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Composition, Classification and Species Response Patterns of Remnant Tallgrass Prairies in Texas

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ABSTRACT: Thirty-five remnant upland grasslands within the Blackland, San Antonio, Fayette and Upper Coastal prairies were sampled for species frequency, foliage cover and richness. PCA ordination and cluster analysis were used to ordinate and classify these communities. The majority of these grasslands are dominated by Schizachyrium scoparium with Sorghastrum nutans the second most important species. Andropogon gerardii and Bouteloua curtipendula increase in importance with increasing soil clay content, organic matter and pH and decreasing total annual precipitation. Paspalum plicatulum becomes an important secondary species in communities over acid Alfisols in the Fayette Prairie and acid Alfisols and Vertisols of the Upper Coastal Prairie. High precipitation (>90 cm) areas over Alfisols at the northern end of the Blackland Prairie support a unique grassland dominated by Sporobolus silexcanus with Carex meadii as an important secondary species. In this same area on Vertisols communities are found that are dominated by Tripsacum dactyloides and Panicum virgatum. Species respond independently and continuously along soil and climatic gradients except where locally sharp transitions occur between Alfisols and Vertisols. Species diversity did not vary significantly among communities. Soil pH was positively correlated with species richness, which was related to slightly higher richness of stands on Alfisols which have low pH, and slightly higher richness of Coastal Prairie stands which also have generally lower pH values.

INTRODUCTION

The Blackland, Fort Worth, San Antonio, Fayette and Upper Coastal prairies occupy a N-S strip comprising approximately 8 million ha within E central Texas (Godfrey et al., 1973) (Fig. 1). Native vegetation of these grasslands has largely been destroyed by cultivation, overgrazing and urbanization. Although several authors have described these prairies (Dyksterhuis, 1946; Launchbaugh, 1955; Collins et al., 1975; Butler, 1979; Diamond, 1983; Smeins and Diamond, 1983), no attempt has been made to compare patterns of community composition and species diversity among them. The Upper Coastal Prairie has traditionally been separated from other Texas prairies (Tharp, 1926; Gould, 1975), but lack of quantitative data makes an evaluation of the degree of relationship among the Coastal Prairie and other Texas prairies impossible. This study provides quantitative data on vegetation and soils of uplands within the Blackland, Fayette, San Antonio and Upper Coastal prairies. These data allow detailed analysis of Texas grasslands to: (1) determine relationships among communities; (2) evaluate species-to-species and species-to-environment relationships; (3) clarify classification, and (4) evaluate patterns in species diversity.

STUDY AREA

Location and extent. — The grasslands studied are located in a N-S strip approximately 300 km wide and 100 km long in E and central Texas (Fig. 1). To the N the Blackland Prairie borders on the Red River, whereas to the S the Coastal Prairie grades into the Gulf Coast marshes. The eastern border is defined by the Post Oak Savannah, while the western border is defined by the western Cross Timbers in the N, the Edwards Pla-
teau in the central section and the South Texas Plains and Lower Coastal Prairie in the S. Narrow strips of Post Oak Savannah separate the Blackland, San Antonio, Fayette and Upper Coastal prairies (Gould, 1975).

Geology and soils. — The parent material for these grasslands consists primarily of NE-SW strips of marine deposits which decrease in age from N-S. The Blackland Prairie is underlain by Upper Cretaceous material, the San Antonio and Fayette Prairies by Tertiary deposits and the Upper Coastal Prairie by Quaternary deposits (USGS, 1973).

Soils within the Vertisol and Alfisol orders occur over most of the study area, but Mollisols are locally important (Godfrey et al., 1973). Soil type generally corresponds to geologic formation within all Texas prairies, with Alfisols over coarse-textured sedimen-

![Fig. 1. — Soil associations for Texas grasslands](image-url)
tary deposits and Vertisols over fine-textured deposits. Seven major soil associations oc-
cur within the study area (Fig. 1).

Vertisols, Alfisols and Mollisols within the study area have in common a very slowly
permeable, clayey subsoil. These subsoils, coupled with a generally flat topography,
make most Texas prairies poorly drained (Godfrey et al., 1973). Vertisols are clayey in
all horizons, while Alfisols typically have a loam or clay-loam surface horizon. Gilgai or
“hogwallow” topography, with microdepressions and microknolls, is typical of Vertisols
(Gustafson, 1975). Areas over Alfisols may have sandy, circular mounds called mima or
pimple mounds (Butler, 1979; Diamond, 1980). These mounds, which range up to 1.5
m in height and 20 m in diam, are particularly prominent on the Upper Coastal Prairie
and northeastern Blackland Prairie, where they may cover up to 25% of the landscape
(Collins, 1972; Smeins et al., in press). Mima mounds appear to be products of past
drainage patterns, wave action or wind erosion associated with coastal environments,
but no hypothesis about their origin is universally accepted (Bernard and LeBlanc,
1965).

Climate. - Isohyets generally trend from N-S and average annual precipitation varies
from approximately 80 cm/year in the NW to 120 cm/year in the SE. Precipitation pat-
tern is bimodal, with highs in the spring and autumn except the upper coast which has
a uniform distribution of rainfall throughout the year. Length of the frost-free period
varies from approximately 250 days in the N to 310 days in the S. Average January low
is –1 C in the N and 6 C in the S, while the average July high is approximately 35 C
across all Texas grasslands (U.S. Environ. Data Serv., 1968).

METHODS

Stand selection. - During the autumn and winter of 1979-1980, the study area was
surveyed to locate remnant upland stands of native vegetation. Approximately 50 rem-
nant stands were located, and 35 were selected for further study. These stands were con-
sidered representative of the variation within and among these prairies based on pre-
vious studies and field reconnaissance. All stands selected were used as hay meadows
and were mowed once or twice a year. None were currently grazed or had a past history
of overgrazing by domestic livestock, and all had unbroken native sod. None had a rec-
ord of treatment with fertilizers or herbicides, and none had been burned within the
past 10 years. Thus, all stands had similar land-use histories. Although annual mowing
may affect composition of grasslands (Conard, 1953), it is considered to be a much less
severe disturbance than that caused by cultivation or abusive grazing (Dyksterhuis,
1946; Launchbaugh, 1955; Collins, 1972). Additionally, since it was nearly constant in
terms of timing and frequency across all stands, it allowed for comparison of composi-
tion and interspecific relationships without the added influence of unequal past pertur-
bation.

Vegetation data. - In the spring and early summer of 1981, 35 remnant stands were
sampled for species frequency and foliage cover using 25 rectangular, 25 x 50 cm qua-
drats in each stand. This quadrat size was chosen based on accepted methods from pre-
vious studies, and a species-area curve which indicated that 25 quadrats of this size
would encounter over 90% of all the species in a stand (Diamond, 1983). Also, 25 qua-
drats of this size provided values of mean total cover and mean cover of the one or two
dominant species in each stand that were 90% reliable within 10% of the mean based
on the formula,

\[ n = \frac{t^2 s^2}{E^2} \]

when t is the tabled t-value for 24 df, α0.1; s^2 is the variance and E is the half width (0.10 of
the mean) of the confidence interval (Avery, 1975). Quadrats were placed in a stratified random
manner within each stand by locating several equidistant parallel lines across the stand and
determining quadrat location along each line by random numbers. All stands were sampled within 1 month to minimize phenological variation. A record was kept of all flowering plants which occurred at each site and a voucher of all species was collected and deposited in the Tracy Herbarium at Texas A&M University. Taxonomic nomenclature follows Gould (1975) for grasses and Correll and Johnston (1970) for other taxa.

Soils data. - Soil samples from 0-10 cm were collected from several locations within each stand and pooled for a composite sample. Soil texture, organic matter content and pH were determined for these composite samples in the laboratory (Black, 1965). Soils were classified to series by soil scientists from the U.S. Soil Conservation Service.

Data analyses. - Principal components analysis (PCA), reciprocal averaging (RA) and polar ordination (based on percentage dissimilarity, coefficient of community and Euclidean distance) were calculated for the full set of 35 stands (Gauch, 1977). Separate ordinations were performed on frequency and cover data of all perennial species and on frequency of perennial graminoids alone.

To elucidate ordination-environmental relationships, product-moment correlation coefficients were calculated between environmental variables and stand position along the derived axes. Climatic variables analyzed included average annual temperature, growing season (May-September) temperature, nongrowing season temperature, annual precipitation, growing season precipitation, nongrowing season precipitation and soil organic matter content, pH, percent sand, silt and clay.

Cluster analyses based on a product-moment correlation matrix and a similarity matrix similar to Euclidean distance (Rohlf et al., 1980) were calculated for the 35 stands. A weighted paired-group similarity phenogram using arithmetic averages was produced from the correlation matrix, while a distance phenogram was produced from the similarity matrix.

Simpson's index (C) and the Shannon-Wiener Index (H') were calculated for each stand (Whittaker, 1972). In addition, richness, measured as the number of species present per stand, was calculated for each stand. Diversity indices and richness values were used as comparative measures in order to relate between habitat diversity across variation in soils and climate.

RESULTS AND DISCUSSION

Ordination. - Ordinations calculated from species frequency produced stand arrangements which agreed with field observations and intuitive examination of data. Ordinations based on frequency of perennial graminoids produced almost identical stand arrangements to those based on all perennial species. The first two axes from PCA using frequency of perennial graminoids accounted for more variation than did any other ordination (sum of the eigenvalues for the first two axes equals 67% for PCA, 56% for RA), and are presented here as a basis for further discussion of vegetation, soils and classification of communities (Fig. 2).

Environmental relationships to the ordination. - Stands on Vertisols from central and northern Texas cluster to the right of the first PCA axis, while stands on Alfisols and Upper Coastal Prairie stands group to the left (Fig. 2). Thus, the first PCA axis cannot be interpreted as a simple soil or N-S gradient. The best one-variable regression model, using stand position on the first axis as the dependent variable, was one using soil pH ($r^2 = 0.74$). The best two-variable model included soil pH and percent organic matter ($r^2 = 0.79$) and the best three variable model contained maximum temperature in the growing season, soil pH and percent clay ($r^2 = 0.86$). Soil variables are important in these models because Alfisols occur low on the first axis and have lower pH, organic matter and clay content than Vertisols, which occur high on the first axis. A few stands on Vertisols of the Upper Coastal Prairie occur low on the first axis, but these have lower pH, organic matter and clay content than Vertisols of central and northern Texas. The importance of growing season maximum temperature in the three-variable model reflects the general trend of coastal sites grouping low vs. central and northern sites.
high on the axis. Thus, the first PCA axis primarily reflects a soils gradient, but also reflects a general S-N arrangement of stands.

The second PCA axis can best be interpreted as a temperature gradient. Correlation coefficients between stand position on the second axis and nongrowing season minimum temperature, yearly minimum and maximum temperature and nongrowing season maximum temperature were all highly significant ($P < 0.0001$). The third PCA axis was not significantly correlated with any measured environmental variable, and a re-

![PCA Diagram]

Fig. 2.—Two-axis display from the results of principal components analysis (PCA) ordination of 35 Texas grasslands based on frequency of perennial graminoids. Plotted are stand locations and associated percent clay and pH of a surface soil sample.
gression using all environmental variables had an $r^2$ value of only 0.51.

Soils data are summarized by soil order and geographic region (Table 1). There is little difference in soil characteristics among regions within the same soil order, with the exception that Vertisols of the Upper Coastal Prairie have lower pH, organic matter and clay content than central and northern Vertisols. Vertisols are clayey in all layers, neutral (central and northern) to slightly acidic (coastal) in reaction and contain 2-6% organic matter. Alfisols have loamy surface layers, slightly acidic pH values and 1-4% organic matter. Organic matter content tended to increase from S-N for both Alfisols and Vertisols. Alfisols of the San Antonio Prairie contained more clay than did Alfisols of other areas, and northern Blackland Alfisols have high silt and low sand content relative to other areas.

Species-environment relationships. — *Paspalum floridanum* and *Sporobolus asper* are important graminoids which have no significant correlations with measured edaphic or climatic variables. These species are widely distributed across all soil types and geographic regions of Texas (Figs. 3 and 4). *Sorghastrum nutans* had a positive correlation ($P<0.01$) with soil pH, but along with *Sporobolus asper* was the only species to occur in all 35 stands sampled. These species apparently have wide tolerance ranges with respect to the combination of edaphic and climatic factors within Texas. *Paspalum floridanum* and *Sporobolus*
Table 1. — Mean textural fractions, organic matter content and pH for Texas grasslands summarized by geographic region and soil order

<table>
<thead>
<tr>
<th>Soil order</th>
<th>Prairie</th>
<th>Coastal</th>
<th>Fayette</th>
<th>Blackland</th>
<th>Northern Blackland</th>
<th>Coastal</th>
<th>San Antonio &amp; Fayette</th>
<th>Northern Blackland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stands</td>
<td>Vertisols</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>Vertisols</td>
<td>2</td>
<td>Alfisols</td>
<td>Alfisols</td>
</tr>
<tr>
<td>Surface texture</td>
<td>C*</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>SL, SCL, CL</td>
<td>L, CL, SCL</td>
<td>SiCL</td>
<td></td>
</tr>
<tr>
<td>Textural fraction (%)</td>
<td>Sand: 20</td>
<td>21</td>
<td>9</td>
<td>10</td>
<td>46</td>
<td>47</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silt: 25</td>
<td>23</td>
<td>26</td>
<td>25</td>
<td>33</td>
<td>26</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay: 55</td>
<td>56</td>
<td>65</td>
<td>65</td>
<td>21</td>
<td>27</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>5.8</td>
<td>7.1</td>
<td>7.1</td>
<td>6.8</td>
<td>5.8</td>
<td>5.7</td>
<td>5.1</td>
<td></td>
</tr>
</tbody>
</table>

* C-Clay, CL-Clay Loam, L-Loam, SCL-Sandy Clay Loam, SiCL-Silty Clay Loam
asperr occur as secondary graminoids, while Sorghastrum nutans is a dominant of some stands. Paspalum floridanum and Sporobolus asper may persist at low levels due to life history patterns (for example: high seed production and viability, seedling morphology) that promote rapid colonization of open microsites.

Schizachyrium scoparium was highly significantly (P < 0.0001) correlated with temperature. This is due to a decrease in importance on northern Blackland sites and is probably a result of competition from dominants on those sites, including Sporobolus siliconus, Carex meadii and Tripsacum dactyloides.

Several species were significantly correlated with both climatic and edaphic variables. One group, which included Andropogon gerardii, Bouteloua curtipendula, Carex microdonta and Stipa leucotricha, was positively correlated (P < 0.01) with percent clay, organic matter and pH of the surface soil and negatively correlated with annual precipitation and growing season maximum temperature. These correlations are consistent with a general N-S decrease in importance, coupled with a decrease in importance over loamy Alfisols vs. clayey Vertisols. A second group, which included Dichanthelium oligosanthes, Fimbristylis puberula and Paspalum plicatum, show the opposite pattern. Paspalum plicatum is restricted to central and southern stands, while D. oligosanthes and F. puberula occur

![Graphical representation of PCA ordination display with species frequency values associated with each stand plotted for six important graminoids within Texas](image-url)
on northern stands over Alfisols as well as central and southern stands. In general, the first group has better competitors in drier cooler areas over clayey soils whereas the second group increases in wetter, warmer areas over loamy soils. *Paspalum plicatulum*, in particular, occurs in both the northern and southern hemispheres from approximately 30°S-30°N latitude. Therefore, it is probably limited by decreasing temperature, but also seems to respond to increased precipitation. Its negative correlation with soil organic matter and pH may also indicate that it is a better competitor on less fertile soils vs. species such as *Andropogon gerardii* and *Bouteloua curtipendula*.

Only one species was significantly correlated with edaphic variables alone. *Paspalum setaceum* was negatively correlated with percent clay and pH and highly positively correlated with percent sand and soil organic matter content. It occurred as a secondary graminoid on Alfisols throughout Texas but was almost excluded from stands on clayey Vertisols.

*Sporobolus sileanus* and *Carex meadii* were dominant, but only present in three stands, whereas *Tripsacum dactyloides* and *Panicum virgatum* were dominants of two stands but only present in four and six stands, respectively (Figs. 3 and 4). Interpretation of the influence of environmental variables by the use of correlation coefficients for these species is difficult since they had only a few nonzero values. However, *S. sileanus* and *C. meadii* were positively correlated with precipitation and negatively correlated with temperature. They were also restricted to stands on silty clay loam Alfisols. *Tripsacum dactyloides* and *P. virgatum* seemed to increase primarily in response to increased precipitation and poor drainage over clayey Vertisols. They are reported as dominants of lowlands throughout Texas and as far N as Nebraska (Diamond, 1983).

Species-species relationships. — Species which were correlated with the same environmental variables were also correlated with each other. Positive correlations probably indicate similar ecological tolerance limits or optima rather than mutualistic or proto-cooperative relationships between species. Negative correlations may indicate dissimilar ecological optima, competition between species or a combination of the two. Species which were highly significantly positively correlated included *Andropogon gerardii* with *Bouteloua curtipendula* and *Eriochloa sericea*; *Stipa leucotricha* with *B. curtipendula*; and *Scleria ciliata* with *Muhlenbergia capillaris*. Species with highly significant negative correlations included *Dichanthelium oligosanthes* with *A. gerardii*, *B. curtipendula* and *Carex microdonata*; and *A. gerardii* with *Fimbristylis puberula* and *Paspalum plicatulum*.

Cluster analysis. — A similarity phenogram from cluster analysis produced groupings similar to those from PCA ordination, was slightly less distorted than a distance phenogram (correlation = 0.84 for the similarity phenogram, 0.81 for the distance phenogram), and is therefore presented here (Fig. 5). Based on analysis of stand groupings within the ordination display, groupings from the similarity phenogram, and analysis of soils and vegetation data from individual stands, four groups of stands were recognized. They were composed of: (1) all 13 Upper Coastal Prairie stands plus four Fayette and two San Antonio Prairie sites over Alfisols; (2) six southern and central Blackland and five Fayette Prairie sites over Vertisols; (3) two northern Blackland sites over Vertisols, and (4) three northern Blackland sites over Alfisols. Two stands included in the first group, one in the Upper Coastal Prairie and one in the San Antonio Prairie, appeared transitional between the first two groups within the ordination display, but were considered most closely related to stands within the first group based on analysis of soil and vegetation data.

Community types. — Mean frequency and foliage cover values were calculated for the four groups identified, which represent four community types (Table 2). Based on these summaries, characteristic species of the four community types are: (1) *Schizachyrium scoparium*, *Paspalum plicatulum* and *Sorghastrum nutans* for Upper Coastal Prairie sites and San Antonio and Fayette Prairie communities over Alfisols; (2) *S. scoparium*, *S. nutans* and *Andropogon gerardii* for Fayette and southern and central Blackland stands; (3) *Tripsacum dactyloides*, *Panicum virgatum* and *S. nutans* for northern Blackland communities over
Table 2. — Mean absolute frequency and relative foliage cover of species by community type for 35 Texas grasslands. Only species which are most characteristic of a community are listed. Means are based on stands of occurrence.

<table>
<thead>
<tr>
<th>Community type Number of stands</th>
<th>SSna 12</th>
<th>SPSn 18</th>
<th>SpC 3</th>
<th>TPaSsn 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Number of stands</td>
<td>Frequency %</td>
<td>Cover %</td>
<td>Number of stands</td>
</tr>
<tr>
<td>GRAMINOIDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andropogon gerardii</td>
<td>12</td>
<td>45</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td>12</td>
<td>47</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Carex meadii</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>C. microdonta</td>
<td>12</td>
<td>40</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Coenorchis cylindrica</td>
<td>2</td>
<td>10</td>
<td>T</td>
<td>6</td>
</tr>
<tr>
<td>Dianthus oligochara</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Dichanthium oligochara</td>
<td>2</td>
<td>16</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Eremophila pubera</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Eryngium virginatum</td>
<td>5</td>
<td>21</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Festuca tenuiflora</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>15</td>
</tr>
<tr>
<td>P. pilosum</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>7</td>
</tr>
<tr>
<td>P. setaceum</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>11</td>
</tr>
<tr>
<td>P. setaceum sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>11</td>
</tr>
<tr>
<td>Schizachyrium scoparium</td>
<td>12</td>
<td>89</td>
<td>29</td>
<td>18</td>
</tr>
<tr>
<td>Scleria ciliata</td>
<td>1</td>
<td>6</td>
<td>T</td>
<td>13</td>
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<tr>
<td>Sorgastrum nutans</td>
<td>12</td>
<td>89</td>
<td>18</td>
<td>18</td>
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<td>Sporobolus asper</td>
<td>12</td>
<td>32</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>S. silicatus</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Stipa leucotricha</td>
<td>12</td>
<td>27</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Tripsacum dactyloides</td>
<td>2</td>
<td>4</td>
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<td>Species</td>
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<td>Acacia hirta</td>
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<td>26</td>
<td>1</td>
<td>11</td>
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<td>A. pratensis</td>
<td>1</td>
<td>8</td>
<td>T</td>
<td>7</td>
</tr>
<tr>
<td>Bispora americana</td>
<td>10</td>
<td>20</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Gnaphalium sp.</td>
<td>9</td>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hedyotis nigricans</td>
<td>11</td>
<td>22</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Helianthus maximilliani</td>
<td>1</td>
<td>20</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Hymenopappus scabiosaeus</td>
<td>9</td>
<td>12</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Liatris sp.</td>
<td>3</td>
<td>8</td>
<td>T</td>
<td>6</td>
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<tr>
<td>Linum medium</td>
<td>3</td>
<td>12</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Neptunia lutea</td>
<td>7</td>
<td>52</td>
<td>1</td>
<td>5</td>
</tr>
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<td>Physostegia intermedia</td>
<td>7</td>
<td>14</td>
<td>T</td>
<td>8</td>
</tr>
<tr>
<td>Ratibida columnaris</td>
<td>3</td>
<td>19</td>
<td>1</td>
<td>4</td>
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<td>Rudbeckia hirta</td>
<td>5</td>
<td>11</td>
<td>T</td>
<td>9</td>
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<tr>
<td>R. nudiflora</td>
<td>10</td>
<td>20</td>
<td>1</td>
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<tr>
<td>Sisyridium pruinum</td>
<td>8</td>
<td>10</td>
<td>T</td>
<td>13</td>
</tr>
</tbody>
</table>

1A-Andropogon gerardii, C-Carex meadiii, P-Paspalum plicatum, Pa-Panicum virgatum, S-Schizachyrium scoparium, Sp-Sporobolus siliquus, Sn-Sorghastrum nutans, T-Thysanis dactyloides

2Trace
Vertisols, and (4) *Sporobolus silveanus* and *Carex meadii* for northern Blackland communities over Alfisols. Thus, four community types are designated: the *Schizachyrium-Paspalum-Sorghastrum*, the *Schizachyrium-Sorghastrum-Andropogon*, the *Tripsacum-Panicum-Sorghastrum* and the *Sporobolus-Carex*.

Composition. — The *Schizachyrium-Paspalum-Sorghastrum* community type contained *Dichanthelium oligosanthes*, *Fimbristylis puberula*, *Paspalum floridanum* and *Sporobolus asper* as secondary species (Table 2). The most common forbs were *Aster ericoides*, *Liatris sp.*, *Neptunia lutea*, *Oxalis dillenii*, *Schrankia uncinata* and *Sisyrinchium prunoseum*. Average total foliage cover was 84%. A total of 156 species, 39 graminoids, 116 forbs and one woody shrub were encountered in 18 stands. An average of 51 species was present per stand.

The *Schizachyrium-Sorghastrum-Andropogon* community type contained *Bouteloua curtispendula*, *Carex microdonta*, *Sporobolus asper* and *Stipa leucotricha* as secondary graminoids. *Acacia hirta*, *Bifora americana*, *Hedyotis nigricans*, *Hymenopappus scabiosaeanus* and *Schrankia un-

Fig. 5. — Similarity phenogram from the results of a cluster analysis based on a correlation matrix (unweighted pair group) generated from frequency of perennial graminoids. Thirty-five Texas grasslands are broken into four groups (1-4) and associated soil surface textures are plotted for each stand.
cinata were the most common forbs. Mean total foliage cover was 99%. A total of 153 species, 37 graminoids, 115 forbs and one woody species were present in 12 stands. An average of 41 species was present per stand.

The Tripsacum-Panicum-Sorghastrum community type contained Bouteloua curtipendula, Carex microdonta, Paspalum floridanum and Sporobolus asper as secondary graminoids. Acacia hirta, Aster ericoides, Bifora americana, Hedyotis nigricans, Rudbeckia hirta and Ruellia humilis were common forbs. This community type is characterized by patches of sparse vegetation intermixed with dense cover, and mean foliage cover was 78%. A total of 68 species, 17 graminoids and 51 forbs were present in two stands. A mean of 51 species was present per stand.

The Sporobolus-Carex community type contained Dichanthelium oligosanthes, Fimbristylis puberula, Panicum virgatum, Paspalum floridanum and Sporobolus asper as secondary graminoids. The most common forbs were Aster pratensis, Gnaphalium sp., Linum medium, Nepeta leuca and Schrankia uncinita. Mean total foliage cover was 94%. A total of 85 species, 24 graminoids and 61 forbs were present in three stands. An average of 57 species was present per stand.

Mapping of community types. — Variation in vegetational composition with soil type is pronounced for the Fayette Prairie (Diamond, 1980). Soil type also has a strong influence on vegetation within the Blackland Prairie (Collins, 1972). Vegetation of Upper Coastal Prairie communities, however, was similar over both Alfisols and Vertisols. Therefore, classification and mapping of vegetation generally corresponds with soil type for all except the Upper Coastal Prairie. No relict stands were located on Mollisols within the Blackland Prairie and interpretation of vegetation over these soils depends largely on data from Collins (1972). In addition, no relict stands were located on Alfisols of central and southern portions of the Blackland Prairie. However, two stands were sampled over Alfisols within the San Antonio Prairie (Fig. 6). Interpretation of vegetation on Alfisols within the main belt of the Blacklands will depend on analysis of data from Launchbaugh (1955) and Collins (1972). Finally, the vegetation of the Fort Worth Prairie, a major grassland region W of the Blackland Prairie which was not quantitatively sampled in this study, was classified and mapped based on data from Dyksterhuis (1946).

In addition to the four community types defined based on quantitative data from 35 stands, three more community types are defined. Two minor variants of the Schizachyrium-Sorghastrum-Andropogon community type, based on relative dominance of Andropogon gerardii, are: (1) the Schizachyrium-Andropogon-Sorghastrum community type on Mollisols of the Blackland Prairie, and (2) the Schizachyrium-Sorghastrum community type on Alfisols of the central and southern Blackland and San Antonio prairies (Fig. 6). The final community type is a Schizachyrium type on Mollisols of the Fort Worth Prairie.

Boundaries between community types tend to be abrupt where soil shifts from Vertisol to Alfisol, for example, between the Schizachyrium-Paspalum-Sorghastrum and the Schizachyrium-Andropogon-Sorghastrum within the Fayette Prairie, and the Sporobolus-Carex and Tripsacum-Panicum-Sorghastrum in the northern Blacklands. However, most communities change gradually in composition along gradually changing environmental gradients.

Species diversity. — Although community type and species composition changed, neither Simpson’s nor the Shannon-Wiener index had significant correlations with measured environmental variables. Values for Simpson’s index ranged from 0.11 to 0.34, while the Shannon-Wiener index ranged from 0.8 to 1.2. Species richness (number present per stand) was negatively correlated with soil pH (r = -0.42, P<0.01). Two factors interact to cause the observed correlation with pH: (1) stands over Vertisols (higher pH) tend to have fewer species than those over Alfisols (lower pH) and (2) richness tends to increase southward whereas soil pH decreases.

Ecological affinities. — The Blackland, Fort Worth, San Antonio, Fayette and Upper Coastal prairies form a continuum with Schizachyrium scoparium and Sorghastrum nutans.
prevailing dominants. *Andropogon gerardii* and *Bouteloua curtipendula* increase northward and *Paspalum plicatulum* southward. This composition indicates these grasslands form a continuum with True Prairie communities to the N (Weaver and Fitzpatrick, 1934; Riser *et al.*, 1981; Diamond, 1983). The *Sporobolus-Carex* and *Tripsacum-Panicum-Sorghastrum* community types occur in response to high precipitation in the NE Blackland Prairie. The latter is similar to lowland communities throughout the southern True Prairie as far N as Nebraska, whereas the former represents a unique grassland with a composition not comparable to any other tallgrass community.

Fig. 6.—Grassland community types of E-central Texas with locations of 35 sample sites
LITERATURE CITED


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