

Technical Report No. 150  
DETAILED VEGETATION MAPPING  
OF THE IBP PAWNEE SITE

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## TABLE OF CONTENTS

|   | Page |
|---|------|
| Title Page . . . . .                                | i    |
| Table of Contents . . . . .                         | ii   |
| Abstract . . . . .                                  | iii  |
| Introduction . . . . .                              | 1    |
| Objectives . . . . .                                | 1    |
| Methods of Procedure . . . . .                      | 3    |
| Aerial Photo Mapping . . . . .                      | 3    |
| Vegetational Type Definition . . . . .              | 5    |
| Results and Discussion . . . . .                    | 7    |
| Literature Cited . . . . .                          | 10   |
| Appendix A. Samples of LAI Point Hit Data . . . . . | 11   |
| Appendix B. Summary of Data . . . . .               | 17   |
| Appendix C. List of Species Encountered . . . . .   | 41   |

## ABSTRACT

The Pawnee Site rangelands, although relatively uniform and dominated by blue grama, exhibit phytosociological variation resulting from soil, moisture, relief, and grazing treatment influences upon vegetation. The spatial modelling effort of the Grassland Biome program requires a detailed vegetation map with definitive type units no larger than 0.1 ha (10 m × 10 m). To this end, three forms of remote sensing imagery were utilized: panchromatic photographs at a scale of 1:5800 and color and infrared prints at a slightly smaller scale. Utilizing mirror and lens stereoscopes, first-order delineations were applied to the panchromatic photographs with further detail added following comparison to the color and infrared prints. Type lines were drawn on the black-and-white prints based on photographic tone, texture, pattern, topographic location, and color variations observable on the three imagery forms. Through a secondary photographic procedure the type lines were transferred to a topographic base map with a scale of 1:4800. Ground truth data were based on Leaf Area Indices (LAI) derived from point hits utilizing a motorized point frame with a movable pin.

## INTRODUCTION

The IBP Pawnee Site, located northeast of Nunn, Colorado, is a grassland area dominated primarily by blue grama. This grassland, though relatively uniform, exhibits phytosociological variations due to differences in soil, moisture, relief, and intensity of grazing. The spatial modelling effort of the Grassland Biome program requires a detailed vegetation map of the area in order to define herbaceous variation.

## OBJECTIVES

The initial objective of this project was to develop a detailed vegetation map of the Pawnee Site based on areas delineated by differences observable in aerial photographs. This map includes all of Sec. 23 and the E $\frac{1}{2}$  Sec. 15, i.e., the heavy, medium, and light summer-grazed pastures. Also included on the map are areas which lie outside these three pastures but within the boundaries of the Central Basin Watershed. This includes parts of W $\frac{1}{2}$  Sec. 24, NW $\frac{1}{4}$  Sec. 15, NE $\frac{1}{4}$  of Sec. 22, SW $\frac{1}{4}$  of Sec. 14, and portions of Sec. 9, 10, and 13. The half section that the IBP headquarters is located upon (S $\frac{1}{2}$  Sec. 21) is also included in the map (Fig. 1).

The second objective required that each type area, delineated by lines representing observable photographic differences, be defined in terms of vegetational components and area occupied within the study unit. The herbaceous character of each type was to be defined in terms of Leaf Area Index (LAI) values derived by sampling with a point frame. Type areas were to be determined in hectares.

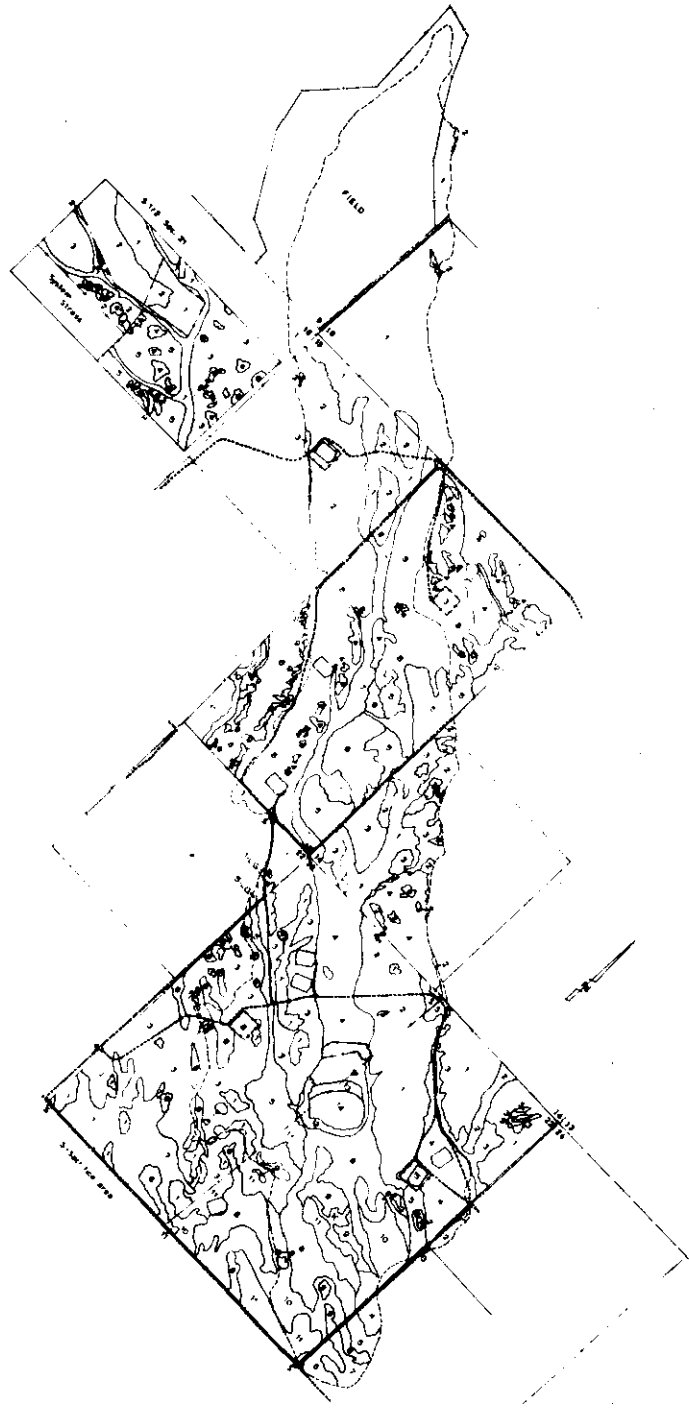


Fig. 1. Vegetational type map of the Central Basin Watershed and the Pawnee Site headquarters. See Appendix B for the details of the plant species in each numbered type.

## METHODS OF PROCEDURE

### Aerial Photo Mapping

Vegetational types were delineated for the area to be mapped using panchromatic aerial photographs having a scale of 1:5800. Color and infrared prints with a slightly smaller scale were compared and contrasted with the panchromatic photos. This was done to complement the interpretation of the latter and to aid in making final decisions of where type lines should be drawn.

Aerial photo interpretation through stereoscopic observation of paired stereo photographs is a precise operation. It requires well-trained and conscientious personnel with comprehensive technical knowledge as well as the time, capability, and intent to successfully and accurately utilize the art of stereoscopic observation in order to interpret and identify differences on the photographs which represent variations in the area photographed. A trained, skillful interpreter is often able to delineate, through a stereoscopic observation of aerial photographs, differences and variations not observable on the ground.

The primary tools used by the aerial photo interpreter for observational study of photographs are the mirror and lens stereoscope. The mirror stereoscope provides the viewer with a large viewable area and little magnification from which the first-order designations of site variations are derived. The lens stereoscope, with 2 to 4 power magnification, provides a much smaller field of view from which the greatest detail is observable.

According to Avery (1968), factors useful in photo interpretation are topographic location, texture, pattern, shape, size, tone, and shadow. Essentially topographic location, texture, pattern, and tone were used for determination of type delineations in the Pawnee Site aerial photographs.

Additional information was available through the study of color and infrared imagery. This was most useful for the delineation of types resulting from site characteristics causing differences in productivity, but not necessarily composition. These variations were often easily observable on the color or infrared photographs, but were almost undistinguishable on the black and white.

The type lines representing delineation of areas with herbaceous variation, as derived by interpretation of visible differences when viewed by stereoscopic inspection, were drawn with red pencil directly onto the panchromatic photographic prints. Transferring these lines to the map with a scale of 1 inch = 400 ft required a secondary photographic process. Using a 35-mm camera and color film, pictures were taken of each pasture or study area unit, the largest of which occupied no more than 130 ha. The camera was positioned at a distance from the aerial photograph such that the specific unit to be photographed was centered in the viewfinder and occupied only one-fourth to one-third of the subsequent colored slide. The restriction was necessary to reduce, as much as possible, the influence of photographic displacement and distortion upon the imagery of the slides.

To transfer the type lines to the base line map, the slides were projected onto the appropriate portion of the wall-mounted map. The projector was mounted on a tripod for locating the position which would align at least three of the pasture corners or location points from the projected slide image onto the identical location points on the base line map. Type lines were then drawn onto the map within the area encompassed by the location points. If only three location points were identically aligned for a rectangular pasture unit, the type lines were drawn only on one-half

of that unit prior to repositioning the projector to align a fourth corner point and two previously aligned points.

Line matching resulting from the projector repositioning was sufficiently accurate to locate type lines with errors no greater than 1 to 2 m. On the ground, comparison with identifiable check-point locations were also able to show very little, if any, line-position error.

#### Vegetational Type Definition

Data for computation of LAI were collected during the summer of 1971 using a motorized point frame with a movable pin developed by Dr. Dennis Knight of the University of Wyoming. The frame settings were distributed over each type using restricted random and systematic selection procedures with 10 pin points read at each frame setting. For each pin, the species and number of plant contacts with the pin point were recorded on a tape recorder. At the end of each day the data were transferred from the recorder to data sheets. The number of points recorded in each type varied from 400 to 600 depending on the density of vegetation within the type, fewer points being recorded as the density increased.

Measurement of LAI, using the method of Warren-Wilson (Wilson, 1963), requires data collection of point contacts with the pin oriented at three angles: 8°, 32.5°, and 65°. The LAI is then calculated by entering the number of average hits per pin (f) for each of the three angles in the formula:

$$LAI = .089f_{8^{\circ}} + .462f_{32.5^{\circ}} + .453f_{65^{\circ}}$$

Early work by Dr. Dennis Knight suggested that a single angle setting could be used on the Pawnee Grassland and that LAI could be computed by



insertion of a modifying constant into the formula (Knight, personal communication). Dr. Knight indicated that Leaf Area Index could be computed from data obtained with a pin setting of 32.5° when the average number of hits per pin is multiplied by the constant 0.87 in the formula:

$$LAI = 0.87f_{32.5^\circ}$$

Near the end of the summer period it was noted that the point frames had inadvertently been constructed such that the leg settings for the 32.5° and 65° angles had been reversed. Since the point data had already been obtained from the majority of the type areas with the pin at the 65° angle and insufficient time was available for complete resampling, a secondary subsampling was conducted with the pin at 32.5°. In addition to the point contact data which were obtained in each type area with the pin set at 65°, three areas were selected within which replicate data were obtained with the pin set at 32.5°. These data were obtained for blue grama, buffalo grass, and the total of all species. The mean of all taxa among the three type areas sampled was then used as a conversion coefficient for the computation of LAI. The conversion coefficient (C), with "Rf" representing the average number of hits per pin obtained from the three type areas sampled both by the 65° pin and 32.5° pin setting, is given by:

$$C = \frac{Rf_{32.5^\circ}}{Rf_{65^\circ}}$$

Computation of LAI values on the remainder of the type areas was subsequently made using the following equation:

$$LAI = (C)(f_{65^{\circ}})(0.87)$$

Appendix A includes a sample of recorded point contact data. The sampling adequacy, in terms of numbers of points ( $N_F$ ) required to effectively estimate LAI, was determined using:

$$N_F = \frac{S}{\bar{X}_F} < .10\bar{X}_F$$

where  $X_F$  represents the sampled number of point contacts of blue grama per frame of 10 pin recordings, and  $S$  is the standard error of the mean of herbaceous contacts per frame. Sampling was considered adequate only when sufficient point contact data had been obtained such that  $S$  was less than 10% of the mean hits per frame. The number of frames required varied from 40 to 60 within a type area.

Following the sampling season, some of the original type lines were modified due to inconsistencies between what appeared on the photos and what could actually be observed on the ground. In some cases, types were so heterogenous that more complete breakdowns of the types were abandoned in favor of less error in delineation.

## RESULTS AND DISCUSSION

The accompanying map shows the vegetation type areas which were determined by photo analysis and field work. LAI data are presented in the tables in Appendix B. Using the procedure described earlier, the

correction coefficient utilized for computation of LAI was determined to be 2.110. The LAI values were determined for blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) and for the total of all species. Other species were so seldom encountered with the sampling procedure used that an accurate estimate of LAI was not possible. An analysis of variance has yet to be conducted on the data; however, there are certain differences which stand out when reviewing the data.

Total LAI in the light-grazed pasture varies from .7435 in type no. 2 to .4956 in type no. 8. Blue grama LAI for these two areas is .5738 and .2019, respectively. It is apparent from this that blue grama makes up a larger portion of the total vegetation cover in type no. 2 than in type no. 8. In the heavy-grazed pasture, type no. 12 shows the LAI for buffalo grass to be .9958. This is also the total value since this was the only species recorded in that type. In contrast, type no. 7 had a value of .3916 for total LAI with no buffalo grass present. An example from the medium-grazed pasture shows that blue grama and buffalo grass in type no. 9 have identical LAI values of .1652. The total LAI for this area is .4865. Type no. 6, adjacent to type no. 9, has LAI values for blue grama, buffalo grass, and the total of all the species as follows: .2800, .0918, and .6012. Type no. 9 is a southwest-facing ridge top and is therefore drier and less productive than type no. 6 which is the drainage area just below it.

When comparing the vegetation map with the soils map and with the topography map of the area, it can be noted that vegetational types and densities interrelate closely with soil variation as well as relief. There does not seem to be much correlation between LAI and grazing treatment.

A method other than the point contact method of measuring LAI could have provided a more accurate estimate of the vegetation parameters sought in this project. This is especially true when the species causing observed photographic imagery differences in the vegetation were some of the very minor species which were often missed by point contact sampling. Where the point frame was not an adequate sampling method to detect these differences in the minor species, some other procedures involving area and/or density measures could well have been utilized to effectively provide rapid estimation of these taxa.

LITERATURE CITED

Avery, T. E. 1968. Interpretation of aerial photographs. 2nd ed. Burgess Publ. Co., Minneapolis. 324 p.

Wilson, J. W. 1963. Estimation of foliage denseness and foliage angle by inclined point quadrats. Aust. J. Bot. 11:95-105.

APPENDIX A

SAMPLES OF LAI POINT HIT DATA

Leaf Area Index point contact data collected in 1971 at the Pawnee Site are Grassland Biome data set A2U00QB. An example of the data follows.







APPENDIX A

(continued)

Type #1 Heavy-grazed pasture.

| Set   | Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |   |
|-------|---------|---|---|---|---|---|---|---|---|---|----|---|---|---|---|---|---|---|---|---|----|---|
| 1-4   | BOGR    | - | - | - | - | - | - | - | - | - | 1  | - | - | - | - | - | - | - | - | - | -  | - |
|       | BUDA    | - | 1 | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | SPCO    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
| 5-8   | BOGR    | - | 1 | - | 1 | - | 1 | - | 1 | - | 1  | - | - | - | - | - | - | - | - | - | -  | - |
|       | SPCO    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
| 9-12  | BUDA    | 1 | - | 2 | 1 | - | 1 | - | 1 | - | 1  | - | - | - | - | - | - | - | - | - | -  | - |
|       | BOGR    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | CAEL    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | VUOC    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
| 13-16 | BOGR    | - | - | - | - | - | - | - | 1 | 1 | 1  | - | - | - | - | - | - | - | - | - | -  | - |
|       | BUDA    | - | - | - | - | - | - | - | - | 1 | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | CAEL    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
| 17-20 | BOGR    | - | 1 | - | - | 1 | 1 | 1 | 1 | 1 | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | CAEL    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
| 21-24 | BOGR    | 2 | - | - | - | 1 | - | 2 | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | CAEL    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
| 25-28 | BOGR    | - | - | - | 1 | 1 | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | OPPO    | - | - | - | 1 | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | BUDA    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | CAEL    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |
|       | VUOC    | - | - | - | - | - | - | - | - | - | -  | - | - | - | - | - | - | - | - | - | -  | - |





**APPENDIX B**  
**SUMMARY OF DATA**

APPENDIX B

(continued)

Appendix Table 1. Light-grazed pasture.

| Type No.                  | Species    | No. of Hits  | Mean Hits/Pin | LAI            |
|---------------------------|------------|--------------|---------------|----------------|
| 1 (N = 400) <sup>a/</sup> | ARLO3      | 5            | .0125         | .1148<br>.3396 |
|                           | BOGR2      | 25           | .0625         |                |
|                           | BUDA       | 74           | .1850         |                |
|                           | CAEL2      | 5            | .0125         |                |
|                           | CAFI       | 3            | .0075         |                |
|                           | OPPO       | 1            | .0025         |                |
|                           | PSTE3      | 1            | .0025         |                |
|                           | <u>7</u>   | <u>114</u>   | <u>.2850</u>  | .5232          |
| 2 (N = 400)               | AGSM       | 3            | .0075         | .5738<br>.0137 |
|                           | ARFR4      | 3            | .0075         |                |
|                           | ARLO3      | 5            | .0125         |                |
|                           | BAOP       | 4            | .0100         |                |
|                           | BOGR2      | 125          | .3125         |                |
|                           | BUDA       | 3            | .0075         |                |
|                           | CAEL2      | 7            | .0175         |                |
|                           | CHNA2      | 2            | .0050         |                |
|                           | OPPO       | 2            | .0050         |                |
|                           | PLPAG      | 1            | .0025         |                |
|                           | SPCO       | 3            | .0075         |                |
|                           | SPCR       | 1            | .0025         |                |
|                           | VUOC       | 3            | .0075         |                |
|                           | <u>13</u>  | <u>162</u>   | <u>.4050</u>  |                |
| 3 (N = 600)               | ARFR4      | 4            | .0067         | .3640          |
|                           | ARLO3      | 13           | .0217         |                |
|                           | BAOP       | 1            | .0017         |                |
|                           | BOGR2      | 119          | .1983         |                |
|                           | CAEL2      | 17           | .0283         |                |
|                           | CAFI       | 1            | .0017         |                |
|                           | CHNA2      | 5            | .0083         |                |
|                           | EREF       | 6            | .0100         |                |
|                           | GUSA2      | 7            | .0117         |                |
|                           | LEDE       | 2            | .0033         |                |
|                           | OPPO       | 13           | .0217         |                |
|                           | PSTE3      | 1            | .0017         |                |
|                           | SIHY       | 5            | .0083         |                |
|                           | SPCO       | 9            | .0150         |                |
|                           | STCO4      | 10           | .0167         |                |
|                           | THTR2      | 1            | .0017         |                |
|                           | VUOC       | 3            | .0050         |                |
| <u>17</u>                 | <u>225</u> | <u>.3750</u> | .6884         |                |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

Appendix Table 1 (continued).

| Type No.    | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|-------------|-----------|-------------|---------------|-------|
| 4 (N = 600) | ARL03     | 12          | .0200         |       |
|             | BAOP      | 2           | .0033         |       |
|             | BOGR2     | 116         | .1933         | .3549 |
|             | BUDA      | 25          | .0417         | .0766 |
|             | CAEL2     | 17          | .0283         |       |
|             | CHNA2     | 1           | .0017         |       |
|             | MUT02     | 5           | .0083         |       |
|             | SCPA      | 2           | .0033         |       |
|             | SPCO      | 9           | .0150         |       |
|             | VUOC      | 4           | .0067         |       |
|             | <u>10</u> | <u>193</u>  | <u>.3217</u>  | .5906 |
| 5 (N = 400) | ARFR4     | 19          | .0475         |       |
|             | ARL03     | 10          | .0250         |       |
|             | BOGR2     | 84          | .2100         | .3855 |
|             | CAEL2     | 14          | .0350         |       |
|             | CHNA2     | 1           | .0025         |       |
|             | GAC05     | 2           | .0050         |       |
|             | HEVI      | 5           | .0125         |       |
|             | LEDE      | 2           | .0050         |       |
|             | MUT02     | 1           | .0025         |       |
|             | OPPO      | 9           | .0225         |       |
|             | SPCO      | 1           | .0025         |       |
|             | STC04     | 1           | .0025         |       |
|             | THTR2     | 3           | .0075         |       |
|             | <u>13</u> | <u>152</u>  | <u>.3800</u>  | .6976 |
| 6 (N = 500) | ARL03     | 8           | .0160         |       |
|             | BOGR2     | 109         | .2180         | .4002 |
|             | CAEL2     | 16          | .0320         |       |
|             | CHNA2     | 3           | .0060         |       |
|             | EREF      | 1           | .0020         |       |
|             | GUSA2     | 3           | .0060         |       |
|             | LARE      | 1           | .0020         |       |
|             | LEDE      | 1           | .0020         |       |
|             | OPPO      | 4           | .0080         |       |
|             | SPCO      | 5           | .0100         |       |
|             | SPCR      | 1           | .0020         |       |
|             | THTR2     | 1           | .0020         |       |
|             | VUOC      | 4           | .0080         |       |
|             | <u>13</u> | <u>157</u>  | <u>.3140</u>  | .5764 |
| 7 (N = 400) | AGSM      | 1           | .0025         |       |
|             | ARFR4     | 1           | .0025         |       |

APPENDIX B

Appendix Table 1 (continued).

| Type No.    | Species    | No. of Hits  | Mean Hits/Pin | LAI   |
|-------------|------------|--------------|---------------|-------|
| 7 (N = 400) | BOGR2      | 96           | .2400         | .4406 |
|             | CAEL2      | 11           | .0275         |       |
|             | OECO       | 1            | .0025         |       |
|             | SPCO       | 1            | .0025         |       |
|             | THTR2      | 6            | .0150         |       |
|             | <u>7</u>   | <u>117</u>   | <u>.2925</u>  |       |
| 8 (N = 500) | AGSM       | 3            | .0060         | .2019 |
|             | ARFR4      | 13           | .0260         |       |
|             | ARLO3      | 5            | .0100         |       |
|             | ASBI       | 1            | .0020         |       |
|             | BOGR2      | 55           | .1100         |       |
|             | CAEL2      | 13           | .0260         |       |
|             | CHNA2      | 2            | .0040         |       |
|             | EREF       | 2            | .0040         |       |
|             | OPPO       | 11           | .0220         |       |
|             | PSTE3      | 3            | .0060         |       |
|             | SIHY       | 1            | .0020         |       |
|             | SPCO       | 2            | .0040         |       |
|             | STCO4      | 22           | .0440         |       |
|             | VUOC       | 2            | .0040         |       |
| <u>14</u>   | <u>135</u> | <u>.2700</u> | .4956         |       |

APPENDIX B

(continued)

Appendix Table 2. Medium-grazed pasture.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI          |
|---------------------------|-----------|-------------|---------------|--------------|
| 1 (N = 400) <sup>a/</sup> | AGSM      | 12          | .0300         |              |
|                           | ARFR4     | 5           | .0125         |              |
|                           | ARLO3     | 16          | .0400         |              |
|                           | BAOP      | 2           | .0050         |              |
|                           | BOGR2     | 91          | .2275         | .4176        |
|                           | BUDA      | 5           | .0125         | .0230        |
|                           | CAEL2     | 5           | .0125         |              |
|                           | EREF      | 21          | .0525         |              |
|                           | OECO2     | 1           | .0020         |              |
|                           | OPPO      | 8           | .0200         |              |
|                           | SIHY      | 1           | .0020         |              |
|                           | SPCO      | 2           | .0050         |              |
|                           | VUOC      | 6           | .0150         |              |
|                           | <u>13</u> | <u>175</u>  | <u>.4375</u>  | .8031        |
| 2 (N = 400)               | AGSM      | 3           | .0075         |              |
|                           | ARFR4     | 15          | .0375         |              |
|                           | ARLO3     | 5           | .0125         |              |
|                           | BOGR2     | 14          | .0350         | .0643        |
|                           | BUDA      | 91          | .2275         | .4176        |
|                           | CAEL2     | 36          | .0900         |              |
|                           | HEVI      | 22          | .0550         |              |
|                           | LYJU      | 2           | .0050         |              |
|                           | OPPO      | 1           | .0025         |              |
|                           | SPCO      | 4           | .0100         |              |
|                           | VUOC      | 2           | .0050         |              |
|                           | <u>11</u> | <u>195</u>  | <u>.4875</u>  | .8949        |
| 3 (N = 400)               | AGSM      | 9           | .0225         |              |
|                           | ARFR4     | 20          | .0500         |              |
|                           | ARLO3     | 4           | .0100         |              |
|                           | BOGR2     | 61          | .1525         | .2800        |
|                           | BUDA      | 3           | .0075         | .0137        |
|                           | CAEL2     | 17          | .0425         |              |
|                           | CHNA2     | 1           | .0025         |              |
|                           | OPPO      | 2           | .0050         |              |
|                           | SPCO      | 15          | .0375         |              |
|                           |           | <u>9</u>    | <u>132</u>    | <u>.3300</u> |
| 4 (N = 400)               | ARLO3     | 7           | .0175         |              |
|                           | BOGR2     | 36          | .0900         | .1652        |
|                           | BUDA      | 70          | .1750         | .3213        |
|                           | CAEL2     | 19          | .0475         |              |
|                           | CAFI      | 1           | .0025         |              |

<sup>a/</sup> N = the total number of pins used



APPENDIX B

Appendix Table 2 (continued).

| Type No.    | Species     | No. of Hits  | Mean Hits/Pin | LAI            |
|-------------|-------------|--------------|---------------|----------------|
| 4 (N = 400) | GAC05       | 1            | .0025         | .6517          |
|             | LIPU        | 1            | .0025         |                |
|             | OPPO        | 2            | .0050         |                |
|             | SPCO        | 5            | .0125         |                |
|             | <u>9</u>    | <u>142</u>   | <u>.3550</u>  |                |
| 5 (N = 400) | AGSM        | 2            | .0050         | .4956          |
|             | ARFR4       | 1            | .0025         |                |
|             | ARLO3       | 2            | .0050         |                |
|             | BOGR2       | 36           | .0900         |                |
|             | BUDA        | 42           | .1050         |                |
|             | CAEL2       | 16           | .0400         |                |
|             | GUSA2       | 3            | .0075         |                |
|             | MUTO2       | 1            | .0025         |                |
|             | OPPO        | 3            | .0075         |                |
|             | SPCO        | 1            | .0025         |                |
|             | <u>VUOC</u> | <u>1</u>     | <u>.0025</u>  |                |
| <u>11</u>   | <u>108</u>  | <u>.2700</u> |               |                |
| 6 (N = 400) | ARFR4       | 1            | .0025         | .6012          |
|             | ARLO3       | 16           | .0400         |                |
|             | BOGR2       | 61           | .1525         |                |
|             | BUDA        | 20           | .0500         |                |
|             | CAEL2       | 8            | .0200         |                |
|             | EREF        | 1            | .0025         |                |
|             | GUSA2       | 2            | .0050         |                |
|             | HEVI        | 1            | .0025         |                |
|             | LEDE        | 1            | .0025         |                |
|             | MUTO2       | 9            | .0225         |                |
|             | OPPO        | 7            | .0175         |                |
|             | SOSE4       | 3            | .0075         |                |
|             | SPCO        | 1            | .0025         |                |
|             | <u>13</u>   | <u>131</u>   | <u>.3275</u>  |                |
| 7 (N = 600) | AGSM        | 1            | .0017         | .2142<br>.1865 |
|             | ARFR4       | 12           | .0200         |                |
|             | ARLO3       | 4            | .0067         |                |
|             | ASSP6       | 2            | .0033         |                |
|             | BOGR2       | 70           | .1167         |                |
|             | BUDA        | 61           | .1016         |                |
|             | CAEL2       | 19           | .0317         |                |
|             | HEVI        | 18           | .0300         |                |
|             | LEDE        | 1            | .0017         |                |
|             | SOSE4       | 1            | .0017         |                |

APPENDIX B

Appendix Table 2 (continued).

| Type No.     | Species      | No. of Hits  | Mean Hits/Pin | LAI   |
|--------------|--------------|--------------|---------------|-------|
| 7 (N = 600)  | SPCO         | 9            | .0150         | .6119 |
|              | VUOC         | 2            | .0033         |       |
|              | <u>12</u>    | <u>200</u>   | <u>.3333</u>  |       |
| 8 (N = 600)  | AGSM         | 1            | .0017         | .5017 |
|              | ARLO3        | 6            | .0100         |       |
|              | BAOP         | 3            | .0050         |       |
|              | BOGR2        | 126          | .2100         |       |
|              | BUDA         | 4            | .0067         |       |
|              | CAEL2        | 11           | .0183         |       |
|              | LEDE         | 1            | .0017         |       |
|              | MUT02        | 5            | .0083         |       |
|              | OPPO         | 2            | .0033         |       |
|              | SPCO         | 2            | .0033         |       |
|              | <u>SPCR</u>  | <u>3</u>     | <u>.0050</u>  |       |
| <u>11</u>    | <u>164</u>   | <u>.2733</u> |               |       |
| 9 (N = 400)  | ARLO3        | 4            | .0100         | .4865 |
|              | BOGR2        | 36           | .0900         |       |
|              | BUDA         | 36           | .0900         |       |
|              | CAEL2        | 11           | .0275         |       |
|              | CAFI         | 2            | .0050         |       |
|              | EVNU         | 1            | .0025         |       |
|              | HEVI         | 11           | .0275         |       |
|              | OPPO         | 3            | .0075         |       |
|              | PLPAG        | 1            | .0025         |       |
|              | <u>SOSE4</u> | <u>1</u>     | <u>.0025</u>  |       |
|              | <u>10</u>    | <u>106</u>   | <u>.2650</u>  |       |
|              | 10 (N = 400) | AGSM         | 9             |       |
| BOGR2        |              | 13           | .0325         |       |
| BUDA         |              | 118          | .2950         |       |
| CAEL2        |              | 18           | .0450         |       |
| CIAR4        |              | 1            | .0025         |       |
| PLPAG        |              | 1            | .0025         |       |
| RAC03        |              | 1            | .0025         |       |
| SOSE4        |              | 17           | .0425         |       |
| SPCO         |              | 2            | .0050         |       |
| <u>VUOC</u>  |              | <u>6</u>     | <u>.0150</u>  |       |
| <u>10</u>    | <u>186</u>   | <u>.4650</u> |               |       |
| 11 (N = 400) | AGSM         | 15           | .0375         | .2891 |
|              | BOGR2        | 36           | .0900         |       |
|              | BUDA         | 63           | .1575         |       |
|              | CAEL2        | 7            | .0175         |       |
|              | CHNA2        | 2            | .0050         |       |

APPENDIX B

Appendix Table 2 (continued).

| Type No.     | Species    | No. of Hits  | Mean Hits/Pin | LAI   |
|--------------|------------|--------------|---------------|-------|
| 11 (N = 400) | DIST       | 1            | .0100         | .6012 |
|              | FRDI       | 1            | .0025         |       |
|              | SOSE4      | 1            | .0025         |       |
|              | VUOC       | 2            | .0050         |       |
|              | <u>9</u>   | <u>131</u>   | <u>.3275</u>  |       |
| 12 (N = 400) | ARFR4      | 5            | .0125         | .5828 |
|              | ARL03      | 16           | .0400         |       |
|              | ASMI10     | 1            | .0025         |       |
|              | ASTA       | 1            | .0025         |       |
|              | BAOP       | 5            | .0125         |       |
|              | BOGR2      | 49           | .1225         |       |
|              | BUDA       | 11           | .0275         |       |
|              | CAEL2      | 5            | .0125         |       |
|              | CAFI       | 3            | .0075         |       |
|              | EREF       | 3            | .0075         |       |
|              | GAC05      | 1            | .0025         |       |
|              | GUSA2      | 2            | .0050         |       |
|              | HEVI       | 20           | .0500         |       |
|              | LIPU       | 1            | .0025         |       |
|              | LYJU       | 1            | .0025         |       |
|              | STC04      | 1            | .0025         |       |
|              | THTR2      | 2            | .0050         |       |
| <u>17</u>    | <u>127</u> | <u>.3175</u> |               |       |

APPENDIX B

(continued)

Appendix Table 3. Heavy-grazed pasture.

| Type No.                  | Species  | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|----------|-------------|---------------|-------|
| 1 (N = 600) <sup>a/</sup> | ARLO3    | 4           | .0067         |       |
|                           | BOGR2    | 144         | .2400         | .4406 |
|                           | BUDA     | 32          | .0533         | .0979 |
|                           | CAEL2    | 11          | .0183         |       |
|                           | CAFI     | 2           | .0033         |       |
|                           | OPPO     | 9           | .0150         |       |
|                           | SPCO     | 3           | .0050         |       |
|                           | STCO4    | 1           | .0017         |       |
|                           | VUOC     | 8           | .0133         |       |
|                           | <u>9</u> | <u>214</u>  | <u>.3567</u>  | .6548 |
| 2 (N = 400)               | ARLO3    | 1           | .0025         |       |
|                           | BOGR2    | 67          | .1675         | .3075 |
|                           | BUDA     | 90          | .2250         | .4131 |
|                           | CAEL2    | 14          | .0350         |       |
|                           | MUTO2    | 3           | .0075         |       |
|                           | OPPO     | 1           | .0025         |       |
|                           | SPCO     | 6           | .0150         |       |
|                           | VUOC     | 4           | .0100         |       |
|                           | <u>8</u> | <u>186</u>  | <u>.4650</u>  | .8536 |
| 3 (N = 400)               | ARLO3    | 1           | .0025         |       |
|                           | BOGR2    | 69          | .1725         | .3167 |
|                           | BUDA     | 53          | .1325         | .2433 |
|                           | CAEL2    | 1           | .0025         |       |
|                           | CAFI     | 2           | .0050         |       |
|                           | MAVI3    | 1           | .0025         |       |
|                           | OPPO     | 2           | .0050         |       |
|                           | SPCO     | 1           | .0025         |       |
|                           | <u>8</u> | <u>130</u>  | <u>.3250</u>  | .5966 |
| 4 (N = 400)               | BOGR2    | 101         | .2525         | .4635 |
|                           | BUDA     | 5           | .0125         | .0230 |
|                           | CAEL2    | 6           | .0150         |       |
|                           | EREF     | 1           | .0025         |       |
|                           | OPPO     | 4           | .0100         |       |
|                           | SPCO     | 5           | .0125         |       |
|                           | VUOC     | 8           | .0200         |       |
|                           | <u>7</u> | <u>130</u>  | <u>.3250</u>  | .5966 |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

Appendix Table 3 (continued).

| Type No.     | Species      | No. of Hits | Mean Hits/Pin | LAI   |
|--------------|--------------|-------------|---------------|-------|
| 5 (N = 400)  | BUDA         | 138         | .3450         | .6334 |
|              | CAEL2        | 19          | .0475         |       |
|              | ELAC4        | 10          | .0250         | .0872 |
|              | VUOC         | 7           | .0175         |       |
|              | <u>4</u>     | <u>174</u>  | <u>.4350</u>  |       |
| 6 (N = 600)  | AGSM         | 13          | .0217         | .7986 |
|              | BUDA         | 17          | .0283         |       |
|              | CAEL2        | 6           | .0100         |       |
|              | ELAC4        | 196         | .3266         |       |
|              | JUTO         | 8           | .0133         |       |
|              | <u>5</u>     | <u>240</u>  | <u>.4000</u>  |       |
| 7 (N = 600)  | ELAC4        | 45          | .0750         | .3916 |
|              | FRDI         | 17          | .0283         |       |
|              | JUTO         | 66          | .1100         |       |
|              | <u>3</u>     | <u>128</u>  | <u>.2133</u>  |       |
| 8 (N = 600)  | BOGR2        | 37          | .0616         | .6669 |
|              | BUDA         | 139         | .2316         |       |
|              | CAEL2        | 23          | .0380         |       |
|              | CIAR4        | 4           | .0067         |       |
|              | SPCR         | 1           | .0017         |       |
|              | VUOC         | 14          | .0233         |       |
|              | <u>6</u>     | <u>218</u>  | <u>.3633</u>  |       |
| 9 (N = 600)  | ARLO3        | 6           | .0100         | .3947 |
|              | BOGR2        | 47          | .0783         |       |
|              | BUDA         | 72          | .1200         |       |
|              | CAEL2        | 4           | .0067         |       |
|              | <u>4</u>     | <u>129</u>  | <u>.2150</u>  |       |
| 10 (N = 500) | ARLO3        | 1           | .0020         | .6094 |
|              | BOGR2        | 93          | .1860         |       |
|              | BUDA         | 43          | .0860         |       |
|              | CAEL2        | 9           | .0180         |       |
|              | HEVI         | 3           | .0060         |       |
|              | OPPO         | 11          | .0220         |       |
|              | SOSE4        | 1           | .0020         |       |
|              | SPCO         | 2           | .0040         |       |
|              | VUOC         | 3           | .0060         |       |
|              | <u>9</u>     | <u>166</u>  | <u>.3320</u>  |       |
|              | 11 (N = 400) | ARLO3       | 3             |       |
| BOGR2        |              | 71          | .1775         |       |
| CAEL2        |              | 11          | .0275         |       |

APPENDIX B

Appendix Table 3 (continued).

| Type No.     | Species     | No. of Hits | Mean Hits/Pin | LAI   |
|--------------|-------------|-------------|---------------|-------|
| 11 (N = 400) | ERCA        | 2           | .0050         |       |
|              | EREF        | 6           | .0150         |       |
|              | OPPO        | 5           | .0125         |       |
|              | PSTE3       | 1           | .0025         |       |
|              | SOSE4       | 2           | .0050         |       |
|              | SPCO        | 4           | .0100         |       |
|              | SPCR        | 4           | .0100         |       |
|              | VUOC        | 6           | .0150         |       |
|              | <u>11</u>   | <u>115</u>  | <u>.2875</u>  |       |
| 12 (N = 400) | <u>BUDA</u> | <u>217</u>  | <u>.5425</u>  | .9959 |
|              | 1           | 217         | .5425         | .9959 |
| 13 (N = 600) | BUDA        | 57          | .0950         | .1744 |
|              | CHDI        | 7           | .0117         |       |
|              | DEPI        | 20          | .0333         |       |
|              | FRDI        | 24          | .0400         |       |
|              | SCPA        | 1           | .0017         |       |
|              | <u>5</u>    | <u>109</u>  | <u>.1816</u>  |       |
| 14 (N = 600) | BUDA        | 3           | .0050         | .0092 |
|              | DEPI        | 7           | .0117         |       |
|              | FRDI        | 48          | .0800         |       |
|              | POAV        | 3           | .0050         |       |
|              | <u>4</u>    | <u>61</u>   | <u>.1017</u>  |       |
| 15 (N = 400) | ARL03       | 3           | .0075         |       |
|              | BOGR2       | 113         | .2825         |       |
|              | BUDA        | 5           | .0125         |       |
|              | CAEL2       | 7           | .0175         |       |
|              | OPPO        | 1           | .0025         |       |
|              | SPCO        | 3           | .0075         |       |
|              | <u>6</u>    | <u>132</u>  | <u>.3300</u>  |       |

APPENDIX B

(continued)

Appendix Table 4.  $W\frac{1}{2}$  Sec. 24.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|-----------|-------------|---------------|-------|
| 1 (N = 400) <sup>a/</sup> | ARL03     | 5           | .0125         |       |
|                           | BOGR2     | 120         | .3000         | .5507 |
|                           | BUDA      | 6           | .0150         | .0276 |
|                           | CAEL2     | 10          | .0250         |       |
|                           | OPPO      | 5           | .0125         |       |
|                           | SPCO      | 3           | .0075         |       |
|                           | <u>6</u>  | <u>149</u>  | <u>.3725</u>  | .6838 |
| 2 (N = 400)               | AGSM      | 4           | .0100         |       |
|                           | ARL03     | 9           | .0225         |       |
|                           | BOGR2     | 52          | .1300         | .2386 |
|                           | BUDA      | 90          | .2250         | .4131 |
|                           | CAEL2     | 6           | .0150         |       |
|                           | EREF      | 2           | .0050         |       |
|                           | GUSA2     | 4           | .0100         |       |
|                           | MUTO2     | 1           | .0025         |       |
|                           | OPPO      | 2           | .0050         |       |
|                           | SPCO      | 1           | .0025         |       |
|                           | SOSE4     | 2           | .0050         |       |
|                           | <u>11</u> | <u>173</u>  | <u>.4325</u>  | .7940 |
| 3 (N = 400)               | BOGR2     | 70          | .1750         | .3213 |
|                           | BUDA      | 66          | .1650         | .3029 |
|                           | CAEL2     | 5           | .0125         |       |
|                           | SPCO      | 2           | .0050         |       |
|                           | <u>4</u>  | <u>143</u>  | <u>.3575</u>  | .6562 |
| 4 (N = 400)               | ARL03     | 5           | .0125         |       |
|                           | BOGR2     | 150         | .3750         | .6884 |
|                           | BUDA      | 8           | .0200         | .0367 |
|                           | CAEL2     | 1           | .0025         |       |
|                           | OPPO      | 5           | .0125         |       |
|                           | SPCO      | 4           | .0100         |       |
|                           | <u>6</u>  | <u>173</u>  | <u>.4325</u>  | .7940 |
| 5 (N = 400)               | BOGR2     | 131         | .3275         | .6012 |
|                           | BUDA      | 17          | .0425         | .0780 |
|                           | CAEL2     | 15          | .0375         |       |
|                           | CHNA2     | 3           | .0075         |       |
|                           | HEVI      | 1           | .0025         |       |
|                           | SPCO      | 1           | .0025         |       |
|                           | <u>6</u>  | <u>168</u>  | <u>.4200</u>  | .7710 |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

Appendix Table 4 (continued).

| Type No.    | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|-------------|-----------|-------------|---------------|-------|
| 6 (N = 400) | AGSM      | 9           | .0225         |       |
|             | ARFR4     | 2           | .0050         |       |
|             | ARLO3     | 22          | .0550         |       |
|             | BOGR2     | 119         | .2970         | .5461 |
|             | BUDA      | 11          | .0275         | .0505 |
|             | CAEL2     | 7           | .0175         |       |
|             | GUSA2     | 8           | .0200         |       |
|             | OPPO      | 2           | .0050         |       |
|             | SPCO      | 1           | .0025         |       |
|             | STCO4     | 2           | .0050         |       |
|             | THTR2     | 1           | .0025         |       |
|             | VUOC      | 1           | .0025         |       |
|             | <u>12</u> | <u>185</u>  | <u>.3700</u>  | .6792 |
| 7 (N = 400) | AGSM      | 1           | .0025         |       |
|             | ARLO3     | 1           | .0025         |       |
|             | BOGR2     | 97          | .2425         | .4452 |
|             | BUDA      | 46          | .1150         | .2111 |
|             | CAEL2     | 4           | .0100         |       |
|             | CAFI      | 1           | .0025         |       |
|             | OPPO      | 2           | .0050         |       |
|             | <u>7</u>  | <u>152</u>  | <u>.3800</u>  | .6976 |



APPENDIX B

(continued)

Appendix Table 5. NE $\frac{1}{4}$  Sec. 22.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|-----------|-------------|---------------|-------|
| 1 (N = 400) <sup>a/</sup> | AGSM      | 3           | .0075         | .2846 |
|                           | ARFR4     | 4           | .0100         |       |
|                           | ARLO3     | 17          | .0425         |       |
|                           | BOGR2     | 62          | .1550         |       |
|                           | CAEL2     | 10          | .0250         |       |
|                           | CHNA2     | 4           | .0100         |       |
|                           | EREF      | 6           | .0150         |       |
|                           | GUSA2     | 1           | .0025         |       |
|                           | MUT02     | 2           | .0050         |       |
|                           | OPPO      | 1           | .0025         |       |
|                           | PLPAG     | 1           | .0025         |       |
|                           | SPCO      | 4           | .0100         |       |
|                           | VUOC      | 1           | .0025         |       |
|                           | <u>13</u> | <u>116</u>  | <u>.2900</u>  | .5324 |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

(continued)

Appendix Table 6. SW $\frac{1}{4}$  Sec. 14.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI          |
|---------------------------|-----------|-------------|---------------|--------------|
| 1 (N = 400) <sup>a/</sup> | ARFR4     | 13          | .0325         |              |
|                           | BOGR2     | 67          | .1675         | .3075        |
|                           | BUDA      | 62          | .1550         | .2846        |
|                           | CAEL2     | 11          | .0275         |              |
|                           | SPCO      | 8           | .0200         |              |
|                           | <u>5</u>  | <u>161</u>  | <u>.4025</u>  | .7389        |
| 2 (N = 400)               | BOGR2     | 82          | .2050         | .3764        |
|                           | BUDA      | 36          | .0900         | .1652        |
|                           | CAEL2     | 4           | .0100         |              |
|                           | GUSA2     | 10          | .0250         |              |
|                           | PSTE3     | 2           | .0050         |              |
|                           | <u>5</u>  | <u>134</u>  | <u>.3350</u>  | .6150        |
| 3 (N = 400)               | AGSM      | 6           | .0150         |              |
|                           | ARFR4     | 29          | .0725         |              |
|                           | ARLO3     | 8           | .0200         |              |
|                           | BAOP      | 3           | .0075         |              |
|                           | BOGR2     | 88          | .2200         | .4039        |
|                           | BUDA      | 14          | .0350         | .0643        |
|                           | CAEL2     | 9           | .0225         |              |
|                           | CHNA2     | 2           | .0050         |              |
|                           | EREF      | 1           | .0025         |              |
|                           | EVNU      | 1           | .0025         |              |
|                           | GUSA2     | 8           | .0200         |              |
|                           | MUTO2     | 9           | .0225         |              |
|                           | OPPO      | 4           | .0100         |              |
|                           | SPCO      | 5           | .0125         |              |
|                           | <u>14</u> | <u>187</u>  | <u>.4675</u>  | .8582        |
| 4 (N = 400)               | AGSM      | 8           | .0200         |              |
|                           | ARFR4     | 14          | .0350         |              |
|                           | ARLO3     | 2           | .0050         |              |
|                           | BAOP      | 5           | .0125         |              |
|                           | BOGR2     | 112         | .2800         | .5140        |
|                           | BUDA      | 4           | .0100         | .0184        |
|                           | EREF      | 3           | .0075         |              |
|                           | OECO2     | 3           | .0075         |              |
|                           | SIHY      | 1           | .0025         |              |
|                           | SPCO      | 11          | .0275         |              |
|                           |           | <u>10</u>   | <u>163</u>    | <u>.4075</u> |

<sup>a/</sup> N = the total number of pins used

## APPENDIX B

(continued)

Appendix Table 7. NW¼ Sec. 15.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|-----------|-------------|---------------|-------|
| 1 (N = 500) <sup>a/</sup> | AGSM      | 4           | .0080         |       |
|                           | ARFR4     | 10          | .0200         |       |
|                           | ARLO3     | 5           | .0100         |       |
|                           | BAOP      | 2           | .0040         |       |
|                           | BOGR2     | 134         | .2680         | .4920 |
|                           | BUDA      | 10          | .0200         | .0367 |
|                           | CAEL2     | 21          | .0420         |       |
|                           | CHNA2     | 6           | .0120         |       |
|                           | EREF      | 2           | .0040         |       |
|                           | GAC05     | 1           | .0020         |       |
|                           | GUSA2     | 3           | .0060         |       |
|                           | HEVI      | 1           | .0020         |       |
|                           | LEDE      | 1           | .0020         |       |
|                           | MUT02     | 4           | .0080         |       |
|                           | SPCO      | 2           | .0040         |       |
|                           | VUOC      | 4           | .0080         |       |
|                           | <u>16</u> | <u>210</u>  | <u>.4200</u>  | .7710 |
| 2 (N = 500)               | AGSM      | 1           | .0020         |       |
|                           | ARFR4     | 4           | .0080         |       |
|                           | ARLO3     | 8           | .0160         |       |
|                           | BAOP      | 3           | .0060         |       |
|                           | BOGR2     | 145         | .2900         | .5324 |
|                           | BUDA      | 9           | .0180         | .0331 |
|                           | CAEL2     | 17          | .0340         |       |
|                           | EREF      | 2           | .0040         |       |
|                           | OPPO      | 1           | .0020         |       |
|                           | SPCO      | 3           | .0060         |       |
|                           | VUOC      | 3           | .0060         |       |
|                           | <u>11</u> | <u>196</u>  | <u>.3920</u>  | .7196 |
| 3 (N = 500)               | ARFR4     | 2           | .0040         |       |
|                           | ARLO3     | 1           | .0020         |       |
|                           | BOGR2     | 91          | .1820         | .3341 |
|                           | BUDA      | 57          | .1140         | .2092 |
|                           | CAEL2     | 5           | .0100         |       |
|                           | GUSA2     | 3           | .0060         |       |
|                           | LEDE      | 1           | .0020         |       |
|                           | OPPO      | 1           | .0020         |       |
|                           | <u>8</u>  | <u>161</u>  | <u>.3220</u>  | .5911 |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

(continued)

Appendix Table 8. Sec. 9, 10, and 16.

| Type No.                  | Species | No. of Hits | Mean Hits/Pin | LAI          |
|---------------------------|---------|-------------|---------------|--------------|
| 1 (N = 400) <sup>a/</sup> | AGSM    | 5           | .0125         |              |
|                           | ARFR4   | 2           | .0050         |              |
|                           | ARL03   | 2           | .0050         |              |
|                           | ASTA    | 1           | .0025         |              |
|                           | ATCA2   | 4           | .0100         |              |
|                           | BOGR2   | 129         | .3225         | .5920        |
|                           | BUDA    | 3           | .0075         | .0137        |
|                           | BRTE    | 2           | .0050         |              |
|                           | OPPO    | 1           | .0025         |              |
|                           | PLPAG   | 2           | .0050         |              |
|                           | SPCO    | 3           | .0075         |              |
|                           | SPCR    | 1           | .0025         |              |
|                           | VUOC    | 2           | .0050         |              |
|                           |         | <u>13</u>   | <u>157</u>    | <u>.3925</u> |
| 2 (N = 400)               | ARFR4   | 12          | .0300         |              |
|                           | BOGR2   | 122         | .3050         | .5599        |
|                           | BUDA    | 8           | .0200         | .0367        |
|                           | CAFI    | 1           | .0025         |              |
|                           | GUSA2   | 2           | .0050         |              |
|                           | LARE    | 2           | .0050         |              |
|                           | SAKAT   | 1           | .0025         |              |
|                           | SPCO    | 2           | .0050         |              |
|                           |         | <u>8</u>    | <u>150</u>    | <u>.3750</u> |

<sup>a/</sup> N = the total number of pins used

## APPENDIX B

(continued)

Appendix Table 9.  $S\frac{1}{2}$  Sec. 21.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI            |
|---------------------------|-----------|-------------|---------------|----------------|
| 1 (N = 400) <sup>a/</sup> | AGSM      | 27          | .0675         | .3534          |
|                           | BUDA      | 77          | .1925         |                |
|                           | CAEL2     | 58          | .1450         |                |
|                           | EREF      | 1           | .0025         |                |
|                           | SPCO      | 3           | .0075         |                |
|                           | SOSE4     | 1           | .0025         |                |
|                           | VUOC      | 2           | .0050         |                |
|                           | <u>7</u>  | <u>169</u>  | <u>.4225</u>  |                |
| 2 (N = 500)               | AGSM      | 50          | .1000         | .2130<br>.1175 |
|                           | ASM010    | 2           | .0040         |                |
|                           | BOGR2     | 58          | .1160         |                |
|                           | BUDA      | 32          | .0640         |                |
|                           | CAEL2     | 28          | .0560         |                |
|                           | CHNA2     | 5           | .0100         |                |
|                           | GAC05     | 1           | .0020         |                |
|                           | GUSA2     | 5           | .0100         |                |
|                           | SIHY      | 1           | .0020         |                |
|                           | SPCO      | 4           | .0080         |                |
|                           | VUOC      | 9           | .0180         |                |
|                           | <u>11</u> | <u>195</u>  | <u>.3900</u>  |                |
| 3 (N = 400)               | AGSM      | 3           | .0075         | .3855<br>.0321 |
|                           | ARFR4     | 1           | .0025         |                |
|                           | BAOP      | 2           | .0050         |                |
|                           | BOGR2     | 84          | .2100         |                |
|                           | BUDA      | 7           | .0175         |                |
|                           | CAEL2     | 8           | .0200         |                |
|                           | CHNA2     | 4           | .0100         |                |
|                           | EREF      | 1           | .0025         |                |
|                           | GUSA2     | 6           | .0150         |                |
|                           | LEDE      | 1           | .0025         |                |
|                           | OPPO      | 4           | .0100         |                |
|                           | SIHY      | 1           | .0025         |                |
|                           | SPCO      | 2           | .0050         |                |
|                           | STCO4     | 1           | .0025         |                |
|                           | VUOC      | 3           | .0075         |                |
|                           | <u>15</u> | <u>128</u>  | <u>.3200</u>  |                |
| 4 (N = 500)               | ARL03     | 1           | .0020         | .1579<br>.3561 |
|                           | BOGR2     | 43          | .0860         |                |
|                           | BUDA      | 97          | .1940         |                |
|                           | CAEL2     | 5           | .0100         |                |
|                           | CAFI      | 1           | .0020         |                |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

Appendix Table 9 (continued).

| Type No.    | Species    | No. of Hits  | Mean Hits/Pin | LAI                     |
|-------------|------------|--------------|---------------|-------------------------|
| 4 (N = 500) | CHNA2      | 6            | .0120         | .6131                   |
|             | GUSA2      | 5            | .0100         |                         |
|             | OPPO       | 3            | .0060         |                         |
|             | SPCO       | 2            | .0040         |                         |
|             | SOSE4      | 2            | .0040         |                         |
|             | VUOC       | 2            | .0040         |                         |
|             | <u>11</u>  | <u>167</u>   | <u>.3340</u>  |                         |
| 5 (N = 500) | AGSM       | 1            | .0020         | .3782<br>.0807<br>.5874 |
|             | ARFR4      | 1            | .0020         |                         |
|             | ARLO3      | 6            | .0120         |                         |
|             | BOGR2      | 103          | .2060         |                         |
|             | BUDA       | 22           | .0440         |                         |
|             | CAEL2      | 7            | .0140         |                         |
|             | CAFI       | 1            | .0020         |                         |
|             | EREF       | 1            | .0020         |                         |
|             | GUSA2      | 2            | .0040         |                         |
|             | HEVI       | 3            | .0060         |                         |
|             | OPPO       | 6            | .0120         |                         |
|             | SIHY       | 2            | .0040         |                         |
|             | SPCO       | 2            | .0040         |                         |
|             | STCO4      | 1            | .0020         |                         |
|             | VUOC       | 2            | .0040         |                         |
| <u>15</u>   | <u>160</u> | <u>.3200</u> |               |                         |
| 6 (N = 400) | AGSM       | 3            | .0075         | .2937<br>.6012          |
|             | BUDA       | 64           | .1600         |                         |
|             | CAEL2      | 34           | .0850         |                         |
|             | ELAC4      | 28           | .0700         |                         |
|             | VUOC       | 2            | .0050         |                         |
| <u>5</u>    | <u>131</u> | <u>.3275</u> |               |                         |

APPENDIX B

(continued)

Appendix Table 10. Holding pasture S½ Sec. 21.

| Type No.                  | Species      | No. of Hits  | Mean Hits/Pin | LAI   |
|---------------------------|--------------|--------------|---------------|-------|
| 1 (N = 500) <sup>a/</sup> | AGSM         | 15           | .0300         |       |
|                           | BOGR2        | 13           | .0260         | .0477 |
|                           | BUDA         | 66           | .1320         | .2423 |
|                           | CAEL2        | 15           | .0300         |       |
|                           | CHNA2        | 2            | .0040         |       |
|                           | GUSA2        | 1            | .0020         |       |
|                           | HEVI         | 1            | .0020         |       |
|                           | PLPAG        | 1            | .0020         |       |
|                           | <u>8</u>     | <u>114</u>   | <u>.2280</u>  | .4186 |
| 2 (N = 500)               | ARFR4        | 25           | .0500         |       |
|                           | BOGR2        | 74           | .1488         | .2732 |
|                           | BUDA         | 1            | .0020         | .0037 |
|                           | CAFI         | 1            | .0020         |       |
|                           | EREF         | 5            | .0100         |       |
|                           | GUSA2        | 8            | .0610         |       |
|                           | HEVI         | 1            | .0020         |       |
|                           | LARE         | 1            | .0020         |       |
|                           | LEDE         | 2            | .0040         |       |
|                           | OPPO         | 3            | .0060         |       |
|                           | PSTE3        | 1            | .0020         |       |
|                           | SPCO         | 1            | .0020         |       |
|                           | STCO4        | 1            | .0020         |       |
|                           | VUOC         | 5            | .0100         |       |
|                           | <u>14</u>    | <u>130</u>   | <u>.2600</u>  | .4773 |
| 3 (N = 500)               | BOGR2        | 85           | .1700         | .3121 |
|                           | BUDA         | 1            | .0020         | .0037 |
|                           | GUSA2        | 6            | .0120         |       |
|                           | LEDE         | 1            | .0020         |       |
|                           | OPPO         | 5            | .0100         |       |
|                           | PLPAG        | 1            | .0020         |       |
|                           | SPCO         | 1            | .0020         |       |
|                           | <u>VUOC</u>  | <u>5</u>     | <u>.0100</u>  |       |
| <u>8</u>                  | <u>105</u>   | <u>.2100</u> | .3855         |       |
| 4 (N = 500)               | ARFR4        | 3            | .0060         |       |
|                           | BOGR2        | 58           | .1160         | .2130 |
|                           | BUDA         | 45           | .0900         | .1652 |
|                           | CAFI         | 3            | .0060         |       |
|                           | GUSA2        | 6            | .0120         |       |
|                           | OPPO         | 1            | .0020         |       |
|                           | OXSE         | 2            | .0040         |       |
|                           | <u>STCO4</u> | <u>1</u>     | <u>.0020</u>  |       |
| <u>8</u>                  | <u>119</u>   | <u>.2380</u> | .4369         |       |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

(continued)

Appendix Table 11. Light-grazed diet pasture.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|-----------|-------------|---------------|-------|
| 1 (N = 500) <sup>a/</sup> | AGSM      | 1           | .0020         |       |
|                           | ARFR4     | 15          | .0300         |       |
|                           | BOGR3     | 83          | .1660         | .3048 |
|                           | BUDA      | 48          | .0960         | .1763 |
|                           | CAEL2     | 3           | .0060         |       |
|                           | CHNA2     | 5           | .0100         |       |
|                           | GAC05     | 1           | .0020         |       |
|                           | OPPO      | 2           | .0040         |       |
|                           | <u>8</u>  | <u>158</u>  | <u>.3160</u>  | .5801 |
| 2 (N = 500)               | AGSM      | 4           | .0080         |       |
|                           | BOGR2     | 126         | .2520         | .4626 |
|                           | BRJA      | 1           | .0020         |       |
|                           | BRTE      | 1           | .0020         |       |
|                           | BUDA      | 16          | .0320         | .0587 |
|                           | CAEL2     | 3           | .0060         |       |
|                           | EREF      | 2           | .0040         |       |
|                           | OPPO      | 1           | .0020         |       |
|                           | SIHY      | 1           | .0020         |       |
|                           | SPCO      | 1           | .0020         |       |
|                           | SPCR      | 1           | .0020         |       |
|                           | VUOC      | 11          | .0220         |       |
|                           | YUGL      | 2           | .0040         |       |
|                           | <u>13</u> | <u>170</u>  | <u>.3400</u>  | .6241 |

<sup>a/</sup> N = the total number of pins used



## APPENDIX B

(continued)

Appendix Table 12. Heavy-grazed diet pasture.

| Type No.                  | Species   | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|-----------|-------------|---------------|-------|
| 1 (N = 500) <sup>a/</sup> | ARFR4     | 10          | .0200         |       |
|                           | ASGR      | 1           | .0020         |       |
|                           | BOGR2     | 78          | .1560         | .2864 |
|                           | BUDA      | 18          | .0360         | .0661 |
|                           | CAEL2     | 3           | .0060         |       |
|                           | CHNA2     | 6           | .0120         |       |
|                           | GUSA2     | 2           | .0040         |       |
|                           | HEHO      | 1           | .0020         |       |
|                           | OPPO      | 2           | .0040         |       |
|                           | SOSE4     | 1           | .0020         |       |
|                           | SPCO      | 2           | .0040         |       |
|                           | <u>11</u> | <u>124</u>  | <u>.2480</u>  | .4553 |
| 2 (N = 500)               | ARFR4     | 1           | .0020         |       |
|                           | BOGR2     | 116         | .2320         | .4259 |
|                           | BUDA      | 13          | .0260         | .0478 |
|                           | EREF      | 1           | .0020         |       |
|                           | GUSA2     | 6           | .0120         |       |
|                           | OPPO      | 4           | .0080         |       |
|                           | SPCO      | 2           | .0040         |       |
|                           | VUOC      | 1           | .0020         |       |
|                           | <u>8</u>  | <u>144</u>  | <u>.2880</u>  | .5287 |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

(continued)

Appendix Table 13a.  $S\frac{1}{2}$  Sec. 21;  $32.5^\circ$  frame setting.

| Type No.                  | Species  | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|----------|-------------|---------------|-------|
| 5 (N = 300) <sup>a/</sup> | AGSM     | 1           | .0033         |       |
|                           | BOGR2    | 137         | .4567         | .3973 |
|                           | BUDA     | 44          | .1467         | .1276 |
|                           | CAEL2    | 5           | .0167         |       |
|                           | GUSA2    | 2           | .0067         |       |
|                           | LEDE     | 1           | .0033         |       |
|                           | OPPO     | 3           | .0100         |       |
|                           | PLPAG    | 1           | .0033         |       |
|                           | SIHY     | 1           | .0033         |       |
|                           | <u>9</u> | <u>195</u>  | <u>.6500</u>  | .5655 |

<sup>a/</sup> N = the total number of pins used

APPENDIX B

(continued)

Appendix Table 13b.  $W\frac{1}{2}$  Sec. 24;  $32.5^\circ$  frame setting.

| Type No.                  | Species  | No. of Hits | Mean Hits/Pin | LAI   |
|---------------------------|----------|-------------|---------------|-------|
| 5 (N = 300) <sup>a/</sup> | BOGR2    | 199         | .6633         | .5771 |
|                           | BUDA     | 36          | .1200         | .1044 |
|                           | CAEL2    | 29          | .0967         |       |
|                           | OPPO     | 1           | .0033         |       |
|                           | SPCR     | 6           | .0200         |       |
|                           | VUOC     | 6           | .0200         |       |
|                           | <u>6</u> | <u>277</u>  | <u>.9233</u>  | .8033 |
| 7 (N = 300)               | BOGR2    | 117         | .3900         | .3393 |
|                           | BUDA     | 45          | .1500         | .1305 |
|                           | CAFI     | 4           | .0100         |       |
|                           | GUSA2    | 1           | .0033         |       |
|                           | OPPO     | 2           | .0067         |       |
|                           | SOSE4    | 2           | .0067         |       |
|                           | SPCO     | 1           | .0033         |       |
|                           | <u>7</u> | <u>172</u>  | <u>.5733</u>  | .4988 |

<sup>a/</sup> N = the total number of pins used

**APPENDIX C**  
**LIST OF SPECIES ENCOUNTERED**

APPENDIX C (continued)

The following is a list of all species encountered with the point frame during sampling on the Pawnee Site.

- AGSM *Agropyron smithii* Rydb.  
ARFR4 *Artemisia frigida* Willd.  
ARLO3 *Aristida longiseta* Steud.  
ASMI10 *Astragalus missouriensis* Nutt.  
ASSP6 *Astragalus spatulatus* Sheld.  
MATA *Aster tanacetifolius* H. B. K.  
ACTA2 *Atriplex canescens* (Pursh) Nutt.  
BAOP *Bahia oppositifolia* (Nutt.) Dc.  
BOGR2 *Bouteloua gracilis* (H. B. K.) Lag.  
BRJA *Bromus japonicus* Thunb.  
BRTE *Bromus tectorum* L.  
BUDA *Buchloe dactyloides* (Nutt.) Engelm.  
CAEL2 *Carex eleocharis* Bailey  
CAFI *Carex filifolia* Nutt.  
CHD1 *Chenopodium disiccatum* A. Nels.  
CHNA2 *Chrysothamnus nauseosus* (Pall.) Britt.  
CIAR4 *Cirsium arvense* (L.) Scop.  
DIST *Distichlis stricta* (Torr.) Rydb.  
ELAC4 *Eleocharis acicularis* (L.) R. & S.  
ERCA *Erigeron canadensis* L.  
EREF *Eriogonum effusum* Nutt.  
EVNU *Evolvulus nuttallianus* Roem. & Schult.  
FRDI *Franseria discolor* Nutt.

APPENDIX C (continued)

- GAC05 *Gaura coccinea* Nutt. ex Pursh  
GUSA2 *Gutierrezia sarothrae* (Pursh) Britt. & Rusby  
HEV1 *Heterotheca villosa* (Pursh) Skinners  
HEH0 *Heterotheca horrida* (Rydb.) Harms.  
JUT0 *Juncus torreyi* Coville  
LARE *Lappula redowskii* (Hornem.) Greene  
LEDE *Lepidium densiflorum* Schrad.  
LIPU *Liatris punctata* Hook.  
LYJU *Lygodesmia juncea* (Pursh) D. Don.  
MAV13 *Mammillaria vivipara* (Nutt.) Haw.  
MUT02 *Muhlenbergia torreyi* (Kunth) Hitchc.  
OEC02 *Oenothera coronopifolia* Torr. & Gray  
OPPO *Opuntia polyacantha* Haw.  
OXSE *Oxytropis sericea* Nutt.  
PLPAG *Plantago purshii* Roem. & Schult.  
POAV *Polygonum aviculare* L.  
PSTE3 *Psoralea tenuiflora* Pursh  
RAC03 *Ratibida columnaris* (Sims.) D. Don.  
SAKAT *Salsola kali tenuifolia* Tausch.  
SCPA *Schedonnardus paniculatus* (Nutt.) Trel.  
SIHY *Sitariano hystrix* (Nutt.) J. G. Smith  
SOSE4 *Sophora sericea* Nutt.  
SPCO *Sphaeralcea coccinea* (Pursh) Rydb.  
SPCR *Sporobolus cryptandrus* (Torr.) A. Gray  
STC04 *Stipa comata* Trin. & Rupr.

APPENDIX C (continued)

- THTR2 *Thelesperma trifidum* (Poir.) Britt.  
VUOC *Vulpia octoflora* (Walt.) Rydb.  
YUGL *Yucca glauca* Nutt.