percent in production due to the fertilizers applied. The claim that rotation grazing in itself results in more uniform grazing of the herbage was not supported. It was concluded that fencing and other costs incident to the division of the pasture into six separate fields must be kept very low in order to make rotation grazing by dairy cattle a profitable practice. The cost of heavy application of fertilizer in this investigation exceeded the value of the additional pasturage due to fertilization. One reason for this result was that common lespedeza came into the unfertilized pasture and increased the yields, while in the fertilized pastures the growth of legumes was suppressed. Midsummer applications of nitrogen were poorly utilized. It is evident that much good judgment must be exercised in the fertilization of pastures as to the kinds and quantities to apply and the methods and times of application. Since the proper practices vary with the soil and climate and perhaps other factors, it is suggested that the advice of the State agricultural college be obtained before applying fertilizers to pastures.

Certain features of the Hohenheim system may be adopted in this country, especially where land values are high and the summers favorable for the growth of grass.

USE OF PERMANENT PASTURES IN WINTER

Winter pastures have an important place in getting stock through the winter cheaply and in thrifty condition. In view of the economy of pasturage, compared with most other feeds, considerable effort is justified in making winter pasturage available. Usually it is better that pasture intended for winter use be ungrazed during the previous summer. This insures a thick mat of grass which will protect the soil from early freezing and prolong the growth of the grass in the fall. Then when the soil is finally frozen, it will not thaw so readily nor be damaged by trampling every time it thaws a little during the winter. The summer growth of grass is more satisfactory for winter use than the lush growth of September and October, which is severely damaged by freezing.

Such grazing furnishes the winter maintenance ration. Hay, straw, or stover should be fed on the more closely grazed spots in the pasture when snow covers the grass. However, if the snow is not too deep or crusted and there is plenty of grass, horses and sheep will paw through the snow and get ample feed for maintenance. This practice has given particularly good results in the southern Appalachian region where snow cover interferes with grazing on the average for only 2 or 3 weeks.

It is not advisable, however, to leave a pasture more than 2 years at a time for winter use, because freedom from grazing in the summer reduces the thickness of the sod and favors the growth of certain weeds and brush.

When cattle are fattened on grass, it is necessary to have an abundance of grass throughout the season. Consequently, a considerable quantity of grass usually is left when the cattle are sold. This may be utilized by the newly purchased stockers. The consensus of opinion is that this winter grazing does no harm although many prefer to keep the stock off the pastures for a few weeks when the grass is beginning to grow in the spring. Feeding hay or corn fodder on the poorest spots of a pasture is a very effective means of improving the stand of grass.

Winter grazing is much more important in the dry and windy western country than in the East, because the vegetation in the former region is more sparse, making hay relatively more expensive. In a dry climate the lighter rainfall does not leach so much of the nutrients from forage left standing. Also the snowfall is lighter and less likely to be left on the level on account of the openness of the country and the greater wind velocity and dryness of the snow. In some regions, such as in Colorado, it has been found economical to combine grazing and hay feeding by cutting the grass and bunching it with a rake. Cattle will clean up such bunches or cocks of hay containing 75 to 100 pounds with very little waste. This method is especially well adapted to handling the last cutting on meadows that produce two or more cuttings.

PRECAUTIONS AGAINST DISEASES AND PARASITES

Although, as previously stated, pastures are conducive to the general health and vigor of livestock, there is need for taking precautions against certain diseases and parasites. Tuberculosis, for instance, though much less common among cattle on ranges than in those confined much of the time in stables, may be spread by such means as infected watering holes and ponds. It is apparent that the droppings of tuberculous animals in the water supply may pollute it sufficiently to infect other cattle that drink the water.

Anthrax, another serious germ disease, is caused by bacilli that thrive best under certain conditions of the soil, especially in regions subject to floods and inundations. Fields containing stagnant pools may be a source of infection. Various parasitic diseases, such as tick fever of cattle and infestation of sheep and other animals with various internal parasites, are associated with the spread of parasites directly or indirectly in connection with grazing. When it is possible, young animals should be given fresh pasture land. Rotating hogs and horses with cattle and sheep in alternate years should lessen materially hazards from parasites.

Certain ailments result from animals' gorging themselves on succulent pasture or from grazing on poisonous plants. Methods of preventing loss from such causes are discussed more fully in the specific recommendations for pasture management. As a general precautionary measure it is advisable to burn to ashes or bury deeply, animals that die of infectious diseases, never leaving them on pasture where the infection may be spread by other animals or birds. Helpful information may be obtained, also, from Department publications, relating to the control and eradication of animal diseases and parasites, which will be furnished on request.

STOCK-POISONING PLANTS [4]

Poisoning of animals from eating certain plants usually occurs when the more nutritious and palatable plants or other feeds are not available in sufficient quantities or in great enough variety to satisfy the animals' appetites or requirements. Most poisonous plants are unpalatable; therefore as a general rule, animals do not readily eat them in sufficient quantities to be seriously injured.

Poisonous plants vary greatly in the following respects: (1) The condition under which animals are poisoned by them, (2) the portion of the plant that is most poisonous, (3) changes in the toxicity of the parts of the plants during growth and in drying, (4) the susceptibility of different species of animals to being poisoned by them, and (5) the effects on the poisoned animals. To diagnose cases of plant poisoning correctly, one must have considerable information about the different plants and their effect on animals. Diagnosis is simplified by a knowledge of the principal poisonous species in the area in which the pasture is located. Essential facts regarding the principal poisonous plants in the United States are given in table 9.

[4] This discussion was prepared by A. B. Clawson, associate physiologist, Pathological Division, Bureau of Animal Industry.

TABLE 9.—*Essential facts regarding principal poisonous plants*

Plant	Location	Parts of plant that usually cause poisoning	Animals most commonly poisoned	Conditions under which poisoning usually occurs and minimum quantity required	Characteristic effects
Arrowgrass (*Triglochin maritima*).	Salt or alkaline marshes and wet places throughout the United States.	Leaves and stems	Cattle and sheep	Eating about 1 percent of animal's weight of green plant in a few minutes.	Difficult breathing, spasms, coma, illness of short duration.
Baccharis (*B. ramulósus*)	Hillsides of western Texas and southern New Mexico and Arizona.	Leaves	Cattle	Scarcity of feed in fall and early winter.	Extreme prostration, severe inflammation of stomach.
Beach laurel (*Leucothoe davisiae*).	Springy ground in Sierra Nevada Mountains of California.	do	Sheep	Eating 0.2 pound in a day's feeding.	Salivation, vomiting, weakness.
Bitter rubberweed, bitterweed (*Actinea odorata*).	Western Texas to southeastern California.	Leaves, stems, and flowers.	do	Eating small quantities daily for several days.	Vomiting, weakness.
Black nightshade (*Solanum nigrum*).	Waste ground from Maine to California.	Green fruit and leaves	Cattle, sheep, goats, chickens, ducks, and geese.	Feeding on green plant	Thirst, diarrhea, loss of appetite, weakness, lack of coordination.
Brake, bracken fern (species of *Pteridium*).	Thickets, hills, and rich woods throughout United States.	Fronds	Horses and cattle	Eating 5 pounds daily for about a month.	Horses: lack of control of legs, weakness. Cattle: hemorrhages in various parts of body.
Cherry (wild) (species of *Prunus*).	Hillsides, along streams, in woods throughout United States.	Leaves	Sheep and cattle	Eating 1 percent of animal's weight of green plant in a few minutes.	Difficult breathing, spasms, coma, illness of short duration.
Cocklebur (species of *Xanthium*).	In fields and waste land of the eastern half and low wet places of the western half of the United States.	First or primary leaves of seedlings.	Pigs and cattle	Eating 0.75 percent of animal's weight of green plant in a few minutes.	Prostration, inflamed stomach.
Death camas (species of *Zygadenus*).	Gravelly hills, depressions, and meadows in western half of United States.	Leaves and stems	Sheep and cattle	Eating 0.5 percent of animal's weight of green plant in a day.	Vomiting, frothing, and weakness.
Drymaria (*D. pachyphylla*)	Denuded areas in western Texas and southern New Mexico.	do	Cattle	do	Depression, weakness, inflamed stomach and intestines.
Dutchman's breeches (*Bekukulla cucullaria*).	In woods, eastern half of United States north of Georgia.	do	do	Feeding on plant, particularly in spring and early summer.	
Greasewood (*Sarcobatus vermiculatus*).	Somewhat alkaline fields in western part of United States.	Leaves	Sheep	Eating 1.5 pounds in a few minutes.	Depression, kidney lesions.
Horsetail, marestail (species of *Equisetum*).	Wet meadows throughout United States.	Tops	Horses	Eating the plant in hay	Weakness, craving for horsetail, diarrhea, loss of flesh, lack of control of legs.

Larkspur (species of *Delphinium*).	Mountains and plains throughout United States.	Leaves of young plants	Cattle	Eating 0.5 percent of animal's weight, especially of young plants, within a few minutes.	Weakness, trembling, constipation.
Loco (species of *Oxytropis* and *Astragalus*).	Plains and some mountain valleys, western half of United States.	Leaves and stems	Cattle, horses, sheep, and goats.	Feeding for several days or weeks on any of the locos.[1]	Constipation, craving for loco, rough coat, incoordination, and peculiar actions.
Lupine (species of *Lupinus*)	Throughout United States	Leaves of young plant and fruit.	Sheep and cattle	Eating 0.5 percent of animal's weight of green plant or fruit in a day.	Sheep: Nervousness with some species of lupine; depression with others. Cattle: Weakness and trembling.
Milkweed (broadleaf) (*Asclepias eriocarpa* and *A. latifolius*).	*A. eriocarpa:* dry valleys in southern half of California.	Leaves	Sheep	Eating 0.1 percent of animal's weight of green plant in a day.	Depression, weakness, inflamed stomach and intestines.
Milkweed (whorled or narrowleaf) (*Asclepias galioides* and *A. mexicana*).	*A. latifolius:* dry plains of Southwest; along ditches, in abandoned fields and dry places, Colorado to Mexico and California.	Leaves and stems	Cattle and sheep	Eating 0.2 percent of animal's weight of green plant in a day.	Incoordination followed by severe spasms.
Mountain-laurel (*Kalmia latifolia*).	Woods and hillsides	Leaves	Cattle, sheep, and goats.	Eating 0.4 percent of animal's weight of green plant in a day.	Salivation, vomiting, and weakness.
Oak (shin oak and Gambel oak) (species of *Quercus*).	Sand hills and lower mountains of Colorado, Utah, and Southwest.	Leaves and leaf buds	Cattle	Feeding largely on oak for 2 weeks or more, especially in the spring.	Emaciation, scabby nose, constipation, followed by diarrhea and weakness.
Oleander (common) (*Nerium oleander*).	Fields, roadsides, edge of woods in southern part of United States.	Leaves	All animals	Eating small quantities	Stupor, trembling, convulsions, paralysis, vomiting, and diarrhea.
Parry aster or woody aster (*Aster parryi*).	Dry flats of Wyoming	Leaves and stems	Sheep	Eating 1.25 pounds of green plant in a day when animals are hungry.	Weakness, prostration, rapid, weak pulse, increased urination, and cyanosis.
Poisonbean (*Daubentonia longifolia*).	Coastal plains of Florida and Texas.	Seeds	Cattle, sheep, and goats.	Eating small quantities of seeds.	Depression, diarrhea, and rapid pulse.
Poisonvetch (some species of *Astragalus*).	Mountains, foothills, and valleys of Intermountain States.	Leaves and stems	Cattle and sheep	Eating considerable quantities during a day's feeding.	Difficult breathing, nausea, and weakness.
Ragwort or groundsel (species of *Senecio*).	Throughout United States	do	Cattle and horses	Feeding for several days on one of the poisonous species.	Jaundice, scabby nose, discomfort, loss of appetite, uneasiness, and loss of flesh.
Rayless goldenrod (*Aplopappus heterophyllus*).	Fields along ditches in western Texas, New Mexico, and Arizona.	do	Cattle, sheep, and horses.	Feeding on the plant frequently for several days.	Marked weakness, trembling, especially after exercise.
Rubberweed (*Actinea richardsoni*).	Gravelly hills and flats in mountains of Colorado, New Mexico, Utah, and Arizona.	do	Sheep	Eating small quantities daily for several days.	Vomiting and weakness.
St. Johnswort (*Hypericum perforatum*).	Fields, waste places, and hills across northern half of United States.	Leaves	Animals with white areas.	Feeding on the plant and being in bright sunlight.	Sore, scabby areas on white skin areas, itching, rapid respiration.

[1] Some poisonous species of *Astragalus* are not locoes.

TABLE 9.—*Essential facts regarding principal poisonous plants*—Continued

Plant	Location	Parts of plant that usually cause poisoning	Animals most commonly poisoned	Conditions under which poisoning usually occurs and minimum quantity required	Characteristic effects
Sheep laurel (*Kalmia angustifolia*).	Moist soil, hillsides, and swamps in Maine and New York to Georgia.	Leaves	Cattle, sheep, and goats.	Eating 0.2 percent of animal's weight of green plant in a day.	Salivation, vomiting, and weakness.
Sneezeweed (*Helenium hoopesii*)	Mountains, meadows, and valleys from Montana to Arizona.	do	Sheep and cattle	Feeding on the plant for 2 weeks or more.	Profuse vomiting and weakness.
Water hemlock (species of *Cicuta*).	Wet places throughout United States.	Roots and rootstocks	do	Eating very small quantities	Violent spasms.
Western azalea (*Azalea occidentalis*).	Moist places in Coast Range and Sierra Nevada Mountains of California.	Leaves	Sheep	Eating a few ounces of leaves	Salivation, vomiting, and weakness.
White snakeroot (*Eupatorium urticaefolium*).	Rich woods and ravines in eastern half of United States.	Leaves and stems	Cattle and sheep	Feeding on the plant for several days.	Marked trembling and weakness, especially after exercise.

In many instances poisoning occurs when some weed has become unusually plentiful in a pasture or when the animals have been feeding largely on a particular plant. In such cases, it is best to remove the animals from the pasture or affected part of the range.

If the cause of the trouble is not fully understood, as complete a description as possible of the cases, and samples of the suspected plant or plants, should be forwarded at once to the State agricultural experiment station or to the United States Department of Agriculture with a request for information bearing on the condition.

In any case of poisoning, treatment is best given or prescribed by a qualified veterinarian. Many poisoned animals that would have recovered had they been left undisturbed have been killed by attempts made by untrained persons to administer remedies. Bleeding, a method in too common practice among stockmen, is very rarely of benefit to the poisoned animal. In attempts to drench sick animals, the medicine being used often gets into the trachea, or windpipe, and results in pneumonia and death. In general it is a good practice to protect the poisoned animals from excessive heat and cold and disturb them as little as possible until veterinary aid can be obtained.

Some suggestions for preventing animals from being poisoned are as follows: Avoid overgrazing of pastures as the animals may be forced to eat poisonous plants, since the most palatable and nutritious plants may be killed out and the less palatable ones are given a chance to grow. See that animals are not forced, for prolonged periods, to eat a limited variety of feeds. When animals are hungry or have been on one type of feed, such as dry hay, for some time, do not turn them into a pasture where there are poisonous plants, especially when these plants are green.

PLANTS SOMETIMES INJURIOUS

A few plants or parts of plants when fed under certain conditions occasionally are injurious to animals. The most important of these plants with the essential facts regarding them are given in table 10.

TABLE 10.—*Essential facts regarding injurious effects produced by some plants or parts of plants*

Plant	Location	Parts of plant that usually cause trouble	Animals most commonly affected	Conditions under which injury usually occurs	Characteristic effects
Alfalfa (*Medicago sativa*)	Throughout United States	Leaves and stems	Cattle and sheep	Feeding on green or wet plants, especially when animals are very hungry or unused to green feed.	Bloat.
Clover, alsike (*Trifolium hybridum*).	Great Plains to Atlantic, and Tennessee to Canada.	do	Cattle, hogs, horses, sheep, with white skin.	Feeding for some time on plant and being in bright sunlight.	Swellings and sores on white areas; jaundice and liver injury in horses.
Clover (species of *Trifolium*)	Throughout United States	do	Cattle and sheep	Feeding on green or wet plants, especially when animals are very hungry or unused to green feed.	Bloat.
Corn	Middle Western States	Stalks left standing in field	Cattle and horses	Grazing in some cornfields in late fall and winter.	Hemorrhagic septicemia, impaction, and acute poisoning.
Dallis grass (*Paspalum dilatatum*).	Southern States	Seed heads when infected with ergotlike fungus.	do	Grazing on plant infected with ergotlike fungus *Claviceps paspali*.	Trembling and nervous paroxysms during which animal may fall.
Johnson grass (*Sorghum halepensis*).	Widely distributed in United States.	Leaves and stems of growing plants.	do	Grazing in fields of young growth stunted by drought.	Difficult breathing, spasms, coma, death in a few minutes.
Potato (*Solanum tuberosum*)	Throughout United States	Green tops and young, green, or sprouting potatoes.	Cattle, horses, and pigs.	Eating green tops or green or sprouting potatoes in considerable quantities.	Diarrhea, loss of appetite, lack of coordination, trembling, thirst.
Sorghum (*Sorghum sorghum*)	Widely distributed in United States.	Leaves and stems of growing plants.	Cattle	Grazing in fields of young growth stunted by drought.	Difficult breathing, spasms, coma, death in a few minutes.
Sudan grass (*Sorghum vulgare* var. *sudanense*).	do	do	do	do	Do.

PREVENTION AND TREATMENT OF BLOATING

Bloating, also known as hoven or tympanites, is a form of indigestion in which the rumen or paunch is distended by gases of fermentation. It occurs chiefly in cattle, though sheep and goats also may be similarly affected. It may be caused by hurried eating, gorging on a new kind of feed, or some undesirable quality in the feed. Legumes such as alfalfa and clover are much more likely to cause bloating than grasses. Therefore, stock should be well filled with dry feed such as good hay or some grass pasturage which is not likely to cause bloating, before being turned on such legume pasture. Pasture which is wet with dew or rain is particularly dangerous. Once cattle are put on a legume pasture it is best to keep them there and give them free access to some good dry roughage in a stack or hay rack. If they must be taken off the pasture long enough to be hungry before they go back, it is important that they be given a good feed before going back, especially if the pasturage is wet.

Remedies for mild cases consist in exercising the animal, throwing cold water on its sides, and putting in its mouth a bit coated with some disagreeable substance such as tar or grease. This stimulates the secretion of saliva and induces swallowing and the stretching of the esophagus, which allows the gas to escape. In severe cases when there is danger of death by suffocation, a trocar should be used to puncture the paunch. The insertion should be in the center of the triangular space below the loin between the last rib and the hip bone, on the left side, the trocar being directed downward, inward, and slightly forward. The canula, or sheath of the trocar, may be tied in place by a string around the body while the gas is escaping. Since puncturing the paunch with this instrument is attended by danger to the animal, if not properly done, the operation should preferably be performed by a qualified veterinarian, who also should prescribe treatment to stop the fermentation.

PASTURES FOR BEEF AND DUAL-PURPOSE CATTLE

The grazing of cattle for strictly beef purposes is one of the most economical methods of marketing an agricultural crop. Cattle require very little attention when handled on pasture or range. If there is adequate feed in the form of grass the labor required to manage the herd properly will consist primarily in distributing salt, keeping water available, and "working" the cattle during certain seasons, which includes such operations as branding, dehorning, castrating, and vaccinating.

On most farms the principal grazing problem in handling beef or dual-purpose cattle is that of extending the grazing season to reduce the quantity of harvested feed required. In general, the costs of winter feed for from 4 to 6 months are from 2 to 4 times as great as the cost of grazing for a period of from 6 to 8 months. To extend the grazing season most effectively, one must have more than one pasture in order to save ungrazed forage for grazing in midsummer, late fall, winter, or early spring. Temporary annual pastures, such as Sudan grass, sweetclover, lespedeza, and winter wheat, barley, or rye, may be used to supplement permanent pastures. With such crops it is possible to begin grazing from 2 to 4 weeks earlier in the spring, to have an abundance of feed during July and August when bluegrass

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and other pasture grasses are dormant, and to extend the period of good grazing from 4 to 8 weeks in the fall and early winter.

The acreage of such temporary pastures as Sudan grass and sweetclover should be only one fourth to one third of the area of good permanent pasture on account of the greater carrying capacity of the temporary pasture for short periods. The acreage of cereal crops will depend on whether they are for grazing alone or for grazing and grain production.

Other important considerations in the grazing of cattle on farms are water supply, salt, other minerals, and shade. Additional supplementary feed will be required for fattening steers and cows being milked.

In determining the kind and quantity of feeds to use as a supplement to grass, one should use supplements adapted to the purpose for which the cattle are kept, and govern the quantity by the quality and quantity of grass available and the time of marketing if the cattle are being fattened. At the beginning of the grazing season the forage contains a higher percentage of protein than it does later on, and accordingly the supplementary feed for the first part of the grazing period for fattening cattle could consist of grain exclusively. For cows producing more than 25 pounds of milk daily a grain mixture richer in protein is required.

As the grass becomes mature and the protein content of its dry matter approaches that of grain, the supplement should include some feed rich in protein, such as oil-mill byproducts. The purpose is to maintain the proper ratio between the proteins and carbohydrates in the ration. For milk production and growing animals, proportionately more protein and also more mineral in the ration are necessary than for fattening cattle. Also the protein requirements of young fattening cattle are greater than those of older cattle. The proportion of the quantity of digestible crude protein to the combined digestible carbohydrates and fat is known as the nutritive ratio. According to a recognized feeding standard (Morrison), fattening rations for calves should have a nutritive ratio of approximately 1:6, for yearlings 1:7, 2-year-olds 1:8, and mature steers 1:10 or more. According to the same standard, a cow giving milk requires 0.7 pound of digestible protein and 8 pounds of total digestible nutrients for maintenance. In addition, for each pound of 3.5-percent milk she requires about 0.05 to 0.06 pound of digestible protein and 0.3 pound of total digestible nutrients. The nutritive ratio for a cow giving 30 pounds of 3.5-percent milk should be 1:6.7.

At the beginning of the growing period the moisture content of young grass is high. The dry-matter content is about 20 percent and consists of a relatively high percentage of protein and ash and a low percentage of crude fiber. It is often advisable to give cattle and sheep some supplementary feed at this period of the grazing season to counteract, to some extent, the laxative effect of the lush grass. In such cases the best supplement is some nonlaxative roughage, such as timothy hay or straw, which gives to the ration bulk that is effective in slowing up the passage of the contents through the digestive system and thereby allows time for the absorption of nutrients. In turning cattle on such feed the transition should be gradual, beginning with an hour or two of pasture each day, depending largely upon supplementary feeds.

During periods of drought when the grass is brown and dry, or in the fall or winter when the forage is mature and leached out, it is desirable to feed some laxative supplement such as linseed or soybean meal or green leafy alfalfa hay. The laxative feed is needed since the forage in the condition mentioned is largely crude fiber with relatively little protein and ash.

Owing to the smaller quantity of manure it receives, a pasture on which cattle are kept only during the time they are grazing is depleted of fertility faster than a pasture having the cattle on it the full 24 hours of each day. On many farms where the rougher or wetter land that is being pastured is situated some distance from the farmstead, and where most of the cattle are kept for milk, such pastures have reached a very low state of fertility. This is due in large part to the custom of turning the cows to pasture after the morning milking, taking them off pasture for the evening milking, keeping them at or near the farmstead during the night, and applying the manure thus saved to other parts of the farm rather than to the pasture.

BREEDING CATTLE ON PASTURE

The common practice in breeding beef cattle is to turn the bull or bulls out with the cows, allowing 1 bull for from 20 to 40 cows, depending on the size and kind of pasture and the age and activity of the bull. When the bull is kept separate from the cows, about twice as many can be bred per bull. This practice is especially desirable when the calves are kept separate from the cows and the cows are brought up twice a day for the calves to nurse. The shy breeders can be weeded out about 6 months sooner by keeping the bull in a pen, marking the cows, and keeping a record of breeding dates or by separating the bred cows from those not bred.

With a large herd of several hundred cows, much may be saved by eliminating shy breeders promptly. The saving results from reducing the investment in bulls and their keep, and from producing a more uniform calf crop. In the case of large herds it may pay to have a man stay with the herd every day for from 6 to 8 weeks and bring the cows up to the bull pens for breeding. By this method a good bull may serve from 75 to 100 cows.

When cows are free of abortion disease, they should be allowed to calve on pasture as conditions there are usually more favorable and sanitary than in or around barns and lots. Cows affected with abortion disease should not be allowed to calve on pastures occupied by healthy stock. One or more small pastures, which save time in watching the cows to see whether they need any help, are valuable. Putting cows about to calve in such pastures is also a good practice with respect to heavy milking beef cows, which need attention until the calves can take all the milk. It is especially important that hogs, horses, and mules be kept out of pastures where cows are calving.

On farms having large pastures of several hundred acres which are not well supplied with water, shade, and good forage, there are advantages in keeping the calves on a small pasture which is well supplied in these respects. As the cows come in twice a day for the calves to nurse, the condition of all the cattle can be carefully watched each day. When the flies are bad the calves can be kept in a darkened barn or shed during the day and turned out at night. Brush which the cattle can walk through, and water in which they can stand knee deep, also afford relief from flies.

CREEP FEEDING SUCKLING CALVES

Creep feeding high-grade beef calves which are dropped early in the spring enables them to be fattened so as to be suitable for slaughter at weaning time or shortly thereafter. In the latter case they should be continued on full feed after weaning. Although such calves are usually allowed to run on pasture with their dams until they are weaned, some cattlemen favor keeping the calves in a separate lot, where they may have grazing, and allowing them to nurse the cows twice a day. In experiments to compare these two methods there has been little difference in the results. If there is only one watering

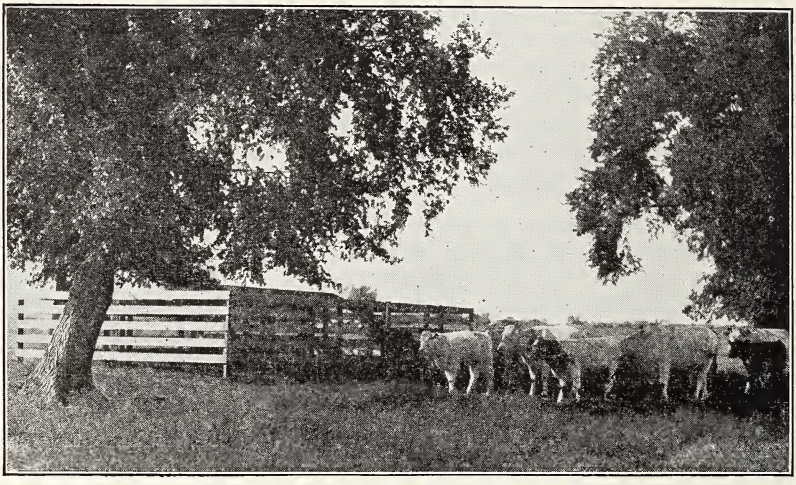

FIGURE 16.—A good creep for feeding grain to suckling calves. They have access by two openings each about 18 inches wide and 30 inches high made by cutting out the second and third boards from the bottom.

place or only one place where the cattle seek shade, the creep should be located near one of these, preferably the shade, because the cows spend more time there (fig. 16).

FATTENING CATTLE ON GRASS ALONE

Cattle in medium to good flesh, when they go on grass, will make about three fourths as much gain as thin cattle. Ordinarily the greatest gains are made during the first half of the grazing. During the latter half of the grazing season, although the gains are much smaller, there is generally a marked improvement in the finish and in the quality of the flesh (fig. 17). Unless one has plenty of nutritious grass it is well to feed grain in the late summer and fall in order to get a satisfactory finish on steers. For 3 or 4 days before shipping, cattle which have been on rather laxative green pasturage should be taken off and given a liberal feed of good grass hay in order to avoid a heavy shrinkage in transit.

FATTENING CATTLE ON GRAIN AND GRASS

In general, the feeding of grain to steers on pasture in the summer has several advantages over winter feeding in dry lot. These advantages include smaller grain requirements per pound of gain, less need for protein concentrates, less labor, no need of shelter, and the spreading of manure at no cost (fig. 18). Self-feeders for grain are satisfactory for fattening cattle on pasture. On the other hand, summer feeding of cattle on grass has the following disadvantages, especially on small farms: A greater yield of feed usually can be obtained

FIGURE 17.—Steers fattened on good pasture in southwestern Virginia.

from crop land; drought may reduce greatly the supply of feed for the cattle; and the price of feeder cattle is commonly higher in the spring than in the fall. Other drawbacks are periods of extreme heat, flies, and the need for having the cattle well finished in order to avoid competition with strictly grass-fed cattle.

Cattle fattened on grain and grass must grade high as slaughter animals in order to bring the premium which is usually paid for grain-fed cattle in the fall when there is a heavy run of "grass beef." Consequently, much care must be taken in selecting and feeding cattle which are to be fattened on grass and grain. If they are purchased the previous fall they should be wintered well. This applies particularly to calves since they tend to grow rather than fatten on grass. Therefore, if they are not in good condition in the spring, they will not get fat enough during the summer to avoid being placed at a disadvantage in competition with western range steers. Although it is necessary to feed calves a small quantity of grain during the winter in order to have them fat enough when they go on grass in the spring,

older cattle make cheaper gains and still reach a satisfactory condition if they have had no grain previous to grain feeding on grass.

In turning steers on pasture, especially those steers that are half fat or in good condition from winter feeding of grain, it is very important for the grass to have had a good start so that the cattle will not scour too badly. When it is short and the water content is high the cattle cannot get enough dry matter to equal the nutrients which they have been accustomed to in dry feed.

Ordinarily, cattle that are half fat at the beginning of the pasture season should be finished in dry lot. However, if the steers that have had a full feed in dry lot are to be turned on grass, it is better to turn them out as soon as the grass starts to grow or a little before so that they can get only very little grass at first. In that way, they may be kept on a full feed of grain and not lose their appetite for it as they

FIGURE 18.—In feeding cattle on pasture, feed bunks should be located on level land, especially the less fertile portions, even though it is necessary to move them oftener. Their location on hillsides results in serious losses of both soil and manure.

would if they were able to get a full feed of grass all at once. If the ground is solid and the steers have plenty of pasture and are full-fed on grain the grass will come on without being appreciably damaged by such a practice. The advantage of having the manure distributed on the pasture will probably offset any damage done to a good sod by such early grazing.

Bluegrass is the outstanding grass for fattening steers in the areas where it thrives, principally on account of its rather high dry-matter content. Other leading grasses for fattening are Bermuda and Rhodes grass in the South and the bluestems, grama, and wheat grasses in the West. In fattening it is important that the animal can readily obtain from 20 to 25 pounds of dry matter per day per 1,000 pounds of live weight. Legumes are less satisfactory for fattening on account of their higher water content. Sweetclover, however, compares favorably with bluegrass during June and July, when it is at its best.

Corn alone is the most extensively used supplement to grass for fattening steers. During the early part of the season no protein sup-

plement is needed because the grass is so rich in protein. As the grass becomes mature it usually pays to add some protein meal in the ratio of 1 part to about 10 parts of corn for 2-year-olds. A somewhat narrower ratio, such as 1 to 8, should be used for yearlings and a wider one for 3-year-olds.

As pasturage is usually more palatable than dry roughage, it is difficult to get cattle to eat enough grain on pasture to fatten as rapidly as they do in dry lot. This is particularly true of mature steers that are to be given a short feed. Such cattle may be fattened more quickly and on less grain per 100 pounds gain in dry lot during the summer, than on pasture, but there are advantages such as savings in labor and roughages which may make the feeding on pasture more profitable. Such advantages and disadvantages must be considered for each case, as no specific recommendations will be applicable in all cases. In the case of immature animals the ability to grow as well as fatten is promoted by the minerals and vitamins present in fresh green feed. Hence, calves and yearlings generally make greater and more economical gains on pasture than they do in dry lot. However, such cattle frequently lack the finish possessed by similar cattle fattened exclusively in dry lot.

PASTURES FOR DAIRY CATTLE

REQUIREMENTS OF THE DAIRY COW

Liberal feeding is one of the fundamentals of successful dairying. Although beef cattle are often carried through periods of feed shortage on only low-grade roughage or poor pasture, such a practice is not desirable for dairy cows. A milking cow insufficiently fed declines rapidly in milk production and in body weight. Even a dry cow must have sufficient feed to maintain her weight, otherwise her production of milk after calving may be unsatisfactory.

Dairy cows do best on immature pasturage. When they graze on grasses with the seed heads developed, milk production declines. Observations at Beltsville, covering three seasons, show that the decline in milk production is greater in June, when the bluegrass is forming seed, than in any other month of the year in spite of the fact that the pasturage in June is fairly abundant. The aim should be to provide the dairy herd with young grass throughout the season.

A dairy cow weighing 1,200 pounds must consume about 25 pounds of dry matter a day, containing about 17 pounds of total digestible nutrients, to support her body weight and to produce 1 pound of butterfat. She should consume about half this quantity if she is dry. The dry matter of pasture plants varies from less than 20 percent when the plants are young and growing to more than 40 percent in times of drought or when the plants are nearing maturity. If the average content of dry matter is 25 percent a cow producing 1 pound of butterfat a day will need 100 pounds of grass a day. The grass must be abundant, otherwise it is physically impossible for a cow to gather as much as 100 pounds a day. Furthermore, remasticating this quantity of grass requires 7 or 8 hours of the cow's time, and she cannot graze and ruminate at the same time.

QUANTITY OF GRASS A COW WILL EAT

An investigation at the United States Dairy Experiment Station at Beltsville, Md., showed that when the pasture plants were young,

tender, and abundant, dairy cows of good production ate enough to make the dry-matter intake from 25 to 30 pounds a day and the intake of digestible nutrients from 17 to 21 pounds. When the pasture plants became more woody and less abundant though still what would ordinarily be considered good pasturage, the consumption of dry matter dropped to 17 pounds, or little more than enough for maintenance and the production of one half pound of butterfat a day. It was also shown that cows would eat as much grass in July as in May provided the herbage in July was as tender and abundant as that in May. Apparently, the heat and flies had no material influence on the quantity of grass the cows would graze. These facts make possible an estimation of the supplementary feed required by dairy cows on pasture.

SUPPLEMENTING PERMANENT PASTURES

There are few places in the United States where permanent pastures remain tender and abundant throughout the grazing season. As a rule in the Northern States the vigorous growth in the spring is followed by a slow growth in the summer, which may become more rapid in the fall. Apparently some of this variation in seasonal growth is due to the tendency of the plants to rest after seed is formed, but some of it is also due to inadequate soil moisture in midsummer. The result is that if the pasture provides the proper quantity of grass for the dairy herd early in the season it will fail to do so later in the season and must be supplemented with other feed. Or if the pasture provides the required amount of grazing in midsummer and fall it will produce more than the cows can use early in the season. In this case some of the pasturage may be made into hay or silage. This will avoid waste of feed and will get the surplus grass off the land so that the young grass can grow and be grazed. Where hay of desirable qualities cannot be made from pasture land, it appears better practice to adjust the size of the permanent pasture or of the herd to the grazing conditions during the first part of the season and to depend on temporary pasturage or other feed to supplement the permanent pastures in the summer and fall. In the South the principal pasture grasses are late starting in the spring and make their greatest growth in the summer. For this reason supplementary pastures in the South are likely to be more urgently needed in the spring than later in the season. Furthermore, on account of the weather conditions supplementary pastures late in the fall or very early in the spring are more practicable in the South than in the North.

Although supplementary pastures are fully discussed elsewhere in this publication, there are a few which merit particular consideration for dairy purposes. One of these is oats. In the North it is ready for grazing at about the time the bluegrass begins to lose its value and will fill the gap between the bluegrass and Sudan grass. In some parts of the South, oats makes an excellent pasture for use in the late fall and early spring. If desired, oats may serve both as a nurse crop for young grass and clover and for grazing. Sudan grass takes first place as a supplementary pasture plant for summer and fall. The first year's growth of sweetclover, which is ordinarily ready to graze in July, is sometimes used to supplement permanent pastures. And on the poorer acid soils the lespedezas are proving popular for summer and fall grazing in the regions adapted to their growth.

SUPPLEMENTARY FEEDS

Cows on good pasture will gather about as much roughage as they can well handle. Grain, therefore, should be the material used in supplementing such pasture. Since good pasture alone will provide the nutrients for cows producing a pound of butterfat a day, grain need be given only to those cows producing more than that quantity. As a general rule, grain should be fed to Holstein cows producing more than 30 pounds of milk a day, to Jersey cows producing more than 20 pounds, and to the other breeds producing intermediate quantities. From 0.4 to 0.6 pound of grain will provide the nutrients for 1 pound of milk, depending on the percentage of butterfat. An advisable plan, therefore, is to give Holstein cows 0.4 pound of grain for each pound of milk produced above 30 pounds and Jersey cows

FIGURE 19.—A closely grazed pasture. Dairy cows on short pastures such as this need to be fed much the same as in winter.

0.6 pound of grain for each pound of milk above 20 pounds. Other breeds should receive intermediate quantities.

This plan has been used successfully at the Department's farm at Beltsville, Md., for a number of seasons. Cows so fed while the pasture was at its best maintained their weight and production as well as those that received more grain. The grass, however, was at its best for only a month or so in the spring. When the predominating grass, Kentucky bluegrass, began to head out the cows declined in both body weight and production, indicating the need for more supplementary feed.

Pastures vary so much in quality that no definite rule for supplementary feeding later in the season is possible. The farmer must be guided by the condition of his cows and by the way the milk flow is being maintained. Any marked falling off of either means that the cows need more feed.

Most permanent pastures become so short in midsummer that cows will not obtain their fill of roughage (fig. 19). When this happens,

hay or silage or both may be used for supplementing pastures or better, perhaps, supplementary pastures may be used. In case there is a surplus of pasture grass in the spring, this grass, if cut early, can be made into hay or silage for use later in the season. It appears to be a good practice to allow milking cows all the hay or silage they will eat in addition to pasture throughout the entire grazing season. When the grazing is good they will eat but little hay, but when the grass becomes short or woody they will eat considerable quantities of hay, and thus less grain will be required to maintain the milk production and body weight of the cows.

The grain fed early in the season or at any time during the season that the grass is young and abundant need not contain more than 12 percent protein. As the pasture plants mature and contain less protein a grain with a higher protein content should be used.

PASTURES FOR DAIRY CALVES AND HEIFERS

Dairy calves less than 1 year of age do not thrive on pasturage alone and the younger the calf the less it can depend on pasturage. Heifers more than 1 year of age do very well on a good pasture without any other feed, but if the pasture becomes short the heifers may have their growth checked. Apparently the older the heifer the better able she is to subsist on pasturage alone. On some pastures, supplementary feed may have to be fed, especially to the younger animals, in order to maintain normal growth.

FEEDING MINERALS TO COWS ON PASTURE

Cows in good production when fed poorly cured hay in winter fail to maintain their mineral reserves. This condition is more pronounced when nonleguminous roughages are fed. The mineral matter of green pasturage, other green forage, or hays cured with much of their natural green color is better assimilated than is the mineral matter of discolored roughage. Direct sunlight also is of benefit to young animals in promoting deposition of calcium. Correction of mineral deficiencies has been discussed under Mineral Content of Pasturage, page 49.

PASTURES FOR HORSES AND MULES

Although pasturage is the natural feed for horses and mules and is often sufficient for maintenance of idle stock, it does not usually furnish enough feed for animals at steady work. Perhaps the nearest approach to the ideal pasture for these animals is the grasses of the semiarid West, which are more like hay than grass a large part of the year. On such feed, the horses used on the cattle range are maintained to a great extent with only limited quantities of supplementary grain. These horses are used only about one half day at a time every 2 or 3 days.

In the case of breeding stock, pastures supply a large portion of the feed required for maintenance and reproduction, and the growth of the young animals.

Turning onto grass may well take the place of medicine in some ailments of horses and mules, as green grass oftentimes tends to act as a general tonic. An animal not accustomed to green feed should be turned on pasture only from 15 to 30 minutes a day at first, the time being gradually increased from day to day.

Turning working horses and mules regularly on pasture at night is a means of keeping the digestive system accustomed to succulent feed. This practice decreases the quantity of hay needed by the animals, but they should receive a small feed of hay with the regular evening ration before being turned out. Horses and mules that are turned on night pasture sweat more at work than those on dry feed, but this disadvantage is overbalanced by the benefits derived during hot weather, when the pasture provides a place to roll, water at will, and a clean, cool place to rest.

When horses and mules that are accustomed to a heavy grain ration are first turned on pasture for a long idle period, they should be given

FIGURE 20.—Good pastures for work horses cut the cost of feed and labor.

small quantities of grain for a few days; otherwise, they may gorge themselves on the green roughage and suffer impaction, rupture of the stomach, or other serious trouble. When horses and mules are laid off from field work for a few days or portions of days at a time, the reduction in grain will depend somewhat on the feed value of the pasture, but generally the grain ration at this time should be about one half the normal requirement.

In addition to benefiting the general health of the animals placed on pasture and reducing feed costs, the maximum utilization of pasturage is of considerable value in reducing the amount of chore labor required for feeding, grooming, and stable cleaning (fig. 20).

Cornstalk fields, grain-stubble fields, or pastures which have not been closely grazed during the summer are desirable sources of a large part of the winter maintenance feed for horses.

PASTURES FOR SHEEP AND GOATS

Although sheep can make good use of hay, grain, and other harvested feeds, they lead all farm animals in their ability to maintain themselves, to fatten, and to produce carcasses of high quality on pasture alone. Their fondness for numerous plants, especially weeds

and shrubs, which other farm animals do not relish, causes them to be kept on many farms chiefly to clean up fields, pastures, and fence rows. However, they cannot use large quantities of rough forage, such as coarse-stalked grasses and cornstalks, to nearly as good advantage as can cattle and horses. Their service is chiefly in biting off the tenderest grass, leaves, and shoots. By such practice the sheep keep down weeds and shrubs when there is sufficient density of stocking to cause them to graze the pasture rather closely.

An acre of good arable land used exclusively for sheep will ordinarily support from 3 to 5 ewes with their lambs until the latter are marketed (fig. 21). On pastures suitable for either cattle or sheep, 5 ewes may be considered the equivalent of 1 cow or mature steer, and the winter

FIGURE 21.—Lambs produced with no grain feeding during the grazing season in the southern Appalachian region. After the lambs are weaned the ewes are put on high, rough land until snow falls.

feed required for 1 breeding cow not in milk would be equivalent to that needed for about 8 ewes.

The practice of flushing ewes, that is, putting them in a gaining condition in the fall before breeding time, commonly increases the lamb crop by about 20 lambs per 100 ewes. This can be accomplished by turning the ewes on an abundance of fresh green pasturage or by feeding from one fourth to one half pound of grain per head daily.

Good winter pasture or range supplemented by good legume hay, when the snow is too deep for grazing, will keep a breeding flock in good condition.

AVOIDING STOMACH WORMS

In most farming sections the flockmaster's greatest troubles are likely to be caused by internal parasites, the effects of which are particularly evident during the latter part of the pasture season. Of these parasites the stomach worm, *Haemonchus contortus*, is the most common and troublesome.

Losses by death or lack of thrift are most serious among lambs in flocks that are kept season after season on old grasslands and on low or poorly drained land. When only a few sheep are kept on a large area of grass which is also pastured by other stock, the danger is less likely to be serious. With closer grazing by sheep, during several months of each season, the danger is increased and is greatest in sections or in seasons of high temperature and excessive moisture. Alternating permanent pastures during the season is valuable in proportion to frequency of rotation and length of time pastures are left ungrazed. On farms where sheep have not been previously kept, trouble from stomach worms is not likely to be serious until the second or third summer.

Regular dosing of sheep and lambs with a 1-percent solution of copper sulphate is an effective method of controlling stomach worms. In the colder sections of the country, dosing every 25 to 30 days during the grazing season is effective. In the Southern States dosing should be commenced as soon as the grass begins to grow and should be repeated every 2 weeks. All lambs weighing 20 pounds or more should be dosed.

In dealing with stomach worms and other parasite problems it is advisable for sheep owners to consult a competent veterinarian. The services of the local extension agencies can be obtained in organizing campaigns for general control measures in a community or county.

ROTATING PASTURES TO CONTROL PARASITES

The rotation of sheep and lambs and other livestock on temporary pastures and cultivated fields is helpful in controlling parasites. In the case of sheep the best plan is to provide fresh pasture every 2 weeks and not allow the flock to go on a field a second time unless the land has been plowed in the interval, or time enough has elapsed to cause the death of the stomach worm larvae that were left on the field during the previous grazing. Some permanent pasture is required for emergency use during periods of drought, excessively wet weather, and in cases of failure to obtain stands of temporary seeding.

It is advisable to depend almost completely on temporary pastures only when the entire farming system is devoted to the production of feed for sheep. The frequent plowing of the land buries most of the parasites that would otherwise be picked up by the sheep. Because of the continued chance of infection of lambs from grass along fence rows and in unplowed yards and barn lots, complete freedom from parasites is seldom obtained. Therefore, as rotated pastures are not 100-percent effective in the control of stomach worms the dosing of the sheep is necessary also to control these worms.

This type of sheep production, which is not extensively used at present in the United States, is a modification of the English system of pasturing the lowlands with sheep, which has proved very successful with the mutton breeds.

SCHEDULE OF TEMPORARY PASTURES

A schedule of temporary pastures suitable for keeping down infestation of stomach worms in sheep is given in table 11. This schedule is based on experience with such crops at the United States Animal Husbandry Experiment Station, Beltsville, Md.

TABLE 11.—*Period during which different crops may be pastured and acreage of each for 100 ewes*

Approximate dates	Crop	Pasture no.	Acreage required for 100 ewes
			Acres
Apr. 1 to Apr. 29	Winter wheat, rye, or barley	1 and 2	20
Apr. 29 to May 27	Alfalfa [1]	3	10
May 27 to June 24	Oats and peas	4	10
June 24 to July 22	Rape	1	10
July 22 to Aug. 19	Soybeans	2	10
Aug. 19 to Sept. 16	Alfalfa	3	10
Sept. 16 to Oct. 14	Rape	4	10
Oct. 14 to Nov. 11	Winter wheat	1 and 2	20

[1] Ordinarily it should be possible to get a crop of hay from the alfalfa in July.

This schedule provides a total of 40 acres to carry 100 ewes from April 1 until the middle of November. In many sections, the use of early spring pasture can be advanced at least a month. However, there will be times when the wheat is too backward or the ground too soft to turn the sheep out on April 1. Under such circumstances some permanent pasture may be used or dry-lot feeding continued. Furthermore, in the summer and fall it may be too dry to obtain adequate pasturage from such crops as rape and winter wheat. At such times stubble fields, aftermath, and cornfields may be available. On good soils that will produce about 40 bushels of corn per acre, 40 acres of such pastures in good years should furnish enough grass for 100 ewes and their lambs to weaning time and some surplus forage which may be harvested for hay.

According to the plan, one of the two 10-acre pastures in winter wheat is plowed and seeded to rape and the other is seeded to soybeans. In the fall both are to be plowed and seeded to winter wheat again. On field 4, oats and peas seeded in early spring are to be followed by rape for fall grazing. In the case of each 4-week period the pasture being used for that period should be divided by a temporary fence so that slightly more than half the pasture may be used the first 2 weeks and the remainder the last 2 weeks.

ROTATIONS WITH PERMANENT AND TEMPORARY PASTURES

An effective system of rotation grazing can be arranged in the regular crop fields of most stock farms, provided there is a sufficient number of fields having sheep fence to permit changing them frequently during the growing season and provided the sheep are properly dosed with copper sulphate solution.

In such a plan, the earliest spring grazing is usually furnished by fall-sown wheat or rye, even though the crop has been grazed previously during the winter (fig. 22). Following this, the flock may be placed on permanent grass pasture on which there were no sheep during the previous year. If such a pasture is not available, a legume in a crop rotation, such as red clover, may be used. Ordinarily the land used would be that on which the sheep grazed wheat at the beginning of the previous year. In such a case, in most sections the danger of worm infestation would probably be much reduced. By the time the third change is necessary some fields usually will have been harvested for hay and the aftermath can be used for grazing.

For ewes or lambs that are carried later in the year, subsequent pasturage is furnished in the stubble fields of the grain crops, and

after that from rape sown in the cornfields. At a still later time the early fall-sown grain furnishes pasturage until the coming winter.

A small acreage of rape or some other forage crop will usually be desirable as an insurance against possible shortage of pasturage in other fields, and more particularly as a safe and satisfactory feed for ewe lambs that are retained for breeding and cannot safely remain with the ewes, particularly if the latter are part of the time on land that may be worm infested.

FENCING SHEEP PASTURES

Movable or temporary fencing is used extensively in grazing sheep as they do not require strong fences and, under farm conditions, it is important that they be confined to what they will clean up in a few weeks.

A handy style of movable fence consists of 32-inch woven wire supported by so-called "Illinois posts" made of half-inch iron rods.

FIGURE 22.—Grazing on winter wheat. In the late fall, winter, and early spring, sheep, and cattle as well, may be grazed on winter wheat, barley, oats, and rye with benefit to the stock, saving in feed costs, and little or no damage to the grain. But it is best to keep them off when the ground is muddy.

Eight inches from the foot of the post there is a branch at right angles. This branch runs out about 8 inches and then turns downward parallel with the post itself. This post can be set readily by pressing on the branch with the foot. The shape of the bottom part gives bracing enough to prevent the sheep from pushing the fence over. The bottom of the fence is kept in place by passing the post between two of the lower wires. The top wire lies in a groove made in the top of the post.

Permanent fences enclosing tracts of land used for sheep should be dog proof. Woven wire from 36 to 42 inches high with stay wires 6 inches apart and 2 or 3 barbed wires above are used for this purpose.

PASTURES FOR GOATS

The grazing of goats is similar to that of sheep, except that goats make more extensive and more efficient use of browse such as shrubs and brush. Also, where plenty of feed is available, goats do not graze so closely as sheep and are, therefore, less likely to suffer from the

internal parasites which give sheep so much trouble. If goats are closely confined to one pasture and the pasturage is not in excess of their needs so that they eat it down closely, they are quite as susceptible as sheep to stomach worms and similar parasitic infestations.

Goats are usually grazed on brushy pastures and ranges. Although they are primarily browsing animals they cannot subsist throughout the winter on brush which loses its leaves in the fall. Green bark is not a good feed for the bulk of their ration. Evergreen brush, such as mountain mahogany in the West, and evergreen oak in the South are good winter feeds. Where such green winter browse is not available, goats require pasture or hay the same as other livestock. They make regular use of weeds and grass where such plants are available, as a sole ration or as a supplement to browse.

In humid areas goats are used extensively to kill brush as a part of clearing land. To do this effectively they should be confined to such areas that they will keep the foliage and sprouts stripped. Generally from 2 to 5 goats per acre are necessary for such work.

Tall brush and trees should be cut so that sprouts coming up from the stumps can be grazed until the roots are killed. In order to keep the goats in good condition and at the same time have the sprouts eaten off thoroughly, the area to be cleared may be divided so that the goats can be moved as often as a substantial quantity of new growth is available. If this is not practicable or does not keep them in thrifty condition, they should have supplementary grazing during the times when no new growth of sprouts is available. Two years of such grazing will kill most brush and stumps.

PASTURES FOR SWINE

Although pastures have an important place in the production of hogs they cannot be used so extensively as for other livestock which have a greater capacity for bulky feed. Hogs can live and even make some gain on grass alone, but young hogs do not make satisfactory growth and cannot be fattened to a desirable market condition. When allowed free range and given access to plenty of mast, hogs are able to care for themselves and will fatten to a moderate degree. For hogs that are confined on farms, the greatest value of pastures lies in the exercise which they provide and the variety which they add to the ration. Only breeding stock should be allowed to range over large pastures. Hogs being fattened should be confined to areas which, though furnishing adequate grazing, prevent excessive exercise. Pasturage may readily replace about 10 percent of the concentrates required to produce 100 pounds of gain and reduce the amount of protein supplement required by approximately 50 percent.

Ordinarily, an acre will furnish pasture for from 5 to 15 hogs averaging 100 pounds in weight. It is a good plan to have two pastures for each lot of hogs. By alternating them the pastures may be grazed fairly closely and still provide good, succulent feed. Pasture crops that are allowed to mature are not good feed for hogs.

It is best to furnish hogs somewhat more pasture than they can keep closely cropped in order to keep them out of the dirt. Bare or nearly bare ground is a temptation to rooting when it is moist and a greater source of parasitic infection than a good cover of vegetation.

It is natural for hogs to root when the ground is soft. To avoid having the sod broken and the pasture pitted with holes, ringing of

hogs is sometimes practiced. But since ringing is painful and may leave a wound, providing opportunity for infection, the operation should be avoided if possible. Swine that have an adequate supply of minerals and other nutrients in their rations are much less likely to root persistently than those which have a craving for something they lack.

In most hog-growing sections of the country permanent pastures are generally used by hog raisers. It is not advisable, however, to use any of the permanent pasture grasses year after year when a considerable number of hogs are kept on them during most of the pasture season. Lots and pastures used every year should be plowed at least once each year to scatter and destroy roundworm eggs and other sources of disease and infection. This practice necessitates the seeding of quick growing crops such as rape, rye, soybeans, and Sudan grass.

Many successful hog growers place on their permanent pastures only a limited number of hogs, such as will permit the pastures to make a sufficient growth to produce a good crop of hay. Plants most generally used are alfalfa, red clover, alsike, white clover, bluegrass, burclover, Bermuda grass, lespedeza, carpet grass, crabgrass, and Dallis grass. Of all the permanent pasture plants alfalfa undoubtedly heads the list for hogs. No other permanent pasture is necessary in localities where this plant can be successfully grown.

When weanling pigs receive 1½ pounds of corn per head daily without any protein supplement except good alfalfa pasture, the range in the quantity of corn needed to produce 100 pounds of gain should be from about 260 to 320 pounds. Pigs on such feed should gain about one half pound per head daily. Ordinarily, in fattening hogs on pasture a grain supplement and some feed rich in protein such as skim milk, tankage, fishmeal, or soybeans, are necessary for best results.

A successful and economical plan of fattening hogs is to "hog down" the corn, and to allow them access to a good alfalfa or red-clover pasture and a protein feed in a self-feeder. The hogs will harvest all the corn in this way and in addition help build up the fertility of the soil. Hogs may also be used advantageously to harvest other grains that cannot be gathered in the usual manner (fig. 23).

Although hogs on pasture need free access to a mineral mixture, such as 70 pounds of bone meal or dicalcium phosphate, 25 pounds of ground limestone or air-slacked lime, and 5 pounds of common salt, they will not use so much as in dry lot because the leaves of green forage are especially rich in readily available calcium and phosphorus.

For hogs, tightly stretched small meshed fence is especially important. If it does not turn the pigs when they are small they get the habit of going through fences and are more likely to make holes for themselves when they get too big for the meshes. A barbed wire just under the woven wire is especially valuable. To be tight, it should be put on and stretched after the woven wire is in place.

To keep hogs raised under farm conditions from suffering from infestation by roundworms, the following general procedure, known as the McLean County system of swine sanitation, should be followed:

Clean the farrowing quarters thoroughly and then scrub with boiling water, adding 1 pound of concentrated lye to 30 gallons of water.

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Brush all loose litter and mud from sides of sow, wash the udder thoroughly with warm water and soap, and then place the sow in the clean farrowing pen. This is done 3 or 4 days before farrowing.

Confine the sow and pigs to the farrowing pens for about 10 days and then haul—do not drive—them to clean pasture. A clean pasture is one that has been plowed and planted since it was used by hogs. Water and feed should be provided in the clean pasture, as the young pigs must not, under any circumstances, be permitted to go back to the permanent hog lot for feed or water until they are 4 months old.

After being placed on a clean pasture, the pigs are sooner or later exposed to the danger of swallowing some roundworm eggs that may be passed by the sow. However, the scattering of the infection over a large, clean pasture diminishes the chances of infection.

The pasture should be located some distance from the permanent hog lots and fenced so that the young pigs cannot get back to the hog lots. It is important

FIGURE 23.—In emergencies, as after severe damage by storm, small grains such as wheat and rye may be harvested to advantage by hogs.

also to avoid locating a clean pasture where the wash from rain on infected ground will contaminate the clean area.

The foregoing directions apply particularly to spring litters of pigs in the Central States. Also washing is not usually necessary in areas where the soil is sandy and does not adhere to the sows. In the case of fall litters, sows kept on clean pastures may be allowed without previous washing to farrow there when weather permits.

The swine-sanitation system frequently increases the number of pigs raised per sow as much as 50 percent. Farmers may also get pigs ready for market from 4 to 8 weeks earlier with a saving of both feed and labor, an increase in uniformity, and a reduction in the number of runts (fig. 24).

A modification of the swine-sanitation system for the South has given very satisfactory results in controlling kidney worms and other parasites as well as roundworms. The modified system involves keeping the ground bare in corners and along fences where the hogs defecate and urinate. Under such conditions sunlight and drying kill the parasites before they can complete their life cycles. More complete details concerning the method of controlling kidney worms may be obtained from the United States Department of Agriculture, Washington, D. C.

In a study of 53,000 hogs raised without regard to sanitation on farms in Georgia and Florida, 92 percent of the livers and all the kidneys were condemned as unfit for food because of kidney-worm infestation. In the case of 525 hogs raised under the special plan, slight kidney-worm lesions were found in the kidneys of 10 percent and only 14 percent of the livers were unfit for food. All livers and kidneys from the animals from 21 herds were entirely free of kidney worms.

A hog wallow made of concrete and located in a convenient, shady place is a benefit in a hog yard, but a mud wallow made by the hogs rooting a hole in the lot or pasture is a nuisance and should not be allowed to remain.

Hogs suffer greatly from heat and must be provided with shade of some kind. This is best provided by trees, where a sufficient number close enough together are available. A very satisfactory structure for providing shade can be made by constructing a framework about 4 feet in height, using posts, poles, or almost any available material,

FIGURE 24.—Pigs raised on pasture. Clean pastures for raising and fattening pigs save grain and protein supplements, avoid roundworm infection and other troubles, save labor, and conserve soil fertility.

and covering the top with hay, straw, or weeds to a depth of about 2 to 3 feet.

PASTURES FOR POULTRY

The proportion of different kinds of pasturage which may be used to advantage in feeding poultry varies with the kind of poultry. Geese can subsist readily on grass alone (fig. 25). Goslings may be grown entirely on grass after they are from 2 to 3 weeks old, though grain is required in fattening them. Ducks rank next among poultry in the advantageous use of pasture and turkeys, guineas, and chickens use the least.

When on good range, such as bluegrass, and receiving also grain, supplemented with milk or a protein feed, such as meat meal, hens will give good egg production and produce eggs at a much lower cost than on balanced rations without pasturage. Good pasture of immature grass furnishes an abundant and cheap supply of vitamins and minerals and provides a high quality of protein. Vitamins A, B, D, E, and G are required for poultry, and of these vitamins A, B, E, and G are present in considerable quantities in good green grass.

Green feed must be tender and low in crude fiber in order to be palatable and of much use to poultry (figs. 26 and 27).

In addition to the nutrients obtained from ranging on pasture, poultry benefit also from the sunshine and exercise. However, in the case of birds producing eggs for market, moderation in the use of green feed, especially legumes, is advisable since too much may cause darker yolks than some markets like. A clean range also aids in keeping the birds free from disease and parasites.

On the average farm, where no special provision is made for grazing poultry and they range at large, their requirements for such feed are

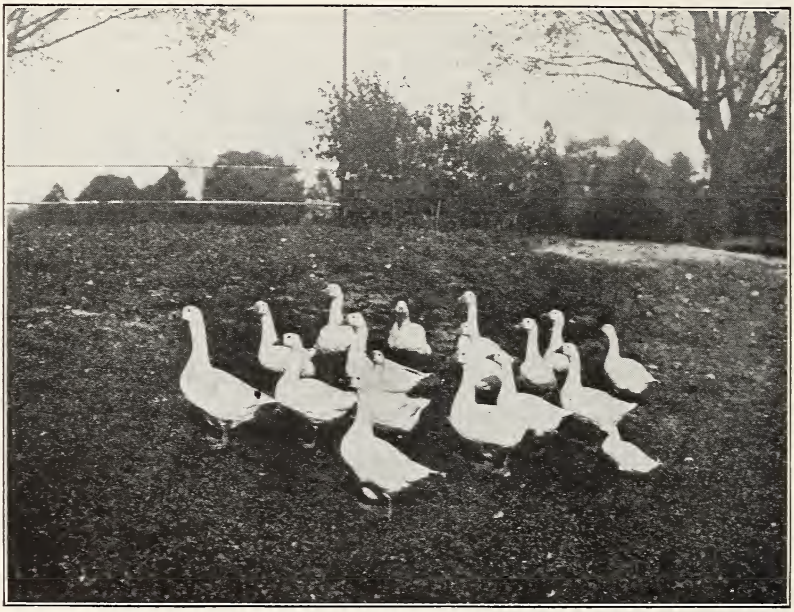

FIGURE 25.—Geese on pasture. This class of poultry is able to subsist entirely on grass, though requiring some grain for fattening.

usually well supplied in the spring and part of the summer. To obtain good growth over a longer period, the soil should be fertile and well supplied with moisture, and plants suitable for feeding poultry should be selected.

For fall, winter, and spring, Italian ryegrass is very satisfactory. It will stand cold weather well and will make some growth when the temperature is above freezing. The small grains may be used, too, but they become hard and fibrous too early in the spring. In the South crimson clover seeded with the rye adds desirable variety. Rape also may be used for winter grazing in the South. A quick, luxuriant growth is necessary for tender, palatable forage.

For summer grazing, particularly in regions where July, August, and September are hot and dry, alfalfa is one of the most satisfactory crops. It is also suitable for general spring and fall use as it withstands frosts. Hard freezes kill the tender growth. Cowpeas or soy-

FIGURE 26.—Chickens on range of grass. Succulent green feed is a valuable part of poultry rations.

FIGURE 27.—Flock of White Holland turkeys on a good grass range.

beans may be used to advantage where alfalfa does not thrive. White clover is especially valuable throughout most of the eastern half of the United States and in irrigated districts of the West, as it comes on early in the spring and again in midsummer on moist soils. Partial shade favors white clover as well as bluegrass during midsummer.

Grasses such as bluegrass, perennial ryegrass, and bromegrass are suitable for spring and fall grazing. In the South, Bermuda grass furnishes summer grazing following legumes and ryegrass, which are suitable for use in the spring. Short grasses such as bluegrass and crested dogtail are much more desirable than tall grasses, such as timothy and Dallis.

At least 1 acre of good land should be provided for every 150 to 200 birds. The area should be divided into 2, 3, or 4 lots so that they may be used when the forage is best and to provide variety.

In cases where rotating is not practicable, mixtures of pasture plants are desirable to furnish variety and increase the length of the grazing season. Suggested mixtures are (1) alfalfa with either orchard grass or timothy; (2) Italian ryegrass, lespedeza, and bur-clover: and (3) bluegrass and white clover.

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