it would seem that they cannot do this individually. Much depends on public policies in regard to agricultural development, and the cattlemen's willingness and ability to work together in meeting their common developmental needs.

**LITERATURE CITED**


**BOYKIN, CALVIN C., AND THOMAS Q. LEBRUN.** 1968. Petroleum products and ability to work together in meeting their common developmental needs. Instructor and Professor Emeritus in Range and Pasture Management, Kansas State University, Manhattan, Kansas.


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**Effect of Clipping Date on Loamy Upland Bluestem Range**

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**Highlight**

The effects on herbage yield and botanical composition of different clipping dates and subsequent removal or return of forage to bluestem range were studied. Yield of herbage was greatest under August 1 clipping. Removing clipped herbage reduced yields. Desirable species decreased under mid-summer clipping. Increaser species were favored by removing clipped forage.

Much hay is harvested from bluestem range in eastern Kansas. Removing approximately a ton of herbage per acre per year should deplete vital plant nutrients and herbage yields. Fertilizers may be justified to replace nutrients removed. A large portion of nutrients grazed are redeposited as animal wastes. Much more nitrogen, phosphorus, and potassium are removed by haying than by grazing. Net removal of nitrogen from grazed land is approximately 1 lb/A/yr, while haying removes 31 lb/A/yr. Only a trace of phosphorus and potassium is removed by grazing, while haying removes about 10 lb/A/yr of phosphorus and 2.5 lb/A/yr potassium (Dyksterhuis, 1961).

Plant composition trends reflect preferences of grazing animals. Haying is nonselective so species not harvested under grazing are cut. Growth habits, causing differences in percentage of the photosynthetic area above or below the mower cutting height, will partially determine changes in botanical composition over a period of years under mowing.

Carbohydrate storage is intimately related to time of mowing. If a particular date of mowing comes at an inopportune time for carbohydrate storage, yields should suffer in subsequent seasons. This study attempted to determine effects on yield and botanical composition of mowing loamy upland bluestem range at different dates in combination with return or removal of herbage after clipping.

**Materials and Methods**

**Study Area.**—The study area is in the northern Flint Hills near Manhattan, Kansas. Vegetation in the region is dominated by big bluestem (Andropogon gerardii Vitman) and little bluestem (A. scoparius Michx.). Indiangrass (Sorghastrum nutans (L.) Nash), switchgrass (Panicum virgatum L.), and sideoats grama (Bouteloua curtipendula (Michx.) Torr.) are also important members of True Prairie. The frost free season is approximately April 20 to early October. The loamy upland range site has a 1 to 2% slope. The soil is a well drained silty clay loam with a silty clay texture in the "B" horizon.

**Experimental Design.**—A triplicated split-plot design on 5 x 40 ft plots was used from 1962 through 1967. Main plots were harvested on six dates (June 1, July 1, August 1, September 1, October 1, and November 1). Plots were divided into two subplots; one with clipped herbage removed, and the other with clipped herbage returned after being weighed. Herbage was clipped at 3 inches from a 3 x 14.5 ft strip in each plot. The remainder of the plot was clipped after the yield plot was harvested. Regrowth on all plots was...
No initial botanical composition data were collected. The area was initially uniform so differences shown in the 1967 plant census probably reflect treatments. Two 2.5-meter line transect samples (Canfield, 1949) were taken in each subplot to estimate basal cover. Species were grouped according to behavior under grazing pressure (Dyksterhuis, 1949).

Results and Discussion

Herbage Yield.—Plots with herbage removed yielded less than those with herbage returned; the difference was greatest under annual August 1 clipping but existed also under annual July 1, September 1, or October 1 clipping (Fig. 1). Early in the growing season, yields did not differ significantly. That suggests that the removal effect may be partially from mulch. Plots clipped early in the season regrew quickly compared with plots clipped later. Less regrowth late in the season leaves the surface less protected during summer, so rain runoff and evaporation are greater. Herbage removal, and thus nutrient removal, was greatest from plots harvested from August to November, which may account for greater differences between herbage-

removal and herbage-returned plots under high production.

Herbage production was highest on plots clipped in August. Reductions in yield caused by clipping late (September 1 and October 1) were greatest on plots where the herbage was returned. Vogel and Bjugstad (1968), working with glade grassland of the Missouri Ozarks, found that any herbage removal in summer reduced forage yields. Yields reported here on herbage-removed plots were highest with clipping during winter dormancy; but on plots where herbage was returned, yields were greater under summer clipping. Cook (1966) pointed out that if warm season grasses are clipped only once, late season (August and September) clipping was most harmful.

A year × clipping date interaction existed and is shown in Table 1. That interaction was due primarily to fluctuations in weather and was mostly due to a change in magnitude of yield difference as opposed to changes in rank. In 1967 fall clipping date plots yielded more than the late summer clipped plots which represents a reversal from previous years results. Precipitation was the lowest on record in 1966, and yields from all plots were low and differed little.

Forage quality is highest during the early growing season and declines rapidly during late summer. Work in true prairie by Briggs et al. (1948) and Conard and Arthand (1957) indicates that early July cutting would yield the most total digestible nutrients. In our study, plots clipped August 1 yielded 405 lb/A more than plots clipped July 1, but forage quality was lower in August. Bluestem range probably should be mowed in early to mid-July for prairie hay. Forage quality then would be fairly high and forage production near maximum.

Herbage yield data should be accompanied by botanical composition data since undesirable, low quality, unpalatable species may dominate. Bluestem prairie is highly resistant to botanical change, even under heavy pressure, but changes in yield potential come fairly rapidly.

Table 1. Herbage yields (lb/A air-dry) on plots clipped at different dates, 1962–1967.

<table>
<thead>
<tr>
<th>Year</th>
<th>June 1</th>
<th>July 1</th>
<th>Aug. 1</th>
<th>Sept. 1</th>
<th>Oct. 1</th>
<th>Nov. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>1738</td>
<td>2263</td>
<td>2623</td>
<td>2608</td>
<td>2253</td>
<td>2428</td>
</tr>
<tr>
<td>1963</td>
<td>2290</td>
<td>2696</td>
<td>2606</td>
<td>2133</td>
<td>1904</td>
<td>2260</td>
</tr>
<tr>
<td>1964</td>
<td>825</td>
<td>1852</td>
<td>2708</td>
<td>2113</td>
<td>2023</td>
<td>2215</td>
</tr>
<tr>
<td>1965</td>
<td>1798</td>
<td>1940</td>
<td>3596</td>
<td>2408</td>
<td>2603</td>
<td>2982</td>
</tr>
<tr>
<td>1966</td>
<td>897</td>
<td>1124</td>
<td>1219</td>
<td>1529</td>
<td>1548</td>
<td>1251</td>
</tr>
<tr>
<td>1967</td>
<td>630</td>
<td>1670</td>
<td>2203</td>
<td>2621</td>
<td>3168</td>
<td>2642</td>
</tr>
</tbody>
</table>

1 LSD: .05 = 363 lb; .10 = 282 lb.
Basal Cover.—Clipping June 1, July 1, and August 1 reduced basal coverage of big bluestem more than did clipping during the dormant season (Fig. 2). However, no difference in basal cover of big bluestem could be attributed to herbage removed. Little bluestem basal cover increased with July 1 clipping; decreased with August 1 clipping. Conard and Arthand (1957) reported increases in little bluestem under early July clipping in eastern Nebraska.

Indiangrass basal cover was relatively high under early season clipping but was considerably lower under late season clipping. Neither removing nor returning clipped herbage affected indiangrass basal cover. Decreasers (Fig. 2) were fewer with August 1 and September 1 clipping than with other clipping dates. The decreasers' basal cover reflected the influence of big and little bluestem.

Little bluestem basal cover increased substantially with removal of herbage regardless of clipping date (Table 2). Since little bluestem is characteristic of xeric sites, it may have increased due to lack of mulch, or lack of moisture.

Increasers were primarily sideoats grama and Kentucky bluegrass (Poa pratensis L.). Clipping dates did not affect sideoats grama basal cover but Kentucky bluegrass basal cover was greater with annual August 1 and September 1 clipping than with other clipping dates (Fig. 3). Failure of sideoats grama to behave as an increaser in the same manner as Kentucky bluegrass relates to the definition of an increaser. Increasers are defined under grazing conditions where one species is more palatable than another.

Mowing is non-selective so sideoats grama, actively growing, suffered much the same as the decreasers. Kentucky bluegrass, on the other hand, was semi-dormant so was harmed much less. Note in Figures 2 and 3 that the high point in basal cover for increasers corresponds with the low point for decreasers. August clipping obviously was detrimental to the desirable species.

Sideoats grama and Kentucky bluegrass basal cover was higher on plots where herbage was removed after clipping (Table 2). Since they normally increase with heavy removal, it is likely that the open stand created by removing mulch benefited them.

Conclusions

1. Herbage yield was greatest under August 1 clipping.
2. Removing clipped herbage lowered production.
3. Under annual August 1 clipping, basal cover of desirable species was lower than under other dates.
4. Increasers were favored by removing clipped forage.
5. The ideal clipping appeared to be July 1 or shortly after, since forage quality, yield, and preservation of stand were in their most desirable combination then.

Table 2. Basal cover (cm/2.5 m line transect) of three species and total plant cover for all clipping dates.

<table>
<thead>
<tr>
<th>clipped herbage</th>
<th>little bluestem</th>
<th>sideoats grama</th>
<th>Kentucky bluegrass</th>
<th>total plant cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>removed</td>
<td>6.58</td>
<td>4.50</td>
<td>5.53</td>
<td>31.06</td>
</tr>
<tr>
<td>returned</td>
<td>3.81</td>
<td>2.83</td>
<td>1.33</td>
<td>28.36</td>
</tr>
</tbody>
</table>

1 All values shown are statistically different at P < .05.
Literature Cited


Technical Notes

A Technique for Field Use of Radioactive Phosphorus

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Highlight

Dry ice was used in the field to solidify solutions of radioactive phosphorus. Cubes of the frozen material were dropped into holes formed adjacent to grass plants, the root systems of which were being studied by use of the radioactive tracer method.

Radioactive phosphorus is often used as a tracer in studying the root systems of plants (Subcommittee, Range Research Methods, 1963). Its use enables the scientist to study the extent of growth of root systems readily and with little labor. One of the principal values realized in using radioactive phosphorus is the minimum disturbance to root systems. The equipment required for field handling and detection of P32 is not necessarily expensive, and when handled in accordance with the prescribed safety rules, it is not as dangerous as other radioactive materials.

Field use, however, presents certain problems involving placement of the material in the soil. Radioactive phosphorus is often mixed with distilled water, transported in glass containers to the research area, and then injected into prepared holes in the soil. Syringes and tubes have been employed in the operation (Burton et al., 1954; Mathis et al., 1965; McClure and Harvey, 1962). This practice requires considerable handling; spillage with its accompanying undesirable contamination can occur. Another method often employed includes the preparation of an agar gel containing the P32 material. The agar preparation while still in liquid form is poured into small paper cups capable of holding a given quantity of material. The preparation is allowed to solidify, after which it is squeezed from the cups into holes in the soil. This method requires the use of laboratory space and apparatus to prepare the agar gel.

A simple method of placing radioactive phosphorus in designated locations in the soil has been used in root studies of perennial grasses on the Agronomy Farm at Texas Technological College. All work was done in the field in an isolated location where contamination would not be dangerous to men or animals. Prescribed isolation rules were followed. The procedure was as follows:

Radioactive phosphorus solutions were compounded in five-gallon quantities. Ordinary glass with a minimum thickness of 3.5 mm will stop the beta rays emitted by P32. Next, a bed of dry ice two inches thick was formed in the bottom of a lead-lined wooden box measuring 1.5 x 10 ft and six inches deep. Paper cups having a capacity of 20 ml were placed in rows on the dry ice and filled with P32 solution which solidified in approximately 30 minutes. The frozen cubes were then removed from the bed of dry ice and the paper cups torn away (Fig. 1). The frozen material was promptly dropped into holes in the soil. Holes were formed to various designated depths and were placed at various distances from plants in the experimental area. They were formed by a Bull hydraulic soil sampling machine and had a diameter large enough to permit the cubes of frozen radioactive material to drop unimpeded to the bottom of each hole. Dry ice kept the cubes frozen until they were used.

The use of P32 in studying root systems of plants is a useful technique and the method described here does not violate procedures for safe handling of radioactive phosphorus. It permits the tracer technique to be used where laboratory space and equipment are not available for preparing radioactive materials for use. It permits the technique to be used in field plots easily and quickly with little expense. It reduces the chances for contamination of the sides of holes as might be the case when the solution method with its tubes and syringes is used to place P32.

Fig. 1. Cups of frozen P32 material on squares of dry ice.