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NATIVE RANGE

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The native grass ranges of the Great Plains have been the subject of intensive investigation for many years. Floristic studies have been conducted in every Plains state. Phytosociological studies of various kinds have been widely made. Succession and degradation under grazing, drouth, plowing, burning, and abandonment have been investigated. Differential clipping studies have investigated the effect on yield, growth, recovery, and chemical composition of various frequencies and heights of clipping. The effects of fertilizers have been studied, and thousands upon thousands of chemical analyses have been made to characterize the nutritive value of native range grasses. Grazing studies involving rotation schemes and differential stocking have been conducted at a number of stations. Mineral supplements, protein supplements, energy supplements, hormones, and antibiotics have been investigated by most of the Plains states and some U.S.D.A. stations in the area. Altogether, native range is perhaps the most thoroughly known and best understood forage used in Oklahoma. Despite the volume of work completed and published, however, no attempt has been made to characterize native range as a forage in any definitive way.

The native ranges of Oklahoma are characterized by a rich grassland flora. While there are many problems concerned with floristics, population dynamics, and general ecology which have not been studied, the gross characteristics of production are reasonably well understood. We know about how much forage is produced on the average, and how much this production varies from year to year and site to site and from one management treatment to another. We know what kind of forage is produced in terms of nutritive value and convertibility into beef or dairy products. We know the principles of management required for sustained yields, and the most important factors limiting production. These gross production characteristics are described in this bulletin.

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History of Investigations

Floristic studies of Oklahoma native grass prairies began with the celebrated visit of Thomas Nuttal to eastern Oklahoma in 1819 and the Long expedition of 1820. The accounts of early travelers through the prairies and plains are useful in understanding the nature of the vegetation and what has happened to it under settlement. Pertinent excerpts may be found in Malin (69), Roe (101) and Harlan (48), together with citations for more complete accounts.

Modern descriptions of the prairie and great plains flora may be found in Weaver (122), Weaver and Albertson (123), Thorp and Whaley (110), Harlan (47, 48), and in the voluminous literature on the identification and taxonomy of species recorded in the area. Specific studies in Oklahoma that might be mentioned are an ecological survey by Bruner (14), the game type vegetation map by Duck and Fletcher (24), a treatment of the grasses of Oklahoma by Featherly (33), an ecological treatment by Harlan (48), phytosociological studies by Rice (95), Smith (107, 108), Penfound (92) and others (37, 59), and the Soil Association Map developed through the cooperation of the U.S.D.A. and Oklahoma State University.*

Experimental work on native range began within 12 months of the establishment of the Oklahoma Agricultural Experiment Station in 1891. Samples of prairie hay were cut at different times and analyzed chemically (82). On the basis of these very preliminary studies, Director J. C. Neal concluded in 1893 that cottonseed meal could be profitably fed to cattle when the native grass was dormant and "... that one of the most pressing needs of Oklahoma is a series of good grasses. A good lawn grass, several grasses for pasture, and several for forage are loudly called for . . . " (82). These first analyses conducted in 1892 do not differ substantially from tens of thousands of analyses which have been conducted since, nor have Dr. Neal's conclusions based on his analyses been altered substantially by over 60 years of research.

During the next 35 years very little experimental work was conducted on native grass, although it was beginning to be characterized by feeding and nutritional trials (89, 94). In the late 1920's a number of studies were initiated. Harper (52) began a fertilizer study that was to run well over 20 years. Gernert (38) began an elaborate study lasting

*This map in simplified form is expected to be available in an Oklahoma Extension circular in the coming year.

6 years with clipping frequencies ranging from 0 to 10 times per year and several fertilizer treatments. Murphy (78, 80) began a series of fertility trials on several soil types and a rotation vs. continuous grazing study lasting 9 years was begun on the 101 Ranch near Marland (48). This renewed interest in native grass coincided with the early work of A. E. Aldous (3) in Kansas and some of the active research in Nebraska by Weaver, Keim (58), Biswell (11) and others (100, 109, 119).

During the 1930's the calcium, phosphorus and magnesium constituents were fairly well characterized through studies by Daniel, Harper, and Murphy (18, 19, 20, 51, 79) and the clipping and grazing studies started earlier were continued or completed. Fraps and Fudge (34) contributed information on chemical composition of grasses in humid Texas and pointed out the likelihood of dietary phosphorus deficiency under certain conditions. Numerous studies on reseeding abandoned land to native grass were conducted in several states as a consequence of the great drouth (12, 108, 120, 121, 122, 123).

In the 1940's an extensive research program on native range got under way at the U. S. Southern Great Plains Experimental Range in southern Harper County. An area of similar size in Payne County was made available to the Oklahoma Agricultural Experiment Station. Gallup and Briggs studied apparent digestibility of prairie hay (36) and Briggs *et al.* (13) conducted a study on the effect of time of cutting on yield and feeding value of prairie hay. A parallel study but without digestion trials was conducted in Nebraska (8, 9). Chemical studies which help to characterize native range as a forage were conducted by Fudge and Fraps for northwest Texas (35), McMillen *et al.* (76) and Langham *et al.* (66) at Goodwell, Watkins (117) in New Mexico, and Savage and Heller (105) at Woodward. The latter was an especially useful study since animal performance in controlled grazing trials could be correlated with chemical composition. Data on the yield of grass by Burnham (16) in New Mexico, Whitfield *et al.* at Amarillo, Texas, (126), McMillen at Goodwell (77) and Albertson *et al.* (1, 2) at Hays, Kansas, provided pertinent information on the production potential of native range. A five-year differential clipping study on seeded stands of several native grasses was published in Nebraska (88).

As a part of the enlarged research programs initiated in the late 1930's and early 1940's, grass breeding work got under way at Stillwater and Woodward and at Manhattan and Hays in Kansas. These programs have provided a series of improved varieties of native grasses for use in reclaiming abandoned cultivated land, and reesarch on seed production has contributed to the availability of these varieties (40, 41, 43, 44, 45, 49, 50, 62). The more recent work has emphasized improvement in seedling vigor to make the task somewhat easier (49, 60, 61).

Results of the Woodward range studies have been made available primarily through mimeographed annual reports during the last 20 years (75). Extensive studies on the value of supplementing native range with a variety of concentrates have been reported in both the Oklahoma (90) and Kansas (56) Feeder's Day Reports for the same period of time. The early clipping and fertility studies have been followed up by further studies in Nebraska (83), Kansas (68), Oklahoma (27, 28, 29, 55) and Texas (10, 54, 99). Cox *et al.* (17) studied the effects of terraces on soil and water conservation in native grass sod. Prairie hay has been compared with alfalfa hay for milk production and for raising dairy calves in Oklahoma (103, 81). Watkins (118), in New Mexico, has published more extensive work on the digestibility of several native grasses in different stages of maturity. Grazing studies at the Ft. Hays, Kansas, Experiment Station (67) are also pertinent.

Studies on seed production of native grasses under irrigation at the Ft. Reno Livestock Research Station (43, 49, 50) and the U. S. Southern Great Plains Field Station (39, 64) have provided important information, not only on seed production, but also on forage production potential where water and fertility are not limiting.

The Norm of Production

The data presented in Table 1 report 162 clipping years and include 3 studies lasting 18 years or longer. The uniformity of average yield is rather remarkable. The mean production from Nebaska to Texas and from the 45-inch annual rainfall isoyet to the 25-inch annual rainfall isoyet is about the same. These data cover good years and drouth years, eastern prairie (Harlan, 48) or "true" prairie (Weaver, 122), mixed prairie (Weaver and Albertson, 123), and steppe vegetation.

The sites selected are for the most part "typical" of the uplands where the remaining native range now occurs. The most important exception to this is the study by Harper, which was located on a Norge loam considered one of the best upland agricultural soils in Oklahoma. The Harper study shows higher yields than any other and raises the weighted average for central Oklahoma considerably because of its long duration. The 38 clipping years in central Oklahoma, omitting the Harper plots, give a weighted yield of 0.91 tons dry matter per acre.

The Oklahoma Agricultural Statistics (87) report average hay yields on over 400,000 acres per year for the 34 years 1919-1947 as 0.86 tons air dry hay per acre. Although this figure should be corrected for moisture, the actual dry matter produced per acre would be slightly higher than this because some of the hay is cut early and total production is not usually recovered in haying operations. Most of these hay meadows are in eastern Oklahoma. The data provide strong support to the experimental studies conducted in the region.

In addition, there is a considerable number of miscellaneous and short term studies which also support the general conclusion that the norm of production in eastern and central Oklahoma is 1 ton dry matter per acre (21, 22, 26, 31, 37, 80, 97, 109). To the westward, production drops slightly as measured by long term studies in Harper County (75) and near Hays, Kansas (1). Few measurements are available for the Panhandle, but studies at Amarillo, Texas (126), Tucumcari, New Mexico (16) and in eastern Colorado (115), as well as a 5-year clipping study at Goodwell (77), indicate that production falls off rapidly to the westward and that 0.5 ton per acre on sandy sites and 0.3 ton on fine textured soils is an approximate norm of production.

One of the most characteristic features of native range production is the consistency of average yield. We know of no other crop which will give so consistent an average yield over so wide a range of climatic conditions.

Variation in production from year to year, however, can be considerable, and is also a characteristic of the norm of production. In the Harper plots, (52) the experiment was so arranged that there were 10 replications of the check treatment and the data may be considered more reliable than in many other studies. In the 20-year period 1929-1949 the lowest yield of the checks was 1131 lbs. of dry matter per acre in 1931 and the highest 4655 lbs. in 1932. The 20-year period was not long enough, however, to include the widest deviation, which occurred in 1950 with a yield of 4933 lbs. of dry matter per acre. As a matter of fact, the mean yield for the first 18 years was 2942 lbs. of dry matter while the average yield for 5 subsequent years was 4028 lbs. Thus, even a 5-year sampling of years may be misleading if the years are unusually good or unusually bad. The range of variation was from 35% of the mean to 167% of the mean.

Another long time series of measurements has been made at the Ft. Supply Experimental Range (74, 75). In general, the sampling methods used involved large numbers of small plots and the mensuration is probably more precise than in most studies. Mean production of sand sage-mixed prairie vegetation was about 1600 lbs. of dry matter per acre, and variation ranged from about 500 lbs. to 2500 lbs. depending on the year. This is a range of approximately 30% of the mean to 160% of the mean.

At Hays, Kansas, Albertson *et al.* (2) found a range in production from 438 lbs. per acre in 1939 to 2951 lbs. in 1951. The mean is taken to be about 1800 lbs. The range was, therefore, from 25% of the mean to 160% of the mean.

Seasonal variation in production of native range is found to vary from 25 to 30% of the mean in poor years to 160 to 165% of the mean in favorable years. Data from a single year or from a study lasting only a few years should be evaluated with this in mind. Investigations of short duration are just as useful as long term studies, however, if there are enough of them to sample seasons reasonably well.

Variation from site to site appears to be of about the same magnitude. The Harper plots located on a soil that would normally be in crop production produced about 160% of the probable mean for the region. Measurements at Manhattan, Kansas, (57) indicate that claypan sites produce about 50% as much as ordinary upland sites and limestone break sites. In western Kansas (113) lowland areas receiving runoff from above were found to yield as much as 200% of the upland in favorable years. On the whole, however, lowland sites in ungrazed prairies yielded about 140% as much as the upland sites. In both eastern and western Kansas, hillsides and break sites yield as much or only slightly less than ordinary upland sites. These general conclusions are supported in Oklahoma by clipping data accumulated by Murphy and Elder (80, 29), and a study on the grand prairie in Texas (5) also gives strong support to the generalization.

It is, of course, possible to find sites which yield almost nothing; but the broad expanses of gently rolling upland characteristic of most native grass ranges in central and eastern Oklahoma and Kansas yield on the average about 1 ton dry matter per acre. Especially favored sites may have an average yield of about 160% of this base figure and very poor sites about 30%. Hillside and break sites do not yield much less than ordinary upland sites. The base yield decreases somewhat in western Oklahoma and drops sharply in the Panhandle to between 0.3 and 0.5 ton per acre, with about the same percentage variation due to site.

The norm of production of native range includes:

1. A remarkably stable average yield of 1 ton of dry matter per acre for central and eastern Oklahoma, dropping slightly in western Oklahoma and decreasing rather sharply in the Panhandle.

2. Seasonal fluctuations in yield ranging from 25 to 30% of the mean to 160 to 165% of the mean. It requires a very bad year to yield so little, and a very good year to yield so much.

3. Variation in mean yield due to site ranging from 30% of the regional mean to 160% of the regional mean. It requires a very poor site to yield so little, and a very good site to yield so much, on the average.

Production Potential

The norm of production does not reflect the ultimate potential of the native grass species. The writer has clipped plots of buffalograss yielding over 5 tons per acre (116). Yields of slightly over 10 tons have been recorded for Caddo switchgrass (50). Sand lovegrass can yield 5 tons and sand bluestem 8 tons (91). Actual pasture yields of 5 tons dry matter have been recorded for big bluestem in Nebraska (83) and a production of 3 tons of little bluestem has been recorded in Texas (99). It is evident that all of the native grasses are capable of producing considerably more than the norm of native range.

Each of the high yields reported above has occurred early in the life of a seeded stand and where, either because of irrigation or abundant rainfall, water has not been limiting. In several of the studies, fertilizers were also added to the point that fertility was not limiting. In studies at the Ft. Reno Livestock Research Station where irrigation was applied and high fertility levels maintained, such high yields could not be sustained (48, 49, 50). The "early stand phenomenon" is another characteristic of native grasses and can be observed in dryland range seedings as well as under the most favorable conditions (16, 75). Five-year-old stands of Caddo at El Reno yielded only 4 tons even where fertility and water were not limiting (91). High fertility levels proved deleterious to side-oats grama, and soil amendments of any kind induced invaders in buffalograss which tended to drive it out. There are factors involved in the relationship between production and age of stand which are more complex than fertility level and moisture supply. These factors need to be investigated.

Limiting Factors for Native Range Production

Rainfall

The first limiting factor in native range production is rainfall. In good years, production is high and in bad years production is low. Harper found significant correlations between rainfall during various intervals before harvest and yield (52). Elder and Murphy (27) found a close correlation between July yield and June rainfall. McIlvain *et al.* (75) has presented data over the 10-year period 1948-1958 showing convincingly that rainfall is more important than management or stocking rate in determining production of native range. Holscher (53) and Tomanek and Albertson (113) also report greater differences between years than between rates of grazing. Heavy grazing tends to aggravate the effects of drouth (Albertson *et al.* (2) and McIlvain (74, 75)), while there is relatively much less difference in production between moderate, light, and no grazing (see also Harlan (46)).

The magnitude of seasonal fluctuations of yields indicates clearly the importance of amount and distribution of rainfall. Despite this fact, there appears to be very little difference in average production over a wide area involving differences of annual precipitation of some 30 inches or more. The limiting factor of moisture supply must consequently be interacting with other limiting factors, and fertility level is the first one to be considered.

Soil Fertility

Responses of native ranges to fertility treatments can be obtained, but they are modest at best (Harlan, (48)). During the 18 years that fertilizers were applied to the Harper plots, the highest treatment (42-20-12.5 annually) averaged 895 lbs. dry matter per acre more than the check, but significant differences due to fertilizers were obtained in only 3 of the 18 years (52). Murphy (78) used somewhat higher rates of soil amendments to obtain slightly greater responses, but concluded the increase could not possibly pay for the fertilizer. Daniel *et al.* (23) at Guthrie used very low rates for six years and obtained no significant increases. On the other hand, fertilized pastures at Guthrie showed a significant increase in production, due primarily to increases in weed production (Huffine and Elder, (55)).

Change in botanical composition as a result of soil amendments has been one of the chief hazards in attempting to increase yields of native range by this means. Elder and Murphy (27) obtained an increase in forbs and weedy grasses where phosphate was applied, and a striking decrease in native grass where both phosphate and nitrogen were applied. Mader (68) obtained a virtual elimination of native grass in 6 years by similar treatments. At El Reno, where composition could be artificially controlled and where irrigation removed water as a limiting factor, fertilizers still brought very modest responses from side-oats grama and switchgrass. The effects of high fertility rates were visible and probably practical, but in most cases not statistically significant (49, 50). On the whole, forbs and weedy grasses are so much more efficient in utilizing applied fertilizers that radical changes in botanical composition are likely to occur. Native ranges do respond to increased fertility levels, but much less efficiently than many species.

Soil Texture

Another possible limiting factor in native range production is soil texture. As we go eastward in both Oklahoma and Kansas we find the native range areas being confined more and more to shallow soil, steep slopes, or level sites with soil having extremely poor internal drainage and high clay content. The good textured soils in eastern Oklahoma are under cultivation and in the natural state would be covered with trees rather than native grass. Some increase in production was obtained at Guthrie by cultivation (30) and a single plowing near Norman produced a substantial increase in production (92, 97). The increase in the latter study was attributed to release of nitrogen. However, a mulching treatment which should have tied up the nitrogen rather effectively still had a substantial increase following plowing. There is some suggestion that the decline in productivity at El Reno under irrigation may be due to soil conditions.

It is recognized that texture and fertility may not be the only factors limiting soil productivity, but few studies have been made to date on these problems.

Management

Management of native range is a limiting factor on production ranking with limitations of moisture supply and soil characteristics. Fortunately, the principles of range management in Oklahoma are simple and rather well understood (42, 48, 71). Differential clipping studies have repeatedly shown that increase in frequency and/or intensity of clipping results in a decrease in yield if long continued (3, 11, 29, 38, 53, 77, 84, 88, 119, 122, 123). In several studies, monthly clipping resulted in a greater total yield at the end of a single season than a single clipping at maturity (1, 88, 111, 122, 123). If the practice is repeated for several years, however, the native vegetation is destroyed (3, 38, 53). A single clipping in July followed by recovery of the aftermath after frost gives the largest sustained yield (8, 9, 13, 29). In haying operations, the aftermath is usually not worth salvaging, but stock may sometimes be wintered on the meadow without undue damage to the grass. Generally the July cutting gives the highest TDN yield of any harvest practice (8, 9, 13).

With respect to grazing intensity, light grazing or no grazing has only slight advantage, if any, over moderate grazing, while heavy grazing reduces the productivity of the vegetation (7, 48, 67, 74, 75, 104, 111, 113). Continued close cropping reduces the leaf area for photosynthesis and places a drain on the food reserves of the plant. Root production is decreased along with the reduction in top production (15, 106) making the plant more susceptible to drouth and further top removal. The lack of litter or surface mulches in heavily grazed pastures also results in increasing moisture stress due to increased runoff and slower infiltration of moisture after rains (25, 57, 96, 113). Regular growing-season deferment tends to increase production of depleted ranges, but has only a slight advantage or no advantage for ranges in top condition (74, 75). Deferred-rotation schemes tend to increase production of forage somewhat over moderate continuous grazing but usually reduce gains per head due to heavier use of more mature forage (6, 56). Divisional rotation schemes have generally not been useful in increasing production (49, 70, 74, 75, 104).

Two widely accepted management practices are used in Oklahoma, and both are entirely satisfactory for maintaining productivity of native range. These are (1) moderate grazing yearlong with a cow-calf operation and (2) rather heavier grazing from green-up in spring to midsummer, followed by complete removal of stock to permit the recovery of the grass. Transient cattle are often used in the latter system although buy-sell programs with calves are also common. This practice is often better for the grass, since it is difficult not to graze too heavily in dry seasons with a cow herd. A combination of the two systems helps to solve this problem, although it must be admitted that in practical operations it is virtually impossible to avoid heavy use during drouth cycles. Another system finding favor is wintering cattle on deferred range and transferring them in the spring to small grain and other tame pastures.

Burning as a management practice has been studied for many years in Kansas, but only incidentally in Oklahoma (59). Long-time studies (24 years) in Kansas have shown yearly late spring burning to reduce yield about 0.2 tons and to change the botanical composition unfavorably to some extent (4, 7, 56, 57). Beef yields tend to be higher on burned than unburned pastures, and burning continues to be a common practice. In Oklahoma, burning is generally not recommended, but actual effects on production have not been measured.

The basis of all satisfactory management systems is the moderate use of native range. Heavy grazing decreases production and if long maintained can lead to severe degradation of the range and ultimate loss of productive vegetation. The decrease in production due to heavy stocking has been measured over a number of years at Ft. Supply (75), Hays (67), Manhattan (56, 57) and elsewhere (e.g., Rogler (102)). The reduction is generally less than that due to drouth years and in most cases is on the order of 30% of the mean yield under moderate grazing. Very heavy or destructive grazing, however, may change the botanical composition of the vegetation to the point that production is reduced as much as 50% of the average yield under moderate grazing (5, 111).

Summary

The principal factors limiting production of native range are:

1. *Amount and distribution of rainfall.* This accounts for most of the seasonal variation in yield.

2. *Soil characteristics, primarily fertility level and texture.* Limitations of land capability largely account for the remarkable uniformity of average yield over a wide geographic area.

3. *Management.* Heavy grazing reduces yield of native range and very heavy grazing destroys it.

Degradation of Native Range

Native ranges in good or excellent condition do not present serious management problems in Oklahoma. One needs only to continue those practices which have preserved the range in this thrifty condition. There are, on the other hand, millions of acres of "native range" in Oklahoma that have been so degraded by bad management that they have become virtually unproductive. These areas represent one of the most important problems in Oklahoma agriculture and are the object of serious concern by research and action agencies in the region.

The process of degradation has been studied rather extensively and is reasonably well understood. Grazing animals tend to select certain plants in preference to others, and plants respond differentially to top removal. Even light grazing will cause changes in the vegetation over no grazing (65, 75, 114). With moderate grazing or a single midsummer mowing the plant composition shifts still more (37, 75, 67, 84, 113). These shifts need not be considered serious, but with heavier and heavier usage the changes in composition become increasingly important (48).

Of the major grasses, one of the least resistant to top removal is switchgrass (29, 37, 65, 84), while both big and little bluestem persist relatively better and blue grama and buffalograss are considerably more resistant to clipping or grazing (77). Part of the differential response to top removal is due to differences in the position of shoot apices and dormant buds (84). Partial defoliation without removal of the shoot apex is not nearly so severe as a top removal that destroys the shoot apex and thereby stimulates dormant buds to elongate. The severity of top removal depends considerably on the timing of the treatment with respect to the position of shoot apices. Little bluestem is somewhat more resistant to grazing pressure than big bluestem, not only because it is less preferred early in the season but also because the shoots elongate somewhat later (84).

Most severe degradation of the range occurs in the dry cycles. The average rancher or farmer does not hurt his native range in good years, but it is frequently difficult not to hurt the range in dry years when forage is short and prices are likely to be low.

Measurements made by Elder (26) have demonstrated a reduction in production of 50% due to infestation of ragweed, and Elwell (32) has shown that in years of severe weed infestation broomweed can reduce grass production 75%. The control of woody plants on the range can increase production of native grass from 70% (72, 74) to several hundred percent (32) depending upon the degree of infestation by the woody plants.

The degradation products of mismanaged range have been described for various types of vegetation (48). In general these are:

Eastern Prairie: Lanceleaf ragweed, triple awn, broomsedge with local encroachment of sumac, persimmon, oaks and other hardwoods and a substantial increase of unpalatable forbs.

Savanna: The development of oak thickets to the near exclusion of the native grasses. The thickets tend to be most dense in the eastern portions of the savanna and somewhat less so in the western reaches and the shin oak areas.

Mixed Prairie: Triple-awn, western ragweed, split-beard bluestem and broomweed on the finer textured soils, with substantial increase of sandsage, sand dropseed, sandbur, sand paspalum, etc., on the sandy sites. Reduction of mixed prairie vegetation to a dense sward of shortgrass is an intermediate stage not considered desirable, but also not particularly serious.

Steppe: Degradation of the high plains steppe vegetation usually results in large expanses of bare ground which become occupied by a variety of annual weeds such as Russian thistle, sunflower, Kochia, annual broomweed or sometimes by prickly pear cactus.

These degradation products cover millions of acres in Oklahoma and are the result of a widespread tendency to overestimate the carrying capacity and productivity of native range. This vast area is a virtual dead weight on the economy of the state and sooner or later must be reclaimed to productive use. The question as to whether much of it can be profitably returned to native range has not yet been answered. Natural revegetation can be extremely slow (112) and reseeding is both expensive and difficult (74). This problem is now the subject of considerable active research in Oklahoma.

Nutritional Characteristics

From the time the warm-season grasses start growing in early- to mid-April until the end of June, native range provides an excellent forage for beef animals. Two pounds of gain per head per day may be expected on yearlings for an 80-day period even if they were well wintered, and higher gains are likely if they were thin when put on the pasture. Larger animals will also gain more than two pounds per day on spring grass (56, 74, 75, 90).

With the onset of summer, the forage becomes drier and less succulent. The grasses start producing stems and seed heads. Tissues contain higher proportions of structural materials, the fiber content increases and the digestibility of various fractions decreases (13, 36, 63, 105, 117, 118, 124). As the summer progresses, energy becomes limiting on gain (90) through lowered intake and reduced digestibility of the forage. Eventually negative nitrogen balances are reached (36, 118) and loss of weight ensues. In central and eastern Oklahoma, the decline in daily gain is rather steep in July and August and may slack off somewhat in September. In western Oklahoma, July and August gains hold up considerably better and yearlings may still be gaining one pound per day in September (74). By October or November weight losses are likely on most native range unless supplements are provided.

From mid-April to the end of September the average gains on yearlings at Ft. Supply are about 300 lbs. (74). In central Oklahoma this is reduced to 250 to 275 lbs. and in eastern Oklahoma is likely to be 200 to 250 lbs. (48). The difference between the areas is primarily due to differences in gain in the summertime, spring gains being about the same. Even at Ft. Supply, however, 80% of the season's gain is obtained by mid-July.

A large number of wintering studies has been conducted in Oklahoma (56, 75, 74, 85, 90, 93, 125). They form a very consistent picture of the nutritive value of native range in winter. Animals on dry range grass receive neither enough digestible energy nor enough protein for good gains. The supply of phosphorus is usually borderline in western Oklahoma, somewhat difficient in central Oklahoma, and rather generally difficient in eastern Oklahoma. When cottonseed meal is fed to satisfy the protein requirement, it will also take care of phosphorus needs. This supplement might leave the calcium-phosphorus ratio somewhat too small and response to the addition of ground limestone has been reported (90, 93). Soybean meal fed to satisfy the protein requirement does not always supply enough phosphorus and steamed bonemeal should also be fed for best response (90, 93). The source of protein does not seem to be important. Sesame meal, corn gluten meal, cottonseed meal, soybean meal, guar, mungbeans, and alfalfa have all been tested and found satisfactory (73, 90).

To supplement dry winter range with enough energy for good gains is generally too expensive to be profitable. A 10-year study at El Reno strongly suggests that cows wintered at a high level have a shorter productive life and produce fewer calves than cows wintered at "low" levels of nutrition (90). One of the common errors in herd management in Oklahoma is overfeeding supplements in the wintertime. A modest wintering level such that yearlings or calves approximately break even or gain no more than about 0.5 lbs. per day appears to be most practical. Animals that lose excessively during the winter gain more during the summer but never catch up to those that were wintered at a moderate level. On the other hand, animals wintered at high levels gain considerably less during the summer and their advantage in weight is seldom enough to pay for the extra costs.

In general, then, native range provides an excellent diet for about three months, a diet declining in digestible energy, protein and phosphorus for an additional three months, and a diet difficient in these constituents for the remaining six months. With appropriate supplements, native range makes a satisfactory diet for year around cow-calf operations or can be exploited during its short period of high nutritive value to make good gains on young growing animals.

This basic picture may be modified to some extent by cool season grasses and forbs. In central and eastern Oklahoma particularly, the native ranges have been invaded by introduced annual *Bromus* species in recent years. These grasses are now sufficiently naturalized that they may be considered a significant part of the flora. Moderate grazing and good management rather favor their development and they may be expected to remain in our native ranges indefinitely. In years of dry falls and winters, these grasses will not contribute enough forage to make much difference, but in years of average or better fall and winter moisture their contribution in late winter can be substantial. In some years enough production is obtained that the protein and phosphorus requirements may be largely met and the supply of digestible energy may increase to the point that good gains are obtained a month or six weeks before the warm season grasses start growth. In favorable years, western wheatgrass and Texas bluegrass may have similar effects in western Oklahoma, but the contribution of these grasses to late winter gain is less consistent.

Native range shows considerable variation in quality from year to year. As a general rule, per head gains are better in dry years than in wet years provided there is a sufficient volume of forage per animal. Daniel and Harper (19, 20, 51) demonstrated a relationship between rainfall and mineral composition of native range. Generally, low moisture resulted in an increase of calcium and a decrease of phosphorus. Rainfall was more important than available phosphorus in the soil or the base exchange in determining mineral composition of the forage. Both big bluestem and little bluestem were found to be rather insensitive to soil nutrients. The range of variation in nutritive value as measured by animal performance is small compared to the range of variation in forage production.

The nutirtive value of prairie hay is rather clearly reflected in a study by Musgrave *et al.* (81) in which it was compared with alfalfa hay for growing dairy calves. The prairie hay gave about 90% of the gain of alfalfa hay. The TDN of alfalfa was more efficient in producing a pound of gain than the TDN of prairie hay and the differences were greater in summer than in winter. In another study with lactating animals, prairie hay plus a 20% concentrate was about as good a ration as alfalfa hay plus a 15% concentrate (103). Other studies have been mentioned (13, 36, 56, 90).

Conversion of Forage Production to Beef Production

Yearling steers on the Ft. Supply Experimental Range have produced an average of 40 pounds gain per acre on moderately grazed sand-sage range over an 18-year period (74). If the average production of forage is 1600 lbs. and if the animals are able to consume half of it, then it takes about 20 lbs. of dry weight forage production to make a pound of gain. In central and eastern Oklahoma where range production averages about 2,000 lbs., the same conversion figure yields a per acre gain of 50 lbs. This is a fairly reasonable figure for the better ranges (48). Using the same conversion factor on the very best ranges averaging 3,000 lbs. production per year the production per acre is 75 lbs. Such a production figure is only rarely achieved year after year. Sixty-five pounds gain per acre is considered very good in the Flint Hills (56) and is a more reasonable top figure for the better ranges in the Osage and the eastern prairie. Assuming 50% of the forage actually consumed, it takes from 20 to 25 lbs. of forage production to produce 1 lb. of beef when grazing native range yearlong with calves at a moderate stocking rate.

The assumption of 50% consumption in moderately grazed ranges, however, is not on very sound grounds (75). So much forage is lost due to causes other than grazing that the actual consumption on a yearlong basis is calculated to be about half of the total disappearance. This point needs further research, but a conversion figure of 10 to 12 lbs. of forage to 1 lb. beef would bring native range more into line with other forages that have been measured. Regardless of the true convertibility, however, it appears that with present management practices one must make available 20 to 25 lbs. of forage in the pasture in order to realize 1 lb. net gain.

Yield of beef per acre depends more on stocking rate than on production of forage. Studies at Ft. Supply (74), Hays (67), Manhattan (56) and numerous other places (46) have shown that the highest yield of beef per acre is obtained with heavy grazing, but the gain per head is considerably lower than at a moderate or light rate of grazing. At Mandan, North Dakota, certain experimental pastures have been deliberately overgrazed for over forty years. Even though the production of forage has been greatly decreased and experimental animals must frequently be removed from the pastures before the end of the grazing season because of lack of forage, these pastures are still producing substantially more pounds of beef per acre than the moderately grazed pastures. The gain per head, however, is unprofitably low. The relationship between production per acre and per head to grazing intensity is reasonably well known (46).

Production per acre from a cow-calf operation is generally less than that with yearlings. In central and eastern Oklahoma, a 475 lb. calf produced from a range with a carrying capacity of 10 acres per animal unit yields 47.5 lbs. per acre. Reducing this to allow a 90% calf crop and about as much again to allow for replacement heifers, the yield is about 40 lbs. per acre. At Ft. Supply, calf weaning weights have been a little over 500 lbs. on about 20 acres per cow for some 25 lbs. per acre gain. The same corrections yield a figure of about 20 lbs. gain per acre from calves as compared with 40 lbs. for yearlings. The reduction in yield of the cow-calf system over the yearling system is greater in western Oklahoma than in eastern Oklahoma.

Native Range vs. Tame Pasture

In central and eastern Oklahoma, alternatives to native range are often a consideration. The production per acre on native range is standard and consistent over a wide area—2,000 lbs. dry forage, 50 lbs. live weight gain from yearlings or 40 lbs. from weaner calves. This may be compared with 150 to 200 lbs. production on yearlings from Bermudagrass and/or small grains. A planned program of tame pasture production can carry an animal unit to two acres and maintain high weaning calf weights. As a rule, a good tame pasture program will produce three to five times as much beef per acre as native range.

On the other hand, a good tame pasture program requires a high order of input in the way of management and labor. It is not possible to obtain high yields from tame pastures without raising the fertility level of the soil substantially. Bermudagrass grown on the same soil as native range and *without* soil amendments does not yield as much as native grass (29, 109).

At the normally low fertility level of soils occupied by native range, we know of no vegetation that will yield as well as the native grass species. If one merely plans to harvest forage from these soils without attempting to increase the fertility level, native range is the most productive kind of forage that can be grown at the present time. If one is going to the effort and expense of raising the fertility level, tame forages will be more rewarding than native range.

Summary

1. The native range of the Plains States has been studied intensively for many years and is better known and understood than any other forage in Oklahoma.

2. The mean production from Nebraska to Texas and from the 45-inch annual rainfall isoyet to the 25-inch annual rainfall isoyet is remarkably uniform.

3. Throughout this vast region the average production is very close to 1 ton dry matter per acre. From the 25-inch isoyet westward, production drops sharply.

4. Seasonal variation in production is from 25 to 30% of the mean to 160 to 165% of the mean.

5. Variation in average production due to site is about the same as that due to rainfall. Hillside and break sites yield only slightly less than ordinary upland sites.

6. All of the native grasses are capable of yielding substantially more than the norm of production of native range.

7. The amount and distribution of rainfall is the most important factor limiting production.

8. The limitations of soil characteristics, primarily fertility level and texture, largely account for the uniformity of average yield over a wide geographic area.

9. Mismanagement, primarily overstocking, is also an important factor limiting production.

10. A large proportion of "native range" has been degraded to the point of very low productivity, primarily as a result of a widespread tendency to overestimate the carrying capacity and productivity of native range.

11. Native range provides an excellent diet for beef animals for about 3 months, a diet declining in digestible energy, protein and phosphorus for an additional 3 months, and a diet difficient in these constituents for the remaining 6 months.

12. With appropriate supplements, native range makes a satisfactory diet for yearlong cow-calf operations, or it can be profitably exploited with young animals during the short period of excellent forage value.

13. Cool season grasses, especially the newly naturalized annual *Bromus* species, improve the nutritional characteristics of native range in late winter in favorable years.

14. The nutritive value of native range varies considerably with the amount and distribution of rainfall. The magnitude of the variation is small compared with the variation in production due to rainfall.

15. Data indicate that 10 to 12 lbs. of native range forage are required to produce 1 lb. gain on yearlings, but at least twice this much must be made available in addition to the reserves that must be left ungrazed to preserve the vigor and productivity of the range.

16. Yield of beef per acre depends more on stocking rate than on forage production. On moderately grazed pastures, yearlings produce

about 40 lbs. beef per acre in western Oklahoma and 50 lbs. in central and eastern Oklahoma, with the very best ranges yielding as much as 65 lbs. per acre.

17. Weaner calf production per acre is less than yearling production and is approximately 20 lbs. for western Oklahoma and 40 lbs. for central and eastern Oklahoma, with the very best ranges producing as much as 55 lb. per acre.

18. On the sites now occupied by native range, tame pastures will not yield as much as native range unless the fertility level is raised. With an increase in fertility level, however, tame pastures can yield three to five times as much.

19. High fertility levels and intensive management are more rewarding with tame pastures than with native range.

Table 1.—Average yield of native grass or prairie vegetation in tons dry matter per acre.*

Region	Reference	No. yrs. in study	Yield (tons dry matter per A.)	Weighted yield by regions (tons dry matter per A.)
EASTERN NEBRASKA	Baker et al. 1951	3	1.2	1.14
	**Newell & Keim 1947	5	1.1	
EASTERN KANSAS	Anonymous 1957	23	1.2	1.14
	Mader 1957	6	0.9	
EASTERN OKLAHOMA	Murphy 1933	4	1.0	1.07
	Elder & Murphy 1958	4	0.9	
	**Elder (unpubl.)	4	1·3	
EASTERN TEXAS	**Holt et al. 1958	4	1.2	1.2
CENTRAL OKLAHOMA	Murphy 1933	3	0.7	1.17
	Gernert 1936	6	0.86	
	**Elwell 1946	4	1.1	
	**Daniel et al. 1947	3	0.9	
	Briggs et al. 1948	3	1.0	
	Daniel et al. 1951	6	1.1	
	Harper 1957	23	1·6	
	Harlan 1958	9	0.9	
	**Elder (unpubl.)	4	0.9	
N. CENTRAL TEXAS	Allred & Nixon 1955	4	0.9	0.9
WESTERN KANSAS	Albertson et al. 1953	6	0.9	0.9
WESTERN OKLAHOMA	McIlvain et al. 1955	18	0.8	0.8
	McMillan & Williams 1944	5	0.8	
PANHANDLE OF TEXAS	**Whitfield et al. 1949	6	0.37	0·45
N· E. NEW MEXICO	**Burnham 1955	9	0.5	
TOTAL CLIPPING YEARS		162		

* In studies where differential treatments of clipping, burning or fertilization were applied, the minimum treatment is reported in each case.

** Data from seeded stands.

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