

HABITAT UTILIZATION BY NON-GAME BIRDS

by

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A Master's Thesis

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

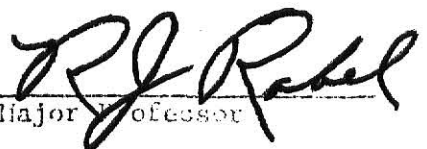
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T39 TABLE OF CONTENTS

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|                                                                                                     |     |
|-----------------------------------------------------------------------------------------------------|-----|
| GENERAL INTRODUCTION                                                                                | 1   |
| PART I: Field Observation of Habitat Utilization by Non-Game Birds                                  | 3   |
| Introduction                                                                                        | 3   |
| Literature Review                                                                                   | 4   |
| Materials and Methods                                                                               | 6.  |
| Analysis                                                                                            | 12. |
| Results                                                                                             | 13. |
| Discussion                                                                                          | 32. |
| PART II: Seed Seasonal Availability of Four Selected Plant Species                                  | 35. |
| Introduction                                                                                        | 35. |
| Literature Review                                                                                   | 36. |
| Materials and Methods                                                                               | 37. |
| Analysis                                                                                            | 39. |
| Results                                                                                             | 40. |
| Discussion                                                                                          | 43. |
| PART III: Metabolic Efficiencies of Field Sparrows and Cardinals<br>for Seeds of Four Plant Species | 45. |
| Introduction                                                                                        | 45. |
| Literature Review                                                                                   | 46. |
| Materials and Methods                                                                               | 47. |
| Analysis                                                                                            | 51. |
| Results                                                                                             | 52. |
| Discussion                                                                                          | 58. |
| PART IV: Preferences of Field Sparrows and Cardinals Among Four<br>Seed Types                       | 61. |
| Introduction                                                                                        | 61. |

|                        |      |
|------------------------|------|
|                        | 11   |
| Literature Review      | 62.  |
| Materials and Methods  | 65.  |
| Analysis               | 68.  |
| Results                | 69.  |
| Discussion             | 78.  |
| ENERGETIC IMPLICATIONS | 81.  |
| ACKNOWLEDGEMENTS       | 91.  |
| LITERATURE CITED       | 92.  |
| APPENDIX               | 96.  |
| Table 1                | 96.  |
| Table 2                | 98.  |
| Table 3                | 101. |
| Table 4                | 103. |
| Table 5                | 105. |
| Table 6                | 107. |
| Table 7                | 108. |
| Table 8                | 109. |
| Table 9                | 110. |
| Table 10               | 111. |
| Table 11               | 112. |
| Table 12               | 113. |

## General Introduction:

To develop an effective wildlife habitat improvement program, detailed knowledge of habitat utilization is essential. This was an investigation of habitat utilization by non-game birds. The primary objective was to evaluate plants as food, cover and nesting resources. The study was divided into four parts: observation of non-game bird activity, determination of cardinal and field sparrow preferences of four selected seed types, determination of cardinal and field sparrow metabolic efficiencies of four selected seed types, and seasonal availability of four selected seed types.

Observations were conducted during summer, fall, winter and spring to determine which plant species were important for non-game birds as nesting, feeding and cover resources. Bird activity was observed on two locations: a 0.5 acre field of native forbs and legumes and a 2 acre area of native shrubs and trees.

Seed seasonal availability was measured to determine seasonal variation in seed availability and to compare seed availability between plant species for roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower.

Cardinal and field sparrow metabolic efficiencies for four seed types were determined. The seed types used were those used in the seasonal availability study.

Preferences of cardinals and field sparrows were determined for four seed types. The same seed types studied for metabolic efficiency were used in the preference trials.

Each part of the study is presented separately as a complete unit.

The first part is field observation of habitat utilization by non-game birds. This is followed by seasonal availability of four selected seed types, cardinal and field sparrow metabolic efficiencies for four seed types and ending with cardinal and field sparrow preference between four seed types.

Part I. Field observation of habitat utilization by non-game birds.

Introduction:

The importance of plants in wildlife habitats has been recognized for many years, but has not been extensively studied. Plants are utilized by birds for nesting sites, cover and as food sources. To improve a habitat for birds it is important to know which plants will fill each of these needs.

The field observation study concentrates on determining which plant species are important to birds. The goal is to identify what characteristics of a plant species make it useful to non-game birds and to rank plant species by amount of usage.

In Kansas, a particularly stressful time for birds is the winter when temperatures are low and food is relatively scarce. Plants that provide shelter and food are most important during this season. In the spring and summer, birds are raising offspring and again food supply is important as is availability of nesting sites. Habitat management for non-game birds should provide a mixture of plant species which in winter provide usable shelter and food; and in the spring and summer provide usable nesting sites and foraging areas. Areas being developed to encourage bird utilization should contain plant species fulfilling year round bird requirements.

Literature Review:

Recording of bird activities (time budgets) has been done by many investigators, but not until the last 2-3 decades have data been collected and presented in quantitative form (Lees 1948; Kluijver 1950; Gibbs 1954, 1956, 1960; Orians 1961). Orians (1961: 303) summarized the importance of time budgets as: "the amount of time and energy which a bird devotes to different activities must inevitably influence its survival and reproductive rates. It follows that there exists for a species in a given environment an optimal time and energy budget."

Kendeigh (1934) was the first to point out the importance of microclimate in determining the distribution of a species. Johnson (1957) and Morton (1967) maintain that a bird species will utilize favorable microclimates when possible, but the birds activities are predicted primarily by the location of the food supply. Certainly the distribution and abundance of food is a limiting factor for many bird species' existence. Gibbs (1956 and 1960) stated that limitation of bird populations is a result of food shortage. Fretwell (1972) proposed that birds living in a seasonal environment are limited by food during the winter, stressfull, season. Perhaps the most important advantage of migration is the availability of more food resources (Cox 1961).

Within a daylight period birds show patterns in activities. Palmgren (1949) indicated a diphasic sleep (inactivity) in the afternoon by birds. However, Verner (1965) in his study of the male long-billed marsh wren (1965: 137) during the breeding season, stated, "field evidence of afternoon rest periods stem chiefly from a reduction in song output, not from observation of resting birds." He maintains

that during the morning hours singing is most noticeable while in the early to mid-afternoon feeding is most intense. Verner also noticed a decrease in the time allotted to foraging as the season progressed, presumably due to the increase in easily obtainable food and warmer ambient temperature lowering the amount of energy required to maintain body temperature.

Lees' (1948) work with robins, blackbirds and blue tits showed that these different species of birds feed at different times of the day, utilizing overlapping resources. This temporal segregation reduces interspecific confrontation, allowing overlapping territories. Sturman(1968) and Willson (1971) confirmed Lees' observation and further found differences between bird species in foraging height and plant species preferred, but no regular seasonal trends in specific type, feeding site or height was noted (Willson 1971). Most bird species use some special foraging techniques (Willson 1971) allowing utilization of a particular area by many species.

In summary, the literature presents three major points about bird activity:

- 1) food tends to be an influencing factor in the utilization of favorable microclimates by birds,
- 2) winter and the breeding season are periods of food stress to many birds in a seasonal environment, and
- 3) bird species sharing a resource can occupy a single habitat by temporal segregation and by phenotypic adaptations for foraging.

### Materials and Methods:

#### Area I. Trees and Shrubs:

The study area was located approximately 16 km southwest of Manhattan, Kansas at the Plant Materials Center (PMC) of the U. S. Soil Conservation Service. The study site consisted of approximately 40 rows of trees and shrubs, with centers 4.6 m apart and 24.4 m long (Figure 1). The trees and shrubs were native plant species of Kansas, Oklahoma, Nebraska and Missouri under evaluation for potential conservation use by the Soil Conservation Service.

A roofed 2.4 m by 2.4 m blind with a viewing platform 3.0 m from the ground was constructed in the trees and shrubs study area (Figure 2). By moving the blind between three locations (a, b and c) within the area, all plant species could be viewed (Figure 1). Ten days of observation (during daylight hours only) was spent at a given location before moving to the next. After each move, two days were allowed to acclimate the birds with the new location of the blind.

#### Area II. Forbs and Legumes:

The field of forbs and legumes observed was located at the Manhattan Plant Materials Center (PMC) also. The study site contained about 100 native forb and legume species planted in 6.1 m rows, 1.8 m apart (Figure 3). The plant species in the area are currently being evaluated by the PMC to determine their fitness for use in Soil Conservation Service plantings. Observations were made from atop a 1.8 m stepladder behind a parked truck. Observations were restricted to weekends to prevent interference from the work of the PMC staff.





|                           |   |                              |
|---------------------------|---|------------------------------|
| American bittersweet      | A | Russianolive                 |
| American bittersweet      |   | Washington hawthorn          |
| Matrimony vine            |   | Western chokecherry          |
| American bittersweet      |   | Sargent crabapple            |
| Bristly locust            |   | Silver buffaloberry          |
| Wichura rose              |   | Cotoneaster sp.              |
| Thornless multiflora rose |   | Currant sp.                  |
| Multiflora rose x rugosa  | B | Purple prairieclover         |
| Smoothstem prairie rose   |   | 'Emerald' crownvetch         |
| Redosier dogwood          |   | Cicer milkvetch              |
| Skunkbush sumac           |   | American plum                |
| Common lilac              |   | Yellow chokecherry           |
| American elderberry       |   | Jerseytea                    |
| Indigobush amorpha        |   | 'Rem-Red' amur honeysuckle   |
| Shrub lespedeza           | C | Amur honeysuckle             |
| Mediterranean salt tree   |   | Red tatarian honeysuckle     |
| Weeping jasmine           |   | Red tatarian honeysuckle     |
| Amur honeysuckle          |   | 'Cardinal' autumnolive       |
| Buckbrush                 |   | Manchu cherry (North Dakota) |
| Winterberry euonymus      |   | Manchu cherry (Missouri)     |
|                           |   | Bessy cherry                 |
|                           |   | Wayfaringtree viburnum       |
|                           |   | Arrowhead viburnum           |

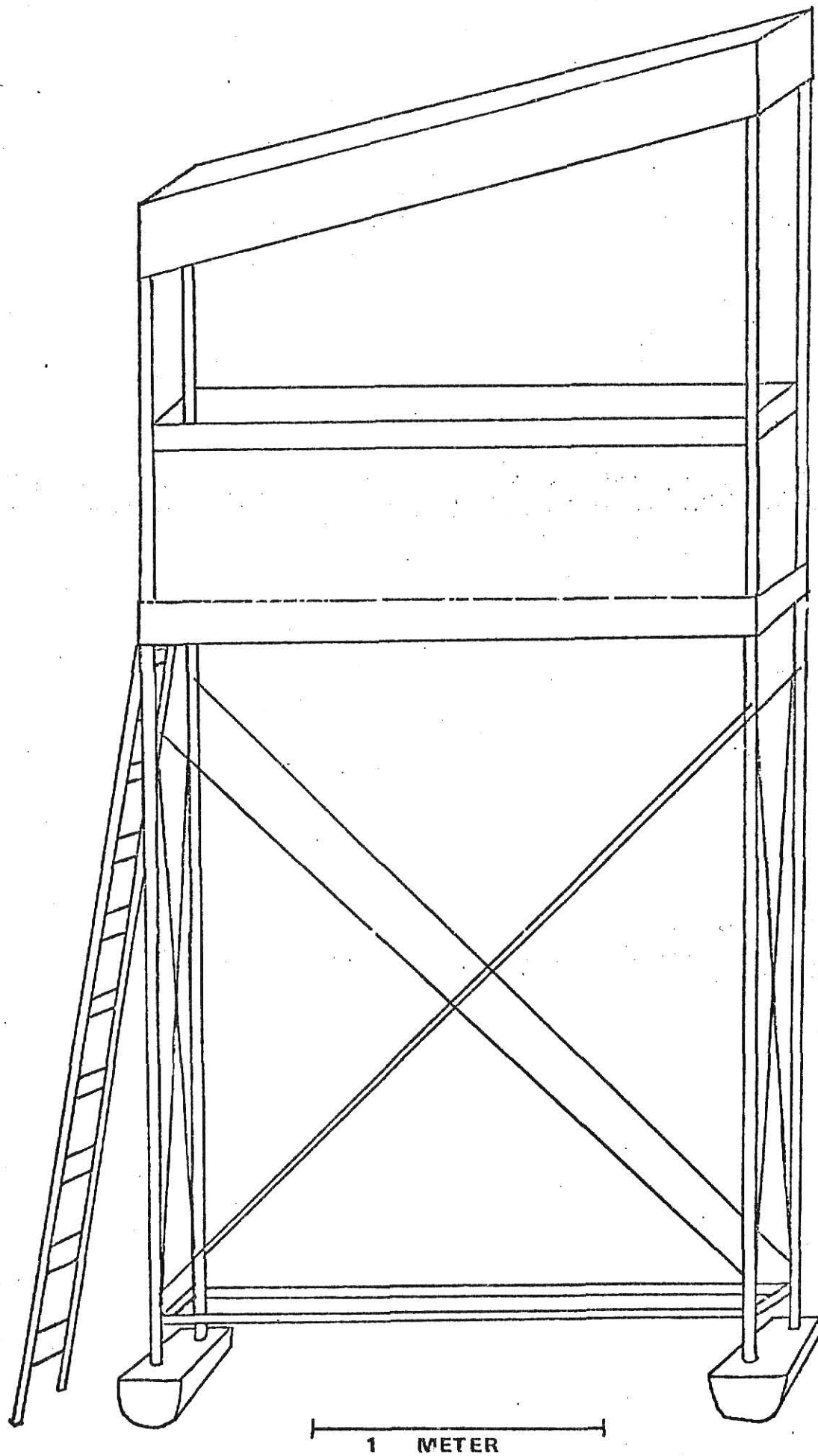
Figure 1. Layout of the trees and shrubs area at the Manhattan Plant Materials Center (total area is about 2 acres). Common names of the plant species are arranged in order of occurrence and respective positions in the area. The area is encircled by cedar species. The letters A, B, and C indicate the three locations the blind was moved between. (see text).



Figure 2. Schematic drawing of the blind used to observe bird activity in the trees and shrub area of the Manhattan Plant Materials Center. Blind viewing platform stood approximately 3 m off the ground and enabled viewing from all sides.

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## Methods:

Observation in the area extended from April 1975 to June 1976. The earlier months (April-May 1975) were spent primarily developing field skills and techniques, therefore will not be included in the results or discussion sections.

The year was divided into four seasons: winter (December, January and February), spring (March, April and May), summer (June, July and August) and fall (September, October and November). For each season, the average number of daylight hours was divided into four equal length observation periods, from dawn (period 1) to dusk (period 4). This method allows seasonal comparison of each period if desired.

In June and July, 1975, activity in each of the four periods was recorded twice in a 10-day period. On the basis of data obtained during this period (June and July 1975) of intense sampling I concluded that an observation schedule which involved viewing during each period once every 10-day period ample to characterize that time interval.

Observation was aided by 3 x 50 mm binoculars. Only non-game bird species were noted. Birds were classified as either granivorous or insectivorous according to Robbins et al. (1966). The type of bird (common name), plant species being used and the time in a particular activity were recorded. Timing of activities was assisted by a pocket-size transistor time device which gave a tone at constant 10 sec intervals.

Bird activity was divided into six categories: foraging (searching and obtaining food), preening (care and maintenance of feathers, legs and beak), chirping (social interaction, individual space maintenance), singing (territorial defense or other reasons), courtship and/or nest-

ing behavior (self-explanatory) and resting (sitting and looking about or sleeping). The inclusion of chirping as a separate activity may be open to criticism. However, I felt that chirping plays an important role in intraspecific social interactions, particularly when considering roosting-site behavior.

To enable comparisons of all rows, a computer program was developed which created a plant quality index based on the amount of activity in each plant species and ranks the plant species by the amount of time spent in each activity. Since a few plant species occurred in two rows data were kept for each row. Two rows of the same plant species can be under different influences, i.e. one may be next to a much used row and therefore may be used more than if it were not. Activity categories were combined to produce three categories considered most important to birds: foraging, reproduction and general activities. Foraging is important year round for survival, thus each season was considered separately. Reproduction includes singing, nesting and courtship and is important during the spring and summer. Singing, while it occurs year round is important only in the spring and summer for reproductive purposes. General activities include preening, resting and chirping and are considered year round.

### Analysis:

The first step of analysis determined the total amount of bird activity within the year that occurred in each of the 32 plant species in the area. Only plant species where more than 1 percent of the total activity for the area occurred were further analyzed. Data from included plant species (14) were analyzed for the amount of each activity occurring in each period for each of the four seasons and the percent of each activity per period. Total time spent in each species was weighted on a per hour of observation time so that all species could be compared on an equal basis. This was necessary because during June-July 1975 twice as much time was spent observing than during other months of the year.

Plant species with more than 1 percent of the total activity occurring in them were assigned ranks from one to five for each season within the categories using the time spent in the most utilized plant species (index value) as 100 percent, ranked 5.

| <u>Rank</u> | <u>Percent of bird activity<br/>time in the plant species</u> |
|-------------|---------------------------------------------------------------|
| 5           | 80-100                                                        |
| 4           | 60- 80                                                        |
| 3           | 40- 60                                                        |
| 2           | 20- 40                                                        |
| 1           | 0- 20                                                         |

It is important to realize that this is a comparative technique between plants occurring in my study area, not an independent quality index.



### Results:

A total of 44 bird species, 16 granivorous, 28 insectivorous, were seen in the study area throughout the year (Appendix Table 1 and 2). Non-game birds were found nesting in the area only two times in 1975 and none in 1976 prior to June. Two nests were found in 'cardinal' autumnolive: one being a yellow-billed cuckoo's, and the other a cardinal's. A third nest was found in thornless multiflora rose and was unoccupied when found. By the shape and location of the nest I presumed it was a cardinal's.

In over 270 hours of observation of 32 plant species (common and scientific names listed in Appendix Table 3) a total of 30 plant species were noted with some bird activity occurring in them. The total activity in the plant species studied is listed in Appendix Table 4. Of these 30 plant species, 14 had 1 percent or more of the total year-long bird activity. These 14 plant species were ranked (Appendix Table 5) as described in the analysis section.

No one plant species is best for all categories, during all seasons for either type of bird (Appendix Table 5). The time spent in each activity for each season by granivores and insectivores is listed for the 14 plant species under consideration in the Appendix, Tables 6-10.

In the winter, granivorous bird species spent a total of about 510 minutes foraging in the 14 plant species (Appendix Table 6). The most foraging activity occurred in silver buffaloberry (85.6 min) and sargent crabapple (80.9 min) by granivorous non-game birds (Figure 4a; Appendix Table 6). The total amount of foraging time in silver buffaloberry (85.6 min) was taken as the index value, equal to 100 percent.

All other plant species are discussed in terms of percent of the index value. Granivorous birds in the winter spent 70 percent and 65 percent of the index time in multiflora rose x rugosa and redosier dogwood (Figure 4a). Very little time was spent in western chokecherry, cotoneaster species, 'cardinal' autumnolive, manchu cherry 1 (from North Dakota), manchu cherry 2 (from Missouri) and skunkbush sumac; each species representing less than 20 percent of the index value (Figure 4a).

Winter foraging by insectivorous birds totalled 13.04 min in the 14 plant species (Appendix Table 7). Analysis of winter foraging activity by insectivorous birds showed one plant species, thornless multiflora rose, utilized more than all other plant species (7.01 min = index value) (Figure 4b; Appendix Table 7). Multiflora rose x rugosa, with the next high for total winter foraging activity, was utilized only 50 percent of the index value (Figure 4b). Twelve plant species were not utilized for foraging activity at all by insectivorous birds during the winter season (Appendix Table 7).

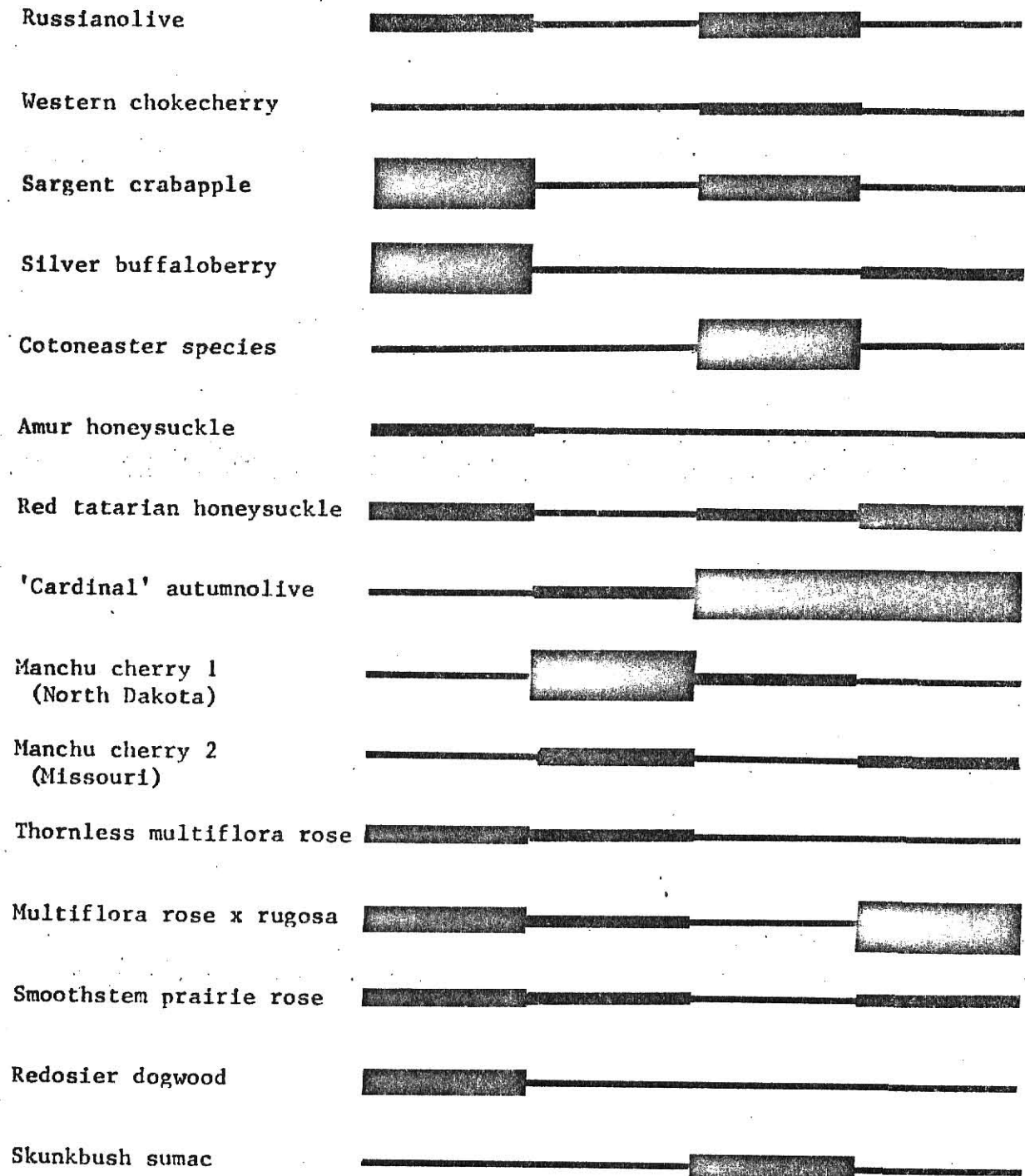
The total amount of foraging during the spring season by granivorous birds was 682.8 min (Appendix Table 6). The plant species most utilized by granivorous birds for spring foraging activity was manchu cherry 1 (from North Dakota) (231.0 min = index value) (Figure 4a; Appendix Table 6). The next most used plant species was manchu cherry 2 (from Missouri) which was utilized only 45 percent of the index value (Figure 4a). Three plant species were not utilized for spring foraging activity by granivorous non-game birds: cotoneaster species, amur honeysuckle and skunkbush sumac (Figure 4a Appendix Table 6).

A total of 41.9 min of foraging by insectivorous birds occurred in the



Figure 4a. Relative importance of 14 species of plants for forage

- activity of 16 species of granivorous non-game birds during the June 1975-June 1976 period.



Plant species                      Winter                      Spring                      Summer                      Fall

Legend: Ranks assigned to plant species based on the percentage of time spent in the most utilized plant species in each season (= index value). (see text).

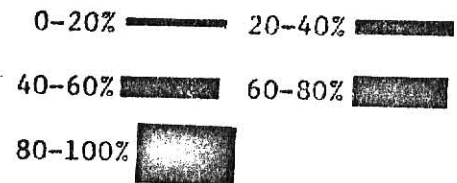
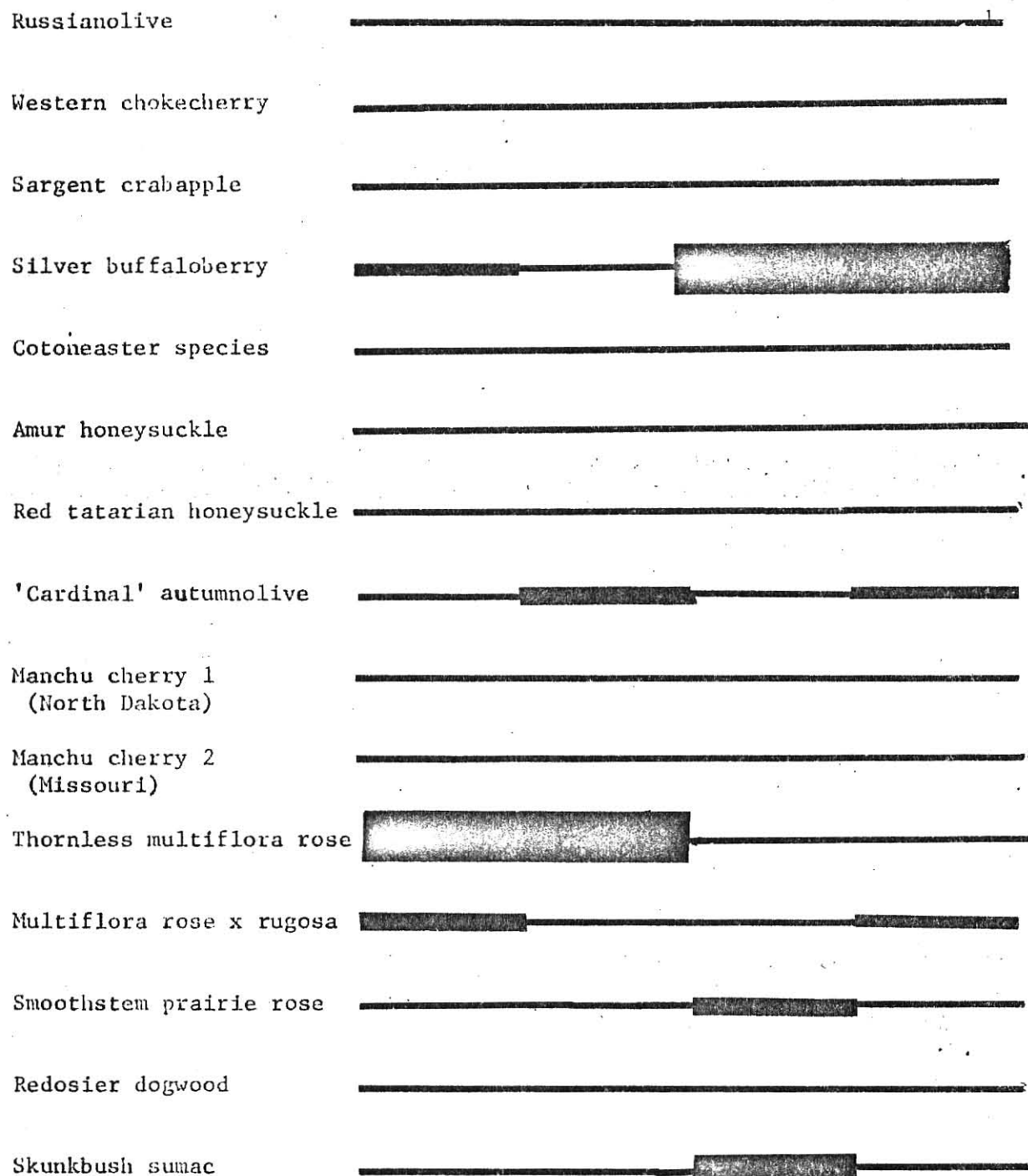


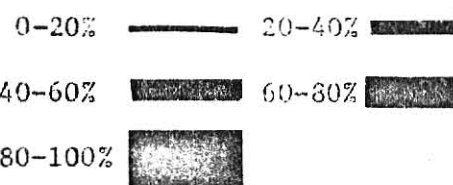


Figure 4b. Relative importance of 14 species of plants for forage activity of 28 species of insectivorous non-game birds during the June 1975-June 1976 period.



Plant species Winter Spring Summer Fall

Legend: Ranks assigned to plant species based on the percentage of time spent in the most utilized plant species in each season (=index value). (see text)





14 plant species during the spring (Appendix Table 7). Insectivorous bird spring foraging activity concentrated in thornless multiflora (22.4 min = index value) (Figure 4b; Appendix Table 7). 'Cardinal' autumnolive was the only other plant species which had more than 20 percent of the index value activity occurring on it (55 percent) (Figure 4b).

Foraging activity by granivorous birds was reduced during the summer (total = 20.7 min) (Appendix Table 6) with the most activity occurring 'cardinal' autumnolive (3.7 min = index value) and cotoneaster species (2.97 min) (Appendix Table 6). Russianolive, sargent crabapple and skunkbush sumac all rank within 60-80 percent of the index value. Multiflora rose x rugosa and redosier dogwood were not utilized (Figure 4a; Appendix Table 6).

Insectivorous birds showed a decline in the total amount of foraging activity in the area during the summer (3.99 min) (Appendix Table 7). Insectivorous birds utilized sargent crabapple (1.21 min = index value) the most for summer foraging (Figure 4b; Appendix Table 7). Skunkbush sumac and smoothstem prairie rose ranked 70 percent and 50 percent, respectively, of the index value (Figure 4b). All other 11 plant species had less than 20 percent of the index value, 5 not being utilized at all (Figure 4b; Appendix Table 7).

Fall foraging activity by granivorous birds totaled 156.66 min in the 14 plant species under consideration (Appendix Table 6). Fall foraging activity by these birds was concentrated in multiflora rose x rugosa (39.78 min = index value) (Figure 4a; Appendix Table 6). 'Cardinal' autumnolive was utilized for foraging a total of 95 percent of the index

value (Figure 4a; Appendix Table 6). Red-tatarian honeysuckle was utilized 57 percent of the index value (Figure 4a). All plant species were utilized to some extent with 9 species utilized less than 20 percent of the index value (Figure 4a).

Total use of the 14 plant species by insectivorous birds foraging in the fall was 40.53 min (Appendix Table 7). Sargent crabapple was used a total of 19.03 min (index value) for fall foraging activity by insectivorous birds (Figure 4b; Appendix Table 7). Multiflora rose x rugosa and 'cardinal' autumnolive were utilized for fall foraging less than 20 percent of the index value (Figure 4b).

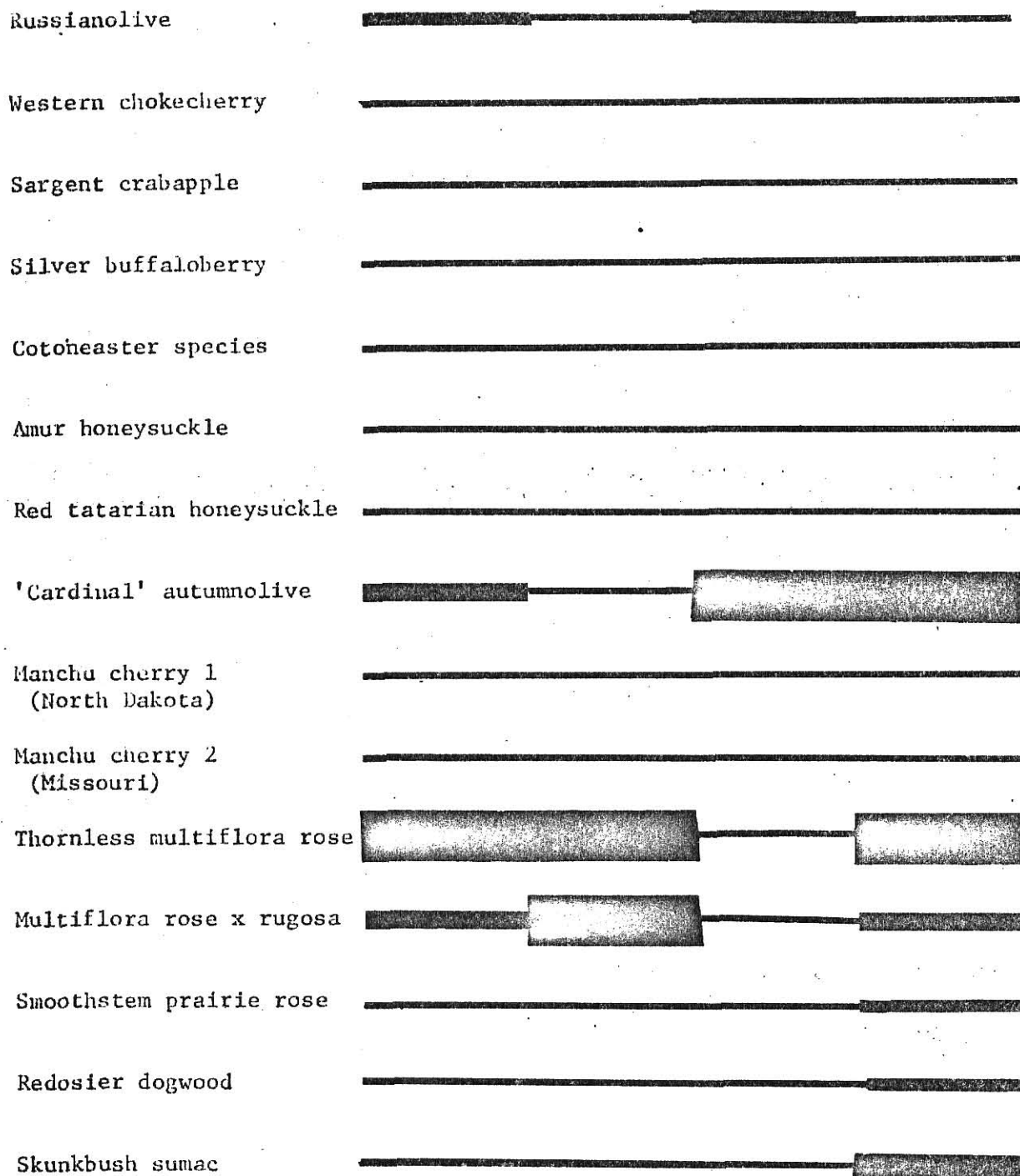
Analysis of time spent in general activity showed more distinctive divisions than did foraging (Figures 5a and 5b). Of a total of 126.21 min (Appendix Table 8), granivorous birds in the winter utilized thornless multiflora rose 57.67 min (index value) and multiflora rose x rugosa 24.49 min (42 percent of the index value) (Figure 5a; Appendix Table 8). Twelve plant species were used less than 20 percent of the index value, four of these were not used at all for general activity during the winter (Figure 5a; Appendix Table 8).

Insectivorous birds show an even greater division between plant species used and not used for general activity during the winter (Figure 5b). Thornless multiflora rose was utilized 30.19 min (index value) of a total of 37.06 min (Figure 5b; Appendix Table 9). All other species (13) were utilized less than 20 percent of the index value (Figure 5b); 11 species were not utilized at all (Appendix Table 9).

The total spring general activity by granivorous birds equaled 93.25 min (Appendix Table 8). General activity occurred almost exclusively



Figure 5a. Relative importance of 14 species of plants for general activity of 16 species of granivorous non-game birds during the June 1975-June 1976 period.



| Plant species | Winter | Spring | Summer | Fall |
|---------------|--------|--------|--------|------|
|---------------|--------|--------|--------|------|

Legend: Ranks assigned to plant species based on the percentage of time spent in the most utilized plant species in each season (=index value). (see text)

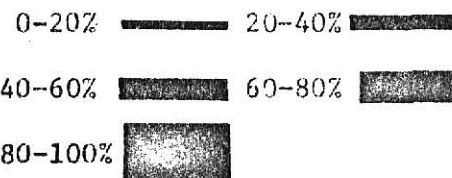




Figure 5b. Relative importance of 14 species of plants for general activity of 28 species of insectivorous non-game birds during the June 1975-June 1976 period.

Russianolive

Western chokecherry

Sargent crabapple

Silver buffaloberry

Cotoneaster species

Amur honeysuckle

Red tatarian honeysuckle

'Cardinal' autumnolive

Manchu cherry 1  
(north Dakota)Manchu cherry 2  
(Missouri)

Thornless multiflora rose

Multiflora rose x rugosa

Smoothstem prairie rose

Redosier dogwood

Skunkbush sumac

Plant species

Winter

Spring

Summer

Fall

Legend: Ranks assigned to plant species  
based on the percentage of time spent in  
the most utilized plant species in each  
season (= index value). (see text)

0-20%

20-40%

40-60%

60-80%

80-100%



in thornless multiflora rose (36.73 min = index value) and multiflora rose x rugosa (36.15 min) (Figure 5a; Appendix Table 8). Seven plant species were utilized between 1-20 percent of the index value and seven plant species were not used at all (Figure 5a; Appendix Table 8).

Of a total of 4.90 min, insectivorous bird species spent 4.60 min (index value) of spring general activity in multiflora rose x rugosa (Figure 5b; Appendix Table 9). Twelve plant species had no general activity by insectivorous birds occurring in them during the spring (Figure 5b; Appendix Table 9).

Summer was a time of little general activity by granivorous birds. Of a total of 17.69 min of general activity, 9.41 min (index value) occurred in 'cardinal' autumnolive (Figure 5a; Appendix Table 8). Russianolive was utilized 21 percent of the index value (Figure 5a). Four plant species were not utilized for general activity by granivorous birds in the summer (Figure 5a; Appendix Table 8).

Summer was the season least utilized for general activities by insectivorous bird species (4.45 min) (Appendix Table 9). Silver buffaloberry was utilized the most (1.44 min = index value) during this season (Figure 5b; Appendix Table 9). Russianolive had 70 percent of the index value, while five plant species had none (Figure 5b; Appendix Table 9).

The amount of general activity by granivorous birds increased sharply in the fall (482.59 min) with the most time being spent in thornless multiflora rose (121.21 min = index value) and 'cardinal' autumnolive (101.14 min) (Figure 5a; Appendix Table 8). Skunkbush sumac was utilized by granivorous birds for general activity 62 percent of the index value (Figure 5a). All other plant species (11) were used to some extent ex-

cept for western chokecherry which was not used at all (Figure 5a; Appendix Table 8).

Total fall general activity by insectivorous birds increased to 17.19 min with over half spent in thornless multiflora rose (6.83 min = index value) and 'cardinal' autumnolive (6.55 min) (Figure 5b; Appendix Table 9). No insectivorous bird general activity was noted in nine plant species (Figure 5b; Appendix Table 9).

A total of 50.36 min was spent in reproductive activity by granivorous birds during the spring and summer (Appendix Table 10). Russianolive was the site of most reproductive activity (15.35 min = index value) with 'cardinal' autumnolive, western chokecherry and cotton-easter species being utilized 78, 63 and 58 percent, respectively, of the index value (Figure 6a; Appendix Table 10). Six plant species were not utilized for any reproductive activity by granivorous birds (Appendix Table 10).

Insectivorous bird species spent 32.22 min of reproductive activity in the study area during spring and summer (Appendix Table 11). Over half of the total reproductive activity occurred on multiflora rose x rugosa (19.00 min = index value) (Figure 6b; Appendix Table 11). No reproductive activity by insectivorous birds occurred in twelve plant species (Appendix Table 11).

Because bird activity in the forbs and legumes area was less than 1 percent on all plant species, no further analysis was made on the data collected on that area. Less than 1 hour of total activity was noted in over 180 hours of observation during the year. About 85 percent of this activity occurred in the spring by foraging insectivores. Birds



Figure 6a. Relative importance of 14 species of plants for reproductive activity of 16 species of granivorous non-game birds during the June 1975-June 1976 period.

|                                   |                                                                                      |
|-----------------------------------|--------------------------------------------------------------------------------------|
| Russianolive                      |     |
| Western chokecherry               |    |
| Sargent crabapple                 |    |
| Silver buffaloberry               |    |
| Cotoneaster species               |    |
| Amur honeysuckle                  |    |
| Red tatarian honeysuckle          |    |
| 'Cardinal' autumnolive            |    |
| Manchu cherry 1<br>(North Dakota) |    |
| Manchu cherry 2<br>(Missouri)     |    |
| Thornless multiflora rose         |  |
| Multiflora rose x rugosa          |  |
| Smoothstem prairie rose           |  |
| Redosier dogwood                  |  |
| Skunkbush sumac                   |  |

---

Plant species

---

Spring & Summer

Legend: Ranks assigned to plant species  
based on the percentage of time spent in  
the most utilized plant species during the  
reproductive seasons (= index value). (see  
text).

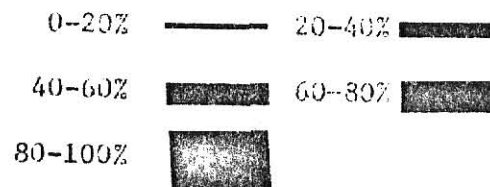




Figure 6b. Relative importance of 14 species of plants for reproductive activity of 28 species of insectivorous non-game birds during the June 1975-June 1976 period.

Russianolive

Western chokecherry

Sargent crabapple

Silver buffaloberry

Cotoneaster species

Amur honeysuckle

Red tatarian honeysuckle

'Cardinal' autumnolive

Manchu cherry 1  
(North Dakota)Manchu cherry 2  
(Missouri)

Thornless multiflora rose

Multiflora rose x rugosa

Smoothstem prairie rose

Redosier dogwood

Skunkbush sumac

Plant species

Spring &amp; Summer

Legend: Ranks assigned to plant species

0-20%

20-40%

based on the percentage of time spent in

40-60%

60-80%

the most utilized plant species during the

80-100%

reproductive seasons (= index value). (see  
text).



were never observed to stay in the area more than a few seconds at a time.

Discussion:

Foraging activity was highest in the area in the spring for both bird types. In the spring, insects appear and plants flower and produce fruit. The area was used heavily for foraging in winter. Since winter is a stressful time, it is useful to know that there are plants in the area that are utilized as food resources during this time. During the fall, the area was used roughly 1/5 as much as it was in the spring while in the summer it was used only 1/20 as much as in the spring. There are several possible reasons why the area was not used extensively during the summer for foraging: 1) fewer birds were around to increase total time, 2) the food requirement for birds is reduced because of temperate climate or 3) alternative foraging sites were found and utilized.

There were more bird species observed in the study area during the summer (Appendix Table 2) than during the winter when the area was heavily used for foraging activity, thus it appears that the first reason fails to explain the lack of utilization of the plant species in the area during the summer. Food requirements are reduced in the summer in terms of temperature maintenance but are somewhat balanced by raising offspring. The third reason would indicate that the plant species in the area do not provide adequate food "forcing" birds to utilize another area. In my opinion this last reason is the most plausible. On many occasions during the summer I would observe large flocks (75 or more) of birds flying into surrounding fields and out of sight. It is probable that these birds are taking advantage of agriculture and the various grain crops that are being grown and harvested at this time in preference to the plants on the FMC.

General activity showed the same trend as foraging activity. Prob-

ably this was the result of birds being in the area where they foraged and pursued general activities alternately.

Reproductive activity in the spring and summer by granivorous birds was seen in eight plant species while that by insectivorous bird species was confined to two plant species. Total times show granivorous birds used the area more than insectivorous birds but the largest discrepancy between the two bird types was noted in foraging and general activity times.

It is difficult to assess the value of a plant species for the survival of animals. Observation of actual utilization provides a tremendous amount of data. Analyzing these data in a way that provides useful comparisons of plant species is difficult. In order to be useful the data must be in an "easy to use" form that allows anyone to find answers to questions about the utilization of any particular plant species or to find which plant species would be best for the welfare of certain birds.

The plant quality index generates a rating system for plant species, rating them as to the amount of time non-game birds spend in them and the activities the birds pursue while in them. By using the index it is possible to determine which plant species best suits conservation purposes. For example, perhaps it is desirable to increase the number of cardinals living in the area. Since cardinals are year round residents in Kansas (Appendix Table 1) they will require foraging and general activity sites all year long, and good nesting and singing sites in the spring and summer. By planting plant species that provide all these things the chances of increasing cardinal densities is raised. It is

impossible to say, of course, how much, how fast or what other consequences will result (increases or decreases in other bird species, or predators).

It was first felt that the forbs and legumes area would be the site of much activity. It was hoped that results of laboratory trial to determine seed preferences (Part IV) would be borne out in the field. This was not the case. There are several possible reasons why the forbs and legumes area was not used more. Even though observations were made on the weekends, the birds may have become conditioned during the week by the PMC's activity and do not consider the area a safe foraging site. Another possible reason is that the plants occur in rows, not dispersed as in nature. This concentrates the seed resource and would seem to make the area a prime feeding habitat for insects and nocturnal rodents which would not be affected by PMC activity. Perhaps birds are out-competed in the unusual circumstances at the study site. This important possibility might be established by more detailed studies of the fate of seeds produced in these sites.

## Part II. Seed seasonal availability of four selected plant species.

### Introduction:

An important part of habitat improvement requires providing adequate year around food sources. When improving areas for granivorous bird species it is important to know when seeds are utilized and, i.e., are they eaten on the plant or on the ground. This part of the study was designed to measure seasonal availability of seeds on the ground from four plant species: roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower. Common and scientific names of the studied plant species are listed in Appendix Table 3.

### Literature Review:

Seed seasonal availability has not been extensively reported. Production of most seed bearing species have been measured by harvesting by hand or by combine. Seed traps have been used by many investigators (Davison et al. 1955). The method I used in my study was first reported by Haugen and Fitch (1955) which involved taking random square-foot ground samples of all plant and soil material down to the depth of  $\frac{1}{2}$  inch. Mature seeds are then separated from debris and counted in the laboratory. Haugen and Fitch (1955) found that the seeds of bicolor lespedeza, thunbergii lespedeza and partridge pea were available on the ground in Alabama for quail and other ground foragers year round.

Robel and Slade (1965) studied the availability of sunflower and ragweed seeds during the fall and winter in Kansas. They used a square-foot grid and by random sampling determined the number of seeds on the ground. Robel and Slade found a moderate increase in numbers available as fall progressed followed by a sharp decline of seeds on the ground in mid-winter. This is consistent with what Baumgras (1943) reported for ragweed seeds.

West's (1967) study of the nutrition of tree sparrows in the winter in Illinois found that 70 percent of the seed fall of grasses is completed before the onset of winter. West also found that there were enough seeds to sustain 100-200 tree sparrows per hectare during winter in Central Illinois.

### Materials and Methods:

The study site was located approximately 16 km southwest of Manhattan, Kansas at the Plant Materials Center (PMC) of the U. S. Soil Conservation Service. The study area was a field of about 100 native forb and legume species planted in 6.1 m rows, 1.8 m apart (Figure 7). The plant species in the area are currently being evaluated by the PMC to determine their fitness for use in Soil Conservation Service plantings. Of the plants studied, roundhead lespedeza was present in 21 rows with plant from four different states (Nebraska, Kansas, Oklahoma and Texas); thickspike gayfeather was present in 5 rows, all plants were from Kansas; sawtooth sunflower was found in 10 rows, all plants were from Kansas; and maximilian sunflower was present in 7 rows (one from Texas, six from Kansas).

Available seeds were defined as those seeds on the surface of the ground or down to 1.27 cm depth (Haugen and Fitch 1955). Most granivorous birds expected in the area forage on the ground by hopping and scratching.

Five random samples per month were collected in the area occupied by each species starting from the mid of the first row to the mid of the last row of that species (Figure 7). At the randomly chosen coordinates a  $930.25 \text{ cm}^2$  steel frame was placed on the ground and a knife was used to cut around the inside of the frame. All material was removed down to 1.27 cm and placed in a paper bag. Each bag was labeled with the date, plant species and sample location. The bag contents were oven dried and the seeds were separated from dirt and debris by a series of sieves adequate for separation of the seed types.

Only mature seeds possessing a full kernel were counted. The con-

dition of the kernel was determined by pressing the seed with a pencil or other pointed object. If the seed was firm, i.e., the seed did not collapse, the kernel was present and considered mature. This method was confirmed by opening 10 seeds from each sample (each bag).



Analysis:

The number of seeds available on the ground for the months within a season were averaged to give the mean number of seeds available on the ground per season ( $\pm$  S.E.) for each plant species. An F-test was used to detect seasonal changes in availability of each seed type on the ground.

### Results:

Seed fall began earliest for roundhead lespedeza and thickspike gayfeather (September-October) and not until mid-October and early November for the two sunflower species. In winter, roundhead lespedeza and thickspike gayfeather are still dropping seeds, the number of seeds on the ground for both species increased from fall to winter (Table 1). Thickspike gayfeather also showed an increase in the number of seeds available in the spring (Table 1). The two sunflowers decreased from fall to winter in the number of seeds available on the ground (Table 1). Maximilian sunflower had significantly more seeds available in the fall than spring ( $\alpha=0.05$ ) (Table 1). There were no significant seasonal differences detected in the other plant species (Table 1).

\* 2

In the fall,  $3662 \pm 1747$  roundhead lespedeza seeds per m<sup>2</sup> were available for consumption by on the ground feeders, increasing to  $4184 \pm 2734$  seeds per m<sup>2</sup> in the winter and declining to  $2630 \pm 2906$  per m<sup>2</sup> in the spring (Table 1). Each season significantly ( $\alpha=0.001$ ) more roundhead lespedeza seeds were available on the ground than any other plant species studied (Table 1). The number of thickspike gayfeather seeds available on the ground in the fall was  $33 \pm 38$  per m<sup>2</sup>. The number of thickspike gayfeather seeds on the ground increasing between fall and winter to  $116 \pm 129$  seeds per m<sup>2</sup> (Table 1). The peak number of sawtooth sunflower seeds

\* mean  $\pm$  S.E.

Table 1. Number of roundhead lespedeza, thickspike gayfeather, sawtooth<sup>41.</sup>  
sunflower and maximilian sunflower seeds available seasonally on the  
ground per m<sup>2</sup>.

| Plant type               | Fall                     | Winter          | Spring          |
|--------------------------|--------------------------|-----------------|-----------------|
|                          | Number of seeds          | Number of seeds | Number of seeds |
| Roundhead<br>lespedeza   | 3662 ± 1747 <sup>a</sup> | 4184 ± 2734     | 2630 ± 2906     |
| Thickspike<br>gayfeather | 33 ± 38                  | 116 ± 66        | 133 ± 129       |
| Sawtooth<br>sunflower    | 90 ± 88                  | 46 ± 43         | 11 ± 14         |
| Maximilian<br>sunflower  | 126 ± 190                | 85 ± 62         | 16 ± 18         |

a. mean ± s.e.

available on the ground occurred in the fall ( $90 \pm 88$  per m<sup>2</sup>) decreasing to  $46 \pm 43$  seeds per m<sup>2</sup> in the winter, and  $11 \pm 14$  per m<sup>2</sup> in the spring.

Ground availability of maximilian sunflower seeds showed the same seasonal trend as sawtooth sunflower, i.e., highest during the fall ( $126 \pm 190$  seeds per m<sup>2</sup>) and then declining during the winter and spring,  $85 \pm 62$  seeds per m<sup>2</sup> and  $16 \pm 18$  seeds per m<sup>2</sup>, respectively (Table 1).

Discussion:

Roundhead lespedeza is greatly superior ( $\alpha = 0.001$ ) to the other plant species in seasonal abundance of seeds on the ground. There are no seasonal differences in the availability of roundhead lespedeza. These results seem to indicate that roundhead lespedeza is not being utilized to any great extent by ground seed predators. Similarly, thickspike gayfeather showed no differences in seed abundance between seasons. The low levels of thickspike gayfeather seeds, in spite of their seeming immunity to seed predation are perhaps attributable to low annual production rates. However, seed production was not measured in this study for any plant species.

The decreased number of sunflower seeds (both sawtooth and maximilian) available on the ground indicates that predation or deterioration of the seeds occurred to some extent. A decrease in the abundance of sunflower seeds is consistent with results reported by Robel and Slade(1965).

There are problems associated with applying the technique of Haugen and Fitch (1955) for measuring availability to a situation such as was found in this study. The study site consisted of rows of plants, instead of scattered plants. Data obtained from samples occurring within the rows had to be discarded due to the presence of seed heads in the rows which in the fall and winter greatly expanded the estimates.

Another problem ensued because of the differences in rows of the species themselves. The PMC is evaluating the same plant species obtained from some 21 different counties in four states. Plants from western (more xeric) areas tended to be less dense and produce less per row (personal observation).

Width of rows varied between species with the sunflowers being many plants thick whereas the thickspike gayfeather seldom reached more than one plant in width. This casts doubts on the differences between plant species in number of seeds available because the differing number of plants per row prevents comparisons between plant species.

Because of these problems, interpretations of these data should be made with caution.

Part III. Metabolic efficiencies of Field Sparrows and Cardinals for seeds of four plant species.

Introduction:

An important factor in habitat improvement programs involves providing adequate food to enable animals to survive through stress periods. Not only must there be enough quantity of food but the food source must be usable in terms of allowing maintenance and growth of the animal.

This section addresses the energy aspects of seed quality. Four seed types: roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower were analyzed for metabolic value to field sparrows and cardinals. Metabolic efficiency was determined by subtracting excretory energy from ingested energy during a trial period. Equally important, an actual assimilation value which considered consumption and metabolic efficiency was obtained from an ad libitum diet of each seed type for both bird species.

### Literature Review:

Kendeigh (1949) was among the first investigators to study the bioenergetics of birds. In his 1949 paper he presented the results of the effect of temperature and seasons on the energetics of English sparrows. Since Kendeigh much work has been done in the field of avian bioenergetics. An extensive literature review and good background information on avian bioenergetics can be found in Kear (1972). A book by Broda (1975) provides excellent general information about bioenergetics, its evolution and state in the and state in the animal kingdom.

My study was designed similarly to that of Clement (1970) who worked with bobwhite (Colinus virginianus). Clement found that bobwhite at 20°C, 10 hours light, had the highest metabolic efficiency on diets of sorghum (82.6 percent) and the lowest on diets of sumac (30.4 percent).

Willson and Harneson (1973) studied the digestive efficiencies of cardinals and song sparrows. Seeds from five wild plant species and one commercial seed were tested: foxtail (mainly Setaria faberi), smartweed (Polygonum pensylvanicum), hemp (Cannabis sativa), pigweed (Amaranthus prob. retroflexus), ragweed (Ambrosia trifida) and the commercial sunflower (Helianthus annuus). They found that at 0° C cardinals had the highest digestive efficiency (metabolic efficiency) on a diet of foxtail (78 percent) and the lowest on the commercial sunflower (67 percent). Song sparrows were most efficient on foxtail (88 percent) and least efficient on smartweed (55 percent). However, song sparrows were not given the sunflower as a test seed. It should be pointed out that no correction was made for weight loss which can be an important factor (Clement 1970; Case 1971).



## Materials and Methods:

### Seeds:

Approximately 50 g each of roundhead lespedeza, thickspike gay-feather, sawtooth sunflower and maximilian sunflower seeds were obtained from the Manhattan Plant Materials Center (PMC), U. S. Soil Conservation Service, for use in metabolic efficiency determinations.

Seeds were grown, and stored at the PMC at approximately 16° C and 50 percent humidity. The seeds were harvested in 1973. During the course of the experiment the seeds were stored at 5° C and 50 percent humidity to inhibit respiration and deterioration (Kendeigh and West 1965).

### Birds

Two adult male cardinals and two field sparrows of undetermined age and sex were mist-netted within a 10 km radius of Manhattan, Kansas in October.

The birds were placed for a period of two weeks within an aviary to acclimate them to captivity and minimize death losses (Fretwell, personal communication). The birds were then placed in individual cages and housed within a walk-in environmental chamber controlled for temperature, relative humidity and photoperiod. Constant environmental conditions (5° C, 50 percent relative humidity and 10 hours of light: 14 hours of darkness) approximated winter conditions for northeastern Kansas (Bark unpublished).

Cages measured 33.0 cm x 21.0 cm x 24.0 cm and were fitted with a removable floor of 12.7 mm-mesh hardware cloth raised about 2 cm above the cage bottom to minimize coprophagy.

When the experimental environmental conditions were reached, birds were weighed every second day to 0.1 g. Weighing was done at the beginning

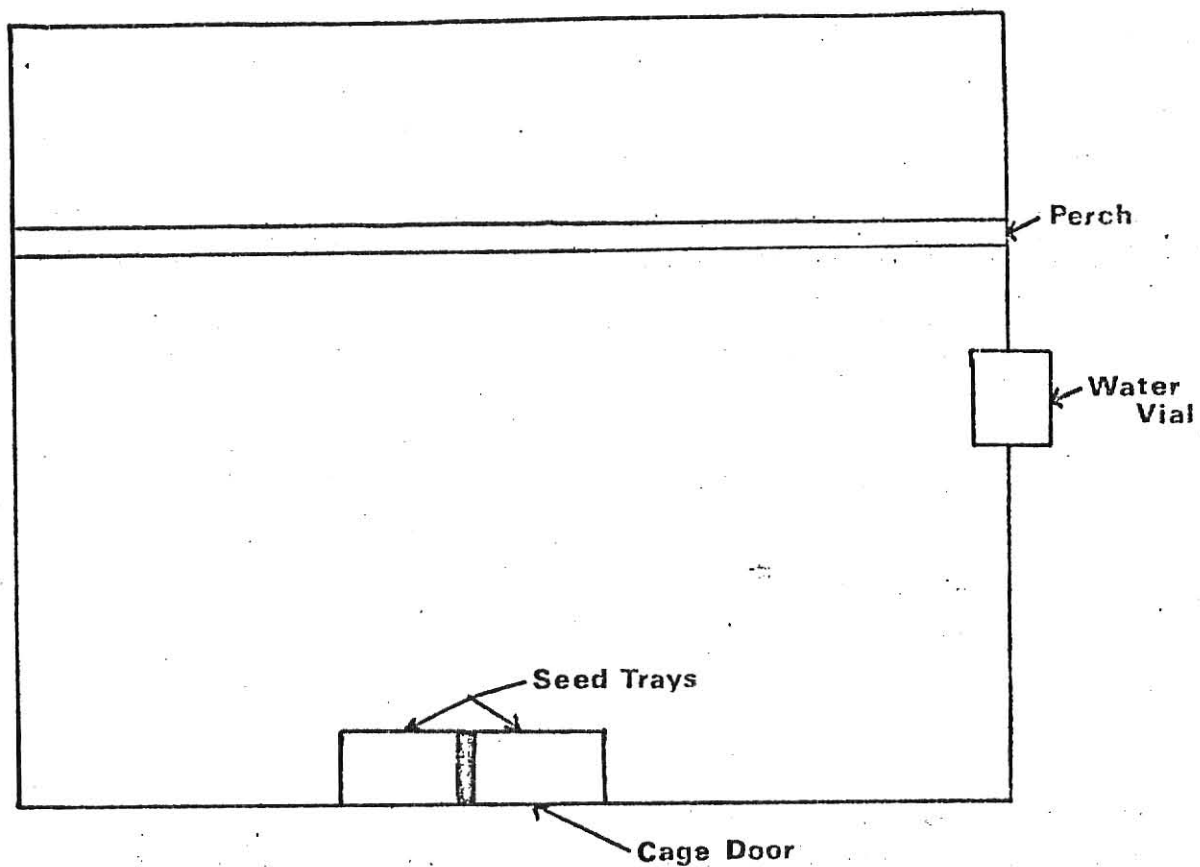


Figure 8. Floorplan of cages used to house birds during metabolic efficiency trials. Cages measured 31 cm x 21 cm x 24 cm with the seed trays measuring 4.8 cm x 3.2 cm x 3.2 cm.

of the light period to minimize diurnal weight change (West 1960). Before a feeding trial was begun weight was allowed to stabilize,  $\pm 5$  percent around the mean weight of each bird.

Prior to the start of the experiment and between trials, birds were given chick starter (details of composition in Appendix, Table 12) ad libitum. Water was supplied at all times.

Metabolic efficiency trials consisted of two sequential 2-day periods. However in the case of a loss in body weight of more than 15 percent, birds were removed from the diet immediately. The trials began at the start of the photoperiod with weighing the birds and cleaning the cages. All birds were given the same seed type which was randomly selected for each trial. Each bird was given a known amount of the test seed type, 32 g for cardinals and 16 g for field sparrow. These amounts were always in excess of potential ingestion amounts. The seeds were placed in dishes 4.8cm x 3.2 cm x 3.2 cm to minimize seed spillage (Figure 8). At the start of the second 2-day period all birds were weighed, and the feces separated from the spilled seed. The weight of uneaten seed (including the spilled uneaten seed) was subtracted from the amount given to determine the amount ingested by each bird. Feces were collected and placed in vials labelled with the bird number and species seed species and date. The vials were stored at  $-16^{\circ}\text{C}$  to prevent deterioration until analyzed for energy content. Preliminary to caloric analyses, the feces and kernels of each seed type were dried at  $60^{\circ}\text{C}$  for 48 hrs to obtain dry weight. Dried feces were ground in a Wiley micro-mill through a 20 mesh-to-the-inch screen.

Caloric determinations of all samples were made using an automatic Parr 1200 adiabatic calorimeter with a Parr 1101 oxygen bomb

under 30 atmospheres of oxygen. Approximately 1-g samples of feces and seed kernel were used in each bombing. Analyses of the feces were done in duplicate. Energy contents of seeds used in the study were determined by 5 replicate 1-g sample analyses for each seed type.

Analysis:

Metabolizable energy was determined by subtracting the energy in the fecal samples from the energy of the food consumed during the 2-day period. In the cases where birds were removed from the diet before 2 days, metabolic efficiency was calculated for the time on the diet. Some slight loss of energy occurs due to fermentation of undigested food and energy utilized by bacteria in the large intestine (Kendeigh 1949), such losses were assumed to be insignificant and no correction was made for these losses.

Metabolic efficiencies were adjusted for weight loss using a factor of 0.356 times the mean weight loss (g) to estimate the excretory energy lost which was the result of weight loss. This factor was determined by starvation experiments using quail (Case 1971) and while such experiments were not performed in this study, it had to be assumed that starvation values would be similar.

Data were analyzed by an analysis of variance and Duncan's New Multiple Range Test (DNMRT) according to Fryer (1966) ( $\alpha = 0.05$ ). Data from the second trial period only was analyzed when two consecutive 2-day periods of data were available because these data were shown to be more reliable during earlier studies (Clement 1970, Case 1971).

Analysis of nutrient composition of the test seed kernels was performed by the Department of Grain Science, Kansas State University. Composition was determined according to the American Association of Cereal Chemists approved method of proximate analysis.

### Results:

Thickspike gayfeather had the most kernels per gram (592.6 kernels per gram); sawtooth sunflower the fewest (566.6 kernels per gram) (Table 2). The most energy per kernel was found in maximilian sunflower (11.9 cal per kernel); roundhead lespedeza had the least (8.4 cal per kernel). Sunflowers had more energy per gram (maximilian sunflower = 6924.6 cal per g, sawtooth sunflower = 6541.2 cal per g) than either thickspike gayfeather (5940.1 cal per g) or roundhead lespedeza (4944.4 cal per g). Roundhead lespedeza had the highest moisture content of the test seeds (6.8 percent) with the water content of thickspike gayfeather being 5.4 percent and that of the sunflowers averaging around 4.6 percent (Table 2). The percent of crude protein and crude fat in the kernels showed sunflowers were higher than thickspike gayfeather or roundhead lespedeza. Maximilian sunflower was 42.1 percent crude protein and 40.7 percent crude fat; sawtooth sunflower was 40.7 percent crude protein and 38.6 percent crude fat; thickspike gayfeather was 39.0 percent crude protein and 27.8 percent crude fat; and roundhead lespedeza was 39.0 percent crude protein and only 4.8 percent crude fat (Table 2). The amount of crude fiber in roundhead lespedeza was the highest (14.4 percent) of the four seed types with thickspike gayfeather and sawtooth sunflower averaging about 3.7 percent. Maximilian sunflower had the lowest percent crude fiber content (2.3 percent) (Table 2).

Each field sparrow lost an average of 1.75 g per day on a diet of roundhead lespedeza and 3.5 g per day on a diet of thickspike gayfeather (Table 3). This is opposed to sawtooth sunflower (average weight change per day = -0.35 g) and maximilian sunflower (average weight change per day = +0.25 g) (Table 3). Field sparrows only ate 0.09 g (0.43 kcal)

Table 2. Some physical characteristics and the results of proximate analysis of roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower. Values for proximate analysis were obtained for kernels only and are expressed in percent composition.

| Seed type                | Number of<br>kernels/g | Calories/<br>kernel | Calories<br>/g | Moisture | Crude<br>protein | Crude<br>fat | Crude<br>fiber |
|--------------------------|------------------------|---------------------|----------------|----------|------------------|--------------|----------------|
| Roundhead<br>lespedeza   | 587.4                  | 8.4                 | 4944.4         | 6.8      | 39.0             | 4.8          | 14.4           |
| Thickspike<br>gayfeather | 592.6                  | 10.0                | 5940.1         | 5.4      | 39.0             | 27.8         | 3.5            |
| Sawtooth<br>sunflower    | 566.6                  | 11.5                | 6541.2         | 4.7      | 40.7             | 38.6         | 3.9            |
| Maximilian<br>sunflower  | 580.4                  | 11.9                | 6924.6         | 4.6      | 42.1             | 40.7         | 2.3            |

Table 3. Means of variables analyzed for metabolic efficiency and energy assimilated by field sparrows on four seed types per day as determined from the second 2-day trial (see text for explanation).

| Seed type                | Weight<br>change (g) | Amount ingested<br>g/day | Amount ingested<br>kcal/day | Amount excreted<br>g/day | Amount excreted<br>kcal/day | Metabolic<br>efficiency | Metabolized<br>energy (kcal/day) |
|--------------------------|----------------------|--------------------------|-----------------------------|--------------------------|-----------------------------|-------------------------|----------------------------------|
| Roundhead<br>lespedeza   | -1.75                | 0.09                     | 0.43                        | 0.04                     | 0.55                        | <1.00 <sup>a</sup>      | 0.00                             |
| Thickspike<br>gayfeather | -3.50                | 0.35                     | 2.08                        | 0.12                     | 0.95                        | 53.34 <sup>a</sup>      | 1.11                             |
| Sawtooth<br>sunflower    | -0.35                | 2.45                     | 16.02                       | 0.78                     | 3.54                        | 77.56                   | 11.26                            |
| Maximilian<br>sunflower  | +0.25                | 3.52                     | 23.16                       | 0.68                     | 3.00                        | 87.60                   | 21.28                            |

a. Due to the small amounts consumed and excreted on these diets, efficiency values should be considered preliminary and suspect.



per day and 0.35 g (2.08 kcal) per day of roundhead lespedeza and thickspike gayfeather, respectively, while they consumed 3.52 g (23.16 kcal) per day of maximilian sunflower and 2.45 g (16.02 kcal) per day of sawtooth sunflower (Table 3). Field sparrows in two days on a diet of roundhead lespedeza excreted more energy (0.55 kcal) per day than they ingested. in the same period (Table 3). Field sparrows faired somewhat better on thickspike gayfeather, though they were only on this seed type one day, excreting 0.12 g or 0.95 kcal yielding a metabolic efficiency of 53.34 percent (Table 3). However, since field sparrows were only able to survive one day on thickspike gayfeather and ate little (relative to the sunflowers), their associated assimilated energy was low, 1.11 kcal (Table 3). A great contrast to roundhead lespedeza and thickspike gayfeather is seen with the sunflowers. Field sparrows excreted 0.78g (3.54 kcal) per day and 0.68 g ( 3.00 kcal) per day on diets of sawtooth sunflower and maximilian sunflower, respectively yielding the highest metabolic efficiencies of 77.56 percent (sawtooth sunflower) and 87.60 percent (maximilian sunflower)(Table 3). There is no significant difference between the metabolic efficiencies for the two sunflower seeds (Table 3). However, in terms of energy assimilated significantly more maximilian sunflower seed was consumed than sawtooth sunflower (85.56 kcal and 49.56 kcal for maximilian sunflower and sawtooth sunflower, respectively)(Table 3).

The average weight loss for cardinals was 5.40 g per day for roundhead lespedeza and 5.10 g per day for thickspike gayfeather (Table 4). This is in contrast to the weight gain for birds on sunflower diets: on sawtooth sunflower cardinals gained 0.60 g per day and 0.40 g per day on maximilian sunflower (Table 4). Cardinals consumed about 5.80 g per

Table 4. Means of variables analyzed for metabolic efficiency and energy assimilated by cardinals on four seed types per day as determined from the second 2-day trial (see text for explanation).

| Seed type                | Weight<br>change (g) | Amount ingested<br>g/day | kcal/day | Amount excreted<br>g/day | kcal/day | Metabolic<br>efficiency | Metabolized<br>energy (kcal/day) |
|--------------------------|----------------------|--------------------------|----------|--------------------------|----------|-------------------------|----------------------------------|
| Roundhead<br>lespedeza   | -5.40                | 1.33                     | 6.99     | 0.54                     | 3.03     | 53.85                   | 3.53                             |
| Thickspike<br>gayfeather | -5.10                | 1.45                     | 8.61     | 0.32                     | 2.02     | 76.62                   | 6.59                             |
| Sawtooth<br>sunflower    | +0.60                | 5.92                     | 38.76    | 1.56                     | 3.52     | 81.47                   | 31.71                            |
| Maximilian<br>sunflower  | +0.40                | 5.74                     | 39.76    | 1.37                     | 2.99     | 84.65                   | 33.80                            |

day (39 kcal) when on the sunflower diets (Table 4). About 1.25 g per day (7 kcal) of roundhead lespedeza and thickspike gayfeather was consumed. The highest metabolic efficiency and total energy assimilated were obtained for the sunflowers (Table 4). The metabolic efficiency of cardinals for maximilian sunflower seed was 84.65; 64.75 kcal of maximilian sunflower seed were assimilated by cardinals during the trial. On a diet of sawtooth sunflower, cardinals had a metabolic efficiency of about 81.47 percent and an assimilated energy value of 63.33 kcal during the trial. There was no significant difference in cardinal assimilation energy values between the two sunflower types (Table 4). Cardinal metabolic efficiencies for roundhead lespedeza averaged 53.85 percent and for thickspike gayfeather 76.62 percent (Table 4). There was no significant difference between roundhead lespedeza and thickspike gayfeather assimilated energy values; cardinals had an assimilated energy of 3.53 kcal per day on roundhead lespedeza and 6.59 kcal per day on thickspike gayfeather (Table 4).

Discussion:

Roundhead lespedeza had the lowest crude protein, energy per g, crude fat, and the highest crude fiber content of the four seeds evaluated. Thus, roundhead lespedeza was the poorest of the four seeds tested.

If cardinals and field sparrows ate as much roundhead lespedeza as other seeds they would do worse. Additionally, roundhead lespedeza appeared to be less palatable than the sunflowers (the field sparrows consumed about 2 g per day less; the cardinals about 4 g per day less lespedeza seed than sunflower seed). Both bird species lost weight on diets of roundhead lespedeza; field sparrows excreted more energy than they consumed.

Cardinals ingested more energy than they excreted but still lost weight. The metabolic efficiency of cardinals for roundhead lespedeza (54 percent) was the lowest obtained in the experiment. The metabolic efficiency of 54 percent combined with a low ingestion resulted in low assimilation energy value, 3.53 kcal, as compared with the sunflowers, about 32 kcal.

Thickspike gayfeather had an energy concentration greater than roundhead lespedeza but lower than the sunflowers. Thickspike gayfeather was comparable to the sunflowers in terms of crude fat (about 6 times that of roundhead lespedeza) and crude fiber content (about 25 percent as much as roundhead lespedeza). Thickspike gayfeather contained the same amount of crude protein as roundhead lespedeza. Cardinals and field sparrows lost weight on thickspike gayfeather but did exhibit a greater metabolic efficiency for it than for roundhead lespedeza. The important difference between thickspike gayfeather and roundhead lespedeza was that birds were able to sustain themselves on a diet of thickspike gayfeather between one and two days while they could maintain themselves on diets of roundhead lespedeza for longer than two days. It seems

likely that the higher metabolic efficiency values obtained for cardinals and field sparrows on thickspike gayfeather are in part due to the limited time on the diet. Even so, the higher metabolic efficiency values seen on the diets of thickspike gayfeather for both bird species illustrated what the potential energy gain would be if the seed were eaten. Again it seemed like palatability was an important factor and the rates of energy assimilated are very low compared to the sunflowers and in the case of the cardinals not significantly different from roundhead lespedeza.

Both sawtooth sunflower and maximilian sunflower were high in crude protein, crude fat and in the amount of energy per g but low in crude fiber content. In terms of energy content, sawtooth sunflower had about 600 more cal per g than thickspike gayfeather while maximilian sunflower had almost 1000 cal per g more. The field sparrows lost little weight on a diet of sawtooth sunflower and gained weight on the maximilian sunflower diet. Cardinals gained weight on both seed types. Both field sparrows and cardinals ingested almost four times more energy than they excreted on a diet of sawtooth sunflower yielding a metabolic efficiency of 77.56 percent (field sparrows) and 81.47 percent (cardinals). Because consumption was high, the assimilated energy values were also high, 11.26 kcal per day for field sparrows (about 25 times that of thickspike gayfeather) and 31.71 kcal per day for cardinals (about 7 times that of thickspike gayfeather).

Maximilian sunflower showed the same trends as sawtooth sunflower. Diets of maximilian sunflower resulted in high metabolic efficiencies by field sparrows and cardinals. Cardinals showed no significant difference in metabolic efficiency or assimilated energy between the two

sunflowers. Field sparrows however, seemed more efficient at metabolizing and assimilating maximilian sunflower seeds than seeds of sawtooth sunflower. The reason for this is not clear as the seeds seem in all ways so similar.

The results of analysis of the seeds of four plant species indicate for field sparrows and cardinals that maximilian and sawtooth sunflowers provide sources of food that will sustain these birds. Roundhead lespedeza and thick-spike gayfeather are of little value for survival of field sparrow and cardinals, and, even if provided in abundance, are not utilized as a significant food source for these two birds.

Determination of useful plant species for non-game bird food resources must consider the metabolic efficiency of the birds for the seed types and the amount of seed consumed by the birds (metabolizable energy x consumption = food value index). No matter how high a metabolic efficiency is for a specific seed, if it is not eaten, that seed is not an energy source for maintenance, growth or reproduction. Similarly, if a seed low in energy content is consumed in large quantities, its food value index could be low if the metabolic efficiency for that seed is low. There seemed to be some tendency for birds in this study to consume greater quantities of higher energy seed (i.e. sunflowers) than lower energy seeds (i.e. roundhead lespedeza and thick-spike gayfeather). However, how birds might distinguish between high and low energy seeds is unclear.

#### Part IV. Preferences of field sparrows and cardinals among four seed types.

##### Introduction:

Birds in nature encounter a large variety of potential food sources each day. Willson (1971) and Robel et al. (1974) have shown that birds select seeds on the basis of size and abundance, but birds do not seem to identify seeds which are high in energy or easily metabolized. In this section of my study I will attempt to determine which of four seed types are preferred by field sparrows and cardinals under laboratory conditions.

These bird species were commonly seen in areas with the seed types present,

Seeds evaluated were roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower. These seeds are considered to be seeds with great potential by the U. S. Soil Conservation Service in their conservation plantings. The seed were produced at the Manhattan Plant Materials Center, S.C.S.

### Literature Review:

MacArthur (1961) found that the number of species occupying a particular habitat is proportional to the diversity of that habitat. A predator depending on a fluctuating food supply (such as a bird feeding on seeds) should be able to "switch" from one food to another depending on the amount of each food type available. Amount and type of food available is one aspect of habitat diversity (MacArthur 1961).

Ivlev (1961) in his study of the ecology of feeding fishes found that selectivity increases with overall food density. Emlen (1966) supports that theory and maintains that predators should accept all food encountered when food is scarce and become more selective when food is abundant. Emlen (1966) suggests that animals eat the most abundant seeds regardless of energy content when food is abundant (confirmed by Willson 1971; and Robel et al. 1974). In theory it is ideal to minimize foraging time and maximize energy intake, however actual conditions usually force compromise in time budget strategies (Schoener 1969b; Rapport 1971).

Smigel and Rosenzweig (1974), on the basis of their study of seed selection by two rodent species, hypothesize that selectivity is inversely proportional to the time required to find a seed. Royama (1970) also maintains that the "predator tries to maximize its hunting efficiency within its limited ability to perceive the abundance of food in various parts of the hunting area." He takes objection to Tinbergen (1960) who explained preference by songbirds for over-abundant insects as being the result of search image formation.

The possibility of nutritional qualities of food being the major criteria for preferences has been investigated with varying results. Martin (1968) states that in tree sparrows protein content does not determine preferences in food selection. Pulliainen (1970) showed that Capercaillie (Tetrao urogallus)



selected for nitrogen-rich pine needles. Moss (1968) and Gardarsson and Moss (1968) found that Icelandic ptarmigan do select food on the basis of nutritional quality and prefer "high" quality food to such an extent that they will eat all such food in an area before eating lower quality foods. However there has been much discussion as to the interpretation of these results. The higher quality food seems to be young shoots which could be preferred for other reasons, most likely tenderness of the plant.

Though Darwin (1859) wrote about the Galapagos finches, interspecific differences in bill size has been little studied in context with seed preferences in birds. Kear (1962) studied a variety of finches in England to determine what, if any, differences there was in preference. Not only did she find differences between species, a positive correlation of seed size with bill size, but she also observed that juveniles tended to select smaller seeds than did adults of the species. She suggested that learning by observation of adults may be important in the formation of preferences. Liefv (1970) noted that in geese, learning of preferences also occurs to some extent. Myton and Ficken (1967) looked at seed preferences between chickadees and titmice in relation to ambient temperature. They found differences between the two species in seeds preferred with titmice on the whole consuming larger seeds.

Willson (1970) and Willson and Harmeson (1973) tested some North American finches for preferences with respect to bill size. They found that large-billed species ate more larger seeds and fewer small seeds than did smaller-billed species. Large-billed species ate a wider diversity of seed types than small-billed species. Seed preference, however, had no basis in amount of energy potentially available to the bird. Rather it seemed that the ease in handling the seed was the more important factor in determining preferences. Preferences at lower temperatures did not shift toward larger

seeds but stayed the same.

In summary, theoretical ecologists have inferred that the ability to discriminate between nutritionally high and nutritionally low seeds is adaptive during certain conditions. It has been demonstrated that some species of birds are able to learn seed preference. Criteria important in judging a seed "good" or "bad" seem to deal more with the physical aspects (size, ease of handling) than with nutritional aspects.

## Materials and Methods:

### Seeds:

Approximately 500 g of roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower seeds were obtained from the Manhattan Plant Materials Center (PMC), U. S. Soil Conservation Service, for use in seed preference trials. The seed were grown and harvested at the PMC in 1973. Seeds were stored at approximately 16°C and 20 percent humidity at the PMC. During the course of the experiment the seeds were stored at 5°C, 50 percent humidity to inhibit respiration and deterioration (Kendeigh and West 1965).

### Birds:

Three first-year male cardinals and three field sparrows (age and sex undetermined) were collected with a 3.36 cm mesh mist nets within a 10 km radius of Manhattan, Kansas in October. The birds were placed for a period of two weeks within an aviary to acclimate them to captivity and minimize death losses (Fretwell, personal communication). The birds were then placed in individual cages and housed within a walk-in environmental chamber controlled for temperature, relative humidity and photoperiod. Constant environmental conditions (5°C, 50 percent humidity and 10 hours light: 14 hours darkness) approximated winter conditions for northeastern Kansas (Bark unpublished). Cages measured 33.0 cm x 21.0 cm x 24.8 cm and were fitted with a removable floor of 12.7 mm hardware cloth raised about 2 cm above the cage bottom to minimize coprophagy.

Birds were weighed every second day to 0.1 g. Weighing was done at the beginning of the light period to minimize diurnal weight change (West 1960). Before the seed preference experiment began weight was allowed to stabilize ( $\pm$  5 percent) around the mean weight for each bird. After the start of the

experiment birds were weighed every 10 days.

Prior to the start of the experiment and between trials birds were given chick starter (composition listed in Appendix Table 12) ad libitum. Water was present at all times. Birds were given an opportunity to eat all test seed types prior to the beginning of the experiment on the assumption that some seed types had been encountered in the wild and the birds were accustomed to handling them (Willson 1971).

A trial consisted of presentation of a randomly selected seed pair to all birds. The seeds were presented in equal volumes and known weights and, in quantity sufficient to preclude a bird from exhausting the supply of any seed type during a trial period. The seed dishes (4.8 cm x 3.2 cm x 3.2 cm) were located 3.2 cm apart in the cage (Figure 9). Each bird experienced each seed pair 4 times and each seed type 10 times during the experiment. The four seed types were paired in all possible combinations giving a total of 6 seed pairs.

Trials began 1 hr after the beginning of the photoperiod and extended 3 hrs. Cages were cleaned before and after each trial. The amount of each seed eaten was determined for each trial by subtracting the weight of seeds uneaten plus those spilled and uneaten, from the weight of seeds given.

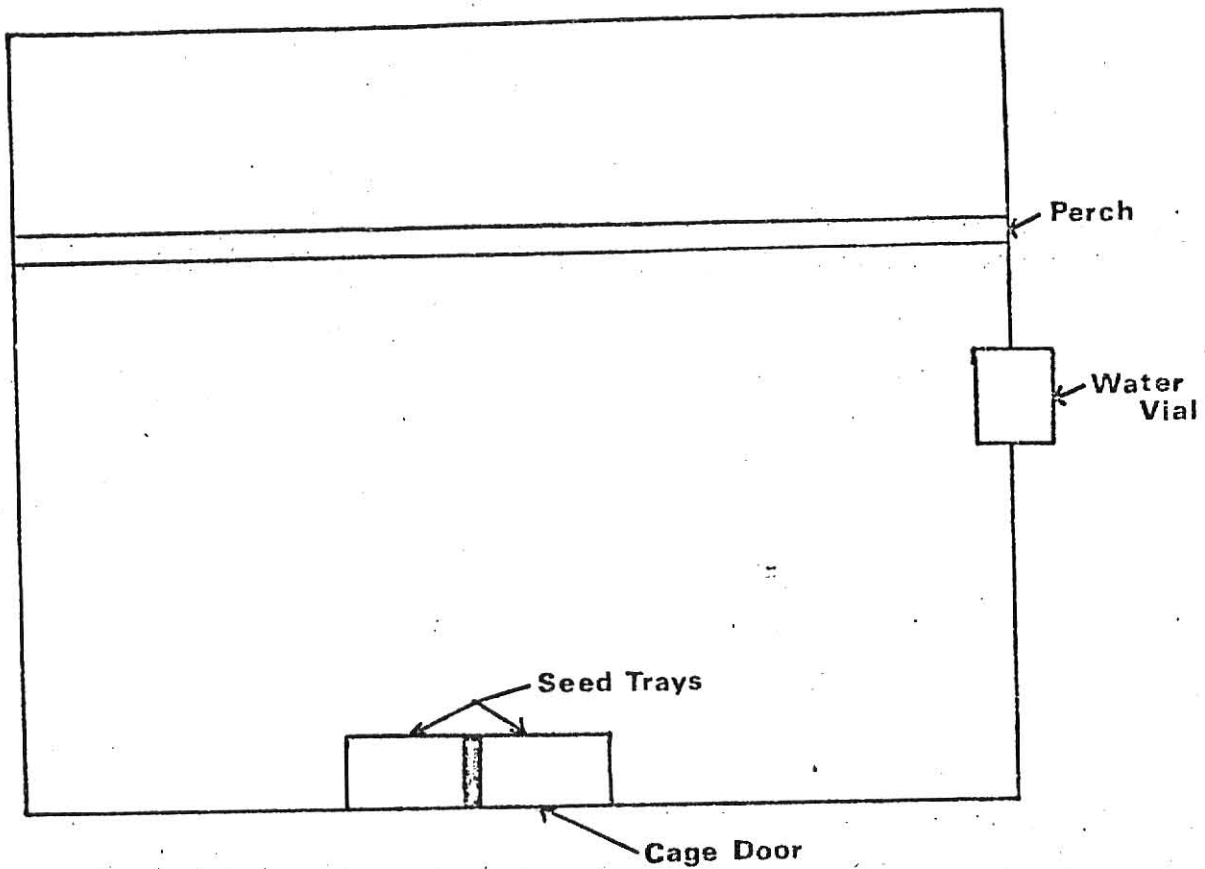


Figure 9. Floor plan of cages used to house birds during seed preference trials. Cages measured 31 cm x 21 cm x 24 cm with the seed trays measuring 4.8 cm x 3.2 cm x 3.2 cm.

Analysis:

Data were analyzed according to a statistical model developed for palatability estimates of cattle rations (Dayton and Morrill 1974). This model considers the effect that each seed type of a pair has on the total mean consumption plus the effect that the combination of those seed types has on the total mean consumption. The mean amount consumed for each of the six treatments (seed pairs) was determined for each bird species. By averaging the six treatment means the overall mean consumption can be calculated. The overall mean consumption is in turn combined with the respective treatment means to derive estimates of the effect each seed type has on the total consumption. These values are then used with the respective treatment means to estimate the effect each seed pair has on the overall mean consumption. From an analysis of variance performed on the treatment means for each bird species, the standard deviations for all estimates are determined. A LSD ( $\alpha = 0.05$ ) determines significance.

When the positive or negative effects of a seed type on the mean consumption is known, estimates of actual consumption can be made. The actual consumption is known and is equal to the overall total consumption of that seed type, no matter with which other seed type it occurs. Since it occurs with another seed type and not by itself, the estimate should be equal to  $\frac{1}{2}$  the actual amount consumed.

### Results:

Thickspike gayfeather had the most kernels per gram (592.6 kernels per g); sawtooth sunflower the fewest (566.6 kernels per g) (Table 5). The most energy per kernel was found in maximilian sunflower (11.9 cal per kernel); roundhead lespedeza had the least (8.4 cal per kernel). Sunflowers had more energy per gram (maximilian sunflower = 6924.6 cal per g; sawtooth sunflower = 6541.2 cal per g) than either thickspike gayfeather (5940.1 cal per g) or roundhead lespedeza (4944.4 cal per g). Roundhead lespedeza had the highest moisture content of the test seeds (6.8 percent) with the water content of thickspike gayfeather being 5.4 percent and that of the sunflowers averaging around 4.6 percent (Table 5). The percent of crude protein and crude fat in the kernels showed sunflowers were higher than thickspike gayfeather or roundhead lespedeza. Maximilian sunflower was 42.1 percent crude protein and 40.7 percent crude fat; sawtooth sunflower was 40.7 percent crude protein and 38.6 percent crude fat; thickspike gayfeather was 39.0 percent crude protein and 27.8 percent crude fat; and roundhead lespedeza was 39.0 percent crude protein and only 4.8 percent crude fat (Table 5). The amount of crude fiber in roundhead lespedeza was the highest (14.4 percent) of the four seed types with thickspike gayfeather and sawtooth sunflower averaging about 3.7 percent. Maximilian sunflower had the lowest percent crude fiber content (2.3 percent) (Table 5).

The analysis of variance of treatment means for weight and number of seeds consumed by both bird types is shown in Table 6.

The overall mean consumption by three field sparrows was 7.38 g (4370 seeds) per 3-hr period (Table 7). Estimates from analysis determined that, if each seed type was fed alone, the field sparrows order of preference would be maximilian sunflower-sawtooth sunflower first, thickspike gayfeather

Table 5. Some physical characteristics and the results of proximate analysis of roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower. Values for proximate analysis were obtained for kernels only and are expressed in percent composition.

| Seed type                | Number of<br>kernels/g | Calories/<br>kernel | Calories<br>/g | Moisture | Crude<br>protein | Crude<br>fat | Crude<br>fiber |
|--------------------------|------------------------|---------------------|----------------|----------|------------------|--------------|----------------|
| Roundhead<br>lespedeza   | 587.4                  | 8.4                 | 4944.4         | 6.8      | 39.0             | 4.8          | 14.4           |
| Thickspike<br>gayfeather | 592.6                  | 10.0                | 5940.1         | 5.4      | 39.0             | 27.8         | 3.5            |
| Sawtooth<br>sunflower    | 566.6                  | 11.5                | 6541.2         | 4.7      | 40.7             | 38.6         | 3.9            |
| Maximilian<br>sunflower  | 580.4                  | 11.9                | 6924.6         | 4.6      | 42.1             | 40.7         | 2.3            |



Table 6. Analysis of variance of treatment means for weight and number of seeds consumed by field sparrows and cardinals.

| <u>Field sparrows</u> |    |                              |                                  |
|-----------------------|----|------------------------------|----------------------------------|
| Source                | DF | Mean squares                 |                                  |
|                       |    | Weight of seeds consumed (g) | Number of seeds consumed (1,000) |
| Bird                  | 2  | 1.57                         | 695                              |
| Treatments            | 5  | 16.68                        | 5698                             |
| Error                 | 10 | 1.22                         | 1103                             |

| <u>Cardinals</u> |    |                              |                                  |
|------------------|----|------------------------------|----------------------------------|
| Source           | DF | Mean squares                 |                                  |
|                  |    | Weight of seeds consumed (g) | Number of seeds consumed (1,000) |
| Bird             | 2  | 0.89                         | 353                              |
| Treatments       | 5  | 64.70                        | 20912                            |
| Error            | 10 | 4.89                         | 1243                             |

Table 7. Estimates from analysis of field sparrow seed preferences. Values indicate increases or decreases in mean amount consumed by three birds during a 3-hr trial period relative to the overall mean.

| Parameter                | Seed consumption    |        |                        |          |
|--------------------------|---------------------|--------|------------------------|----------|
|                          | dry weight (g)      | SE     | number                 | SE       |
| Overall mean consumption | 7.38                | ± 0.26 | 4370.21                | ± 247.51 |
| Roundhead lespedeza      | -1.30 <sup>a*</sup> | ± 0.39 | -916.18 <sup>a*</sup>  | ± 371.27 |
| Sawtooth sunflower       | 0.70 <sup>b</sup>   | ± 0.39 | 363.84 <sup>b</sup>    | ± 371.27 |
| Maximilian sunflower     | 1.25 <sup>b</sup>   | ± 0.39 | 727.13 <sup>b</sup>    | ± 371.27 |
| Thickspike gayfeather    | -0.65 <sup>a</sup>  | ± 0.39 | -174.79 <sup>b</sup>   | ± 371.27 |
| Lespedeza-sawtooth       | 1.69 <sup>a**</sup> | ± 0.37 | 1000.12 <sup>a**</sup> | ± 350.04 |
| Lespedeza-maximilian     | 0.70 <sup>a</sup>   | ± 0.37 | 488.84 <sup>a</sup>    | ± 350.04 |
| Lespedeza-gayfeather     | -2.39 <sup>b</sup>  | ± 0.37 | -1488.97 <sup>b</sup>  | ± 350.04 |
| Sawtooth-maximilian      | -2.39 <sup>b</sup>  | ± 0.37 | -1488.97 <sup>b</sup>  | ± 350.04 |
| Sawtooth-gayfeather      | 0.70 <sup>a</sup>   | ± 0.37 | 488.84 <sup>a</sup>    | ± 350.04 |
| Maximilian-gayfeather    | 1.69 <sup>a</sup>   | ± 0.37 | 1000.12 <sup>a</sup>   | ± 350.04 |

\* within a column of seed types, estimates sharing a common superscript do not differ significantly (LSD 0.05).

\*\* within a column of seed pairs, estimates sharing a common superscript do not differ significantly (LSD 0.05).

and roundhead lespedeza (Table 7). Maximilian sunflower (increased overall mean consumption 1.25 g, 727.13 seeds) and sawtooth sunflower (increased overall mean consumption 0.70 g, 363.84 seeds) did not differ significantly. No significant difference existed between thickspike gayfeather (decreased overall mean consumption 0.65 g, 174.79 seeds) and roundhead lespedeza (decreased overall mean consumption 1.30 g, 916.18 seeds) (Table 7). Estimates obtained on the effects of the various treatments (seed pairs) show that the pairs roundhead lespedeza-sawtooth sunflower, maximilian sunflower-thickspike gayfeather, roundhead lespedeza-maximilian sunflower and thickspike gayfeather-sawtooth sunflower are not significantly different; these four treatments increased field sparrow overall mean consumption (Table 7). Roundhead lespedeza-sawtooth sunflower and maximilian sunflower-thickspike gayfeather increased the overall mean consumption by 1.69 g (1000.12 seeds) while the pairs roundhead lespedeza-maximilian sunflower and sawtooth sunflower-thickspike gayfeather increased the overall mean consumption by 0.70 g (488.84 seeds). The treatments consisting of roundhead lespedeza-thickspike gayfeather and sawtooth sunflower-maximilian sunflower were significantly lower than the other treatments and decreased the overall mean consumption by 2.39g (1488.97 seeds).

The overall mean seed consumption by three cardinals during a 3-hr period was  $17.18 \pm 0.52$  g equivalent to  $9902.1 \pm 263$  seeds (Table 8). If seeds had been fed alone and not in pairs, estimates from analysis shows maximilian sunflower to be the most consumed seed type (increased overall mean consumption 3.66 g, 2198.79 seeds) and significantly greater than sawtooth sunflower, thickspike gayfeather and roundhead lespedeza (Table 8). Consumption of sawtooth sunflower (decreased overall mean consumption 0.3g,

Table 8. Estimates from analysis of cardinal seed preferences. Values indicate increases or decreases in the mean amount consumed by three birds during a 3-hr trial period relative to the overall mean.

| Parameter                | Seed consumption    |        |                        |          |
|--------------------------|---------------------|--------|------------------------|----------|
|                          | dry weight (g)      | SE     | number                 | SE       |
| Overall mean consumption | 17.18               | ± 0.52 | 9902.10                | ± 262.75 |
| Roundhead lespedeza      | -2.58 <sup>a*</sup> | ± 0.78 | -1462.65 <sup>a*</sup> | ± 394.13 |
| Sawtooth sunflower       | -0.03 <sup>b</sup>  | ± 0.78 | -182.47 <sup>b</sup>   | ± 394.13 |
| Maximilian sunflower     | 3.66                | ± 0.78 | 2198.79                | ± 394.13 |
| Thickspike gayfeather    | -1.05 <sup>ab</sup> | ± 0.78 | -553.66 <sup>ab</sup>  | ± 394.13 |
| Lespedeza-sawtooth       | 2.94 <sup>a**</sup> | ± 0.74 | 1679.31 <sup>a**</sup> | ± 371.59 |
| Lespedeza-maximilian     | 1.67 <sup>a</sup>   | ± 0.74 | 938.75 <sup>a</sup>    | ± 371.59 |
| Lespedeza-gayfeather     | -4.61 <sup>b</sup>  | ± 0.74 | -2618.07 <sup>b</sup>  | ± 371.59 |
| Sawtooth-maximilian      | -4.61 <sup>b</sup>  | ± 0.74 | -2618.07 <sup>b</sup>  | ± 371.59 |
| Sawtooth-gayfeather      | 1.67 <sup>a</sup>   | ± 0.74 | 938.75 <sup>a</sup>    | ± 371.59 |
| Maximilian-gayfeather    | 2.94 <sup>a</sup>   | ± 0.74 | 1679.31 <sup>a</sup>   | ± 371.59 |

\* within a column of seed types, estimates sharing a common superscript do not differ significantly ( $LSD_{0.05}$ ).

\*\* within a column of seed pairs, estimates sharing a common superscript do not differ significantly ( $LSD_{0.05}$ ).

182.47 seeds) was not significantly different from thickspike gayfeather (decreased overall mean consumption 1.05g, 553.66 seeds)(Table 8).

While consumption of sawtooth sunflower was significantly greater than roundhead lespedeza, consumption of thickspike gayfeather was not.

The effects of treatments (seed pairs) on cardinal overall mean consumption showed similar trends as was seen for field sparrows. Treatments roundhead lespedeza-sawtooth sunflower, roundhead lespedeza-maximilian sunflower, sawtooth sunflower-thickspike gayfeather and maximilian sunflower-thickspike gayfeather did not differ significantly from each other but were consumed significantly more than the pairs sawtooth sunflower-maximilian sunflower and roundhead lespedeza-thickspike gayfeather (Table 9). Roundhead lespedeza-sawtooth sunflower and maximilian sunflower-thickspike gayfeather increased the overall mean consumption 2.94 g (1679.31 seeds) while roundhead lespedeza-maximilian sunflower and sawtooth sunflower-thickspike gayfeather increased overall mean consumption 1.67 g (938.75 seeds)(Table 8). Roundhead lespedeza-thickspike gayfeather and sawtooth sunflower-maximilian sunflower did not differ significantly in amount consumed of the pair; both decreased the overall mean consumption 4.61 g (2618.07 seeds)(Table 8).

Estimated consumption of each seed type if it had been fed alone (no interaction of seed types present) is compared with the actual consumption of each seed type for field sparrows and cardinals in Table 9. Actual consumption measured included an interaction factor due to the other member of the seed pair. Field sparrows consumed significantly more maximilian sunflower and sawtooth sunflower than roundhead lespedeza and thickspike gayfeather in both g consumed and number of seeds consumed (Table 9). If fed alone, it is estimated that 3 field sparrows would

Table 9. Estimated and actual consumptions of each seed type by field sparrows and cardinals in the preference experiments.

| <u>Field sparrows</u> |                |           |                |           |
|-----------------------|----------------|-----------|----------------|-----------|
| Seed type             | Seeds Consumed |           |                |           |
|                       | Weight (g)     |           | Number (1,000) |           |
|                       | estimate       | 2X actual | estimate       | 2X actual |
| Roundhead lespedeza   | 6.08           | 6.94      | 3.45           | 4.07      |
| Sawtooth sunflower    | 8.08           | 36.58     | 4.73           | 21.49     |
| Maximilian sunflower  | 8.63           | 36.02     | 5.10           | 20.90     |
| Thickspike gayfeather | 6.73           | 9.00      | 4.19           | 5.33      |

| <u>Cardinals</u>      |               |           |                |           |
|-----------------------|---------------|-----------|----------------|-----------|
| Seed type             | Seed Consumed |           |                |           |
|                       | Weight (g)    |           | Number (1,000) |           |
|                       | estimate      | 2X actual | estimate       | 2X actual |
| Roundhead lespedeza   | 14.60         | 14.27     | 8.44           | 8.38      |
| Sawtooth sunflower    | 17.15         | 80.12     | 9.72           | 45.40     |
| Maximilian sunflower  | 20.84         | 93.14     | 12.10          | 54.60     |
| Thickspike gayfeather | 16.13         | 16.00     | 9.35           | 9.48      |

eat 8.63 g per 3-hr of maximilian sunflower; 8.08 g per 3-hr of sawtooth sunflower; 6.73 g per 3-hr of thickspike gayfeather; and 6.08 g per 3-hr of roundhead lespedeza (Table 9 ). Actual consumption, however, of these seeds were: 36.02 g per 3-hr of maximilian sunflower; 36.58 g per 3-hr of sawtooth sunflower; 9.00 g per 3-hr of thickspike gayfeather; and 6.94 g per 3-hr of roundhead lespedeza.

Three cardinals would consume if fed only 1 seed type for 3 hr, 20.84 g of maximilian sunflower, 17.15 g of sawtooth sunflower, 16.13 g of thickspike gayfeather, and 14.60 g of roundhead lespedeza (Table 9 ). Actual consumption from seed pair presentations show that three cardinals eat 93.14 g per 3-hr of maximilian sunflower, 80.12 g per 3-hr of sawtooth sunflower, 16.00 g per 3-hr of thickspike gayfeather and 14.27 g per 3-hr of roundhead lespedeza (Table 9 ).

Discussion:

Cardinals and field sparrows consumed 4 to 5 times more maximilian sunflower and sawtooth sunflower seeds than roundhead lespedeza and thick-spike gayfeather seeds when seeds were presented in pairs or singly (Part III). Clearly birds were able to recognize sunflower seeds and showed a preference for them. The statistical procedure employed to analyze the preference data perhaps underplays this important result.

The statistical procedure of Dayton and Morrill (1974) is designed to evaluate seeds with relation to total consumption. It is immaterial to this statistical procedure whether a seed is actually consumed or "causes" variation in consumption of seeds paired with it. Since a seed is never paired with itself, its individual merits are never evaluated independently. The dependent variable is total consumption, unweighted for the individual contributions of the seed type.

The model of Dayton and Morrill assumed that changes in consumption are due only to the individual effects of each of the seed types in the trial plus the effect of presenting both seed together. Individual effects are evaluated by comparing the mean consumption of all trials containing that seed with the mean consumption of all trials.

It is important to keep in mind that the effects (both interaction and main) assessed are effects on total consumption not indices of individual consumption. The interaction effect is estimated as the difference between expected amount consumed (from the sum of the individual effects) and the actual amount consumed. The following example may clarify. If

- 1) the mean amount consumed in all trials is 10,
- 2) the effect of seed A on mean consumption is +3,
- 3) the effect of seed B on mean consumption is -2,



4) the actual amount consumed is 9,

Then the statistical model equation is:

effect of A + effect of B + effect of interaction = deviation from mean

$$(+3) + (-2) + X = (10 - 9)$$

$$X = -2$$

The interaction effect is estimated to decrease consumption by 2.

This study documents the fact that some interaction does occur when seeds are presented together. Previous preference study results must be viewed with some doubt when no interaction effect is considered (Kear 1966; Willson 1970; Willson and Harmeson 1973). A measurement of actual intake of a seed type fed in combination with another seed type (or types) could give a wrong preference order.

It has been observed on Isle Royale that moose disregard their favored food, fir, in stands where only fir occurs. Moose will consume fir first in mixed stands (Pletscher, personal communication). Thus it would seem that similar phenomena are occurring in both moose and field sparrows and cardinals, namely that a diversity of food types encourages eating of the preferred food. For management purposes, planting of a diversity of food sources, rather than just one or several similar types, is recommended. Since it is not understood how diversity enhances consumption, recommendations cannot be made as to whether the plant types should be species which produce seeds with high assimilation energy values or a diversity, i.e. a mixture of plants with high and low assimilation energy value seeds. It is possible that seeds that are low in assimilation energy provide choice contrast, fiber or some necessary material.

Estimates of consumption of sunflower seed types if they were fed alone (Table 9) were approximately 4.5 times less than actual consumption

of each type when fed in pairs. The actual consumption of roundhead lespedeza and thickspike gayfeather corresponds closely to estimated consumption (Table 9). It is apparent that the interaction effect operated to increase the amount of sunflower seeds consumed when roundhead lespedeza or thickspike gayfeather seeds were present. No increase or decrease in consumption of roundhead lespedeza or thickspike gayfeather was indicated. These results confirm the observation that seed diversity increases consumption of favored seed types but does not alter consumption rates of unfavored seed types.

It is not clear why the presence of "poor" seed types should increase consumption of "good" seed types. In anthropomorphic terms, a smorgas-borg effect is indicated. Perhaps an analogy of cheese and cracker, or bread and butter is appropriate. Interaction is a real phenomena, but this data set does not allow exploration into its causality.

### Energetic Implications

From Parts III and IV it may be concluded that the four varieties of seeds vary in energy content and are consumed with different metabolic efficiency by both cardinals and field sparrows. Seeds with the highest associated metabolic efficiencies increase mean consumption most. This section explores the energetic implications of Part III and Part IV.

Robel et al. (1974) suggested that seeds are consumed according to abundance. Robel's data were collected by analyzing crop contents of bobwhites. Birds such as these bobwhites in natural conditions must forage for seeds thus a time constraint is imposed which is not a consideration when seeds are present ad libitum. Willson (1971) and Willson and Harneson (1973) concluded that seed size or ease of handling is a major determination in seed preference of various finches. Ease of handling introduces a time constraint into the energetics of their experiment. Further Willson's and Harneson's determination of metabolic efficiency makes no note of weight of birds during the experiment. Seeds used in my experiments were approximately equal in size; no difficulties in handling were observed for either bird type; and seeds were presented ad libitum thus removing the time constraint. My study is not intended to discount the importance of seed availability or handling time; but rather to add another dimension, energetic quality, to questions of food preference.

Daily energy requirements for field sparrows and cardinals may be calculated from selected data contained in Part III (Metabolic efficiency). Energy requirement was assessed by averaging energy metabolized per day for birds that maintained a constant ( $\pm 5$  percent) weight. The value obtained for field sparrows was 16.9 kcal/bird/day; for cardinals it was 32.0 kcal/bird/day.

Table 13 compares values obtained for field sparrows in this study

Table 13. Daily energy requirements (kcal) for confined field sparrows determined by three authors.

| Weight of bird (g) | Temperature ( $^{\circ}\text{C}$ ) | Daily energy requirement (kcal/bird) | Citation                     |
|--------------------|------------------------------------|--------------------------------------|------------------------------|
| 14.6               | -20                                | 22.2                                 | Kendeigh (1949) <sup>a</sup> |
| 13.2               | 0                                  | 13.9                                 | Olson (1965) <sup>b</sup>    |
| 13.9               | 0                                  | 15.3                                 | Olson (1965) <sup>b</sup>    |
| 14.6               | 5                                  | 17.2                                 | Taylor (1976)                |

a. calculated from the following formula; photoperiod unknown:

$$\text{Cal/bird/day} = \text{Cal/g/day} \times (23.8 + 0.7(\text{g wt.} - 23.8))$$

where g wt. = weight of the bird, using my data, 14.6

Cal/g/day = 1.31, the maximum rate of energy intake at  $-20^{\circ}\text{C}$  or lower temperatures.

b. calculated by using the following formula for  $0^{\circ}\text{C}$  and 10 hours light:

14 hours dark:

$$14.69 - 0.261t = \text{kcal/bird/day for females weighing 13.2 g;}$$

$$15.59 - 0.285t = \text{kcal/bird/day for males weighing 13.9 g.}$$

where  $t = ^{\circ}\text{C}$ .

with work done by other researchers. It should be stressed that numeric values are particular for the environmental conditions imposed (i.e. confinement, 5° C, 50 percent humidity). There is evidence that sex is a determinate of sustenance requirement (Olson 1965); although sex may be a size correlate rather than an independent factor. Field sparrows in this study averaged 14.6 g as compared to 13.5 g for those studied by Olson (1965).

Others have attempted to extrapolate laboratory estimates of daily subsistence values to natural conditions (Kendeigh 1949, 1970; Cox 1961; Olson 1965). It is apparent that birds in the wild will have energetic requirements higher than those in confinement (under approximately same environmental conditions). Thus it is possible to evaluate seeds not only comparatively but in an absolute sense. If the seed resource cannot be consumed in sufficient quantity to equal the daily metabolic requirement, or a resting bird, that seed cannot be considered an energetically important resource for the bird.

The best method of energetic comparison between seed types is to calculate the energy consumed necessary to produce the daily metabolic energy requirement. From Part III (metabolic efficiency) the kcal/g, and metabolic efficiency are known (Table 14). The equation that gives the grams of seed necessary to supply the daily metabolic requirement is:

G = grams of seed necessary to supply daily metabolic energy requirement.

K = kcal energy per gram (empirically determined constant for each seed type).

M.E. = metabolic efficiency (empirically determined constant for each seed type).

Table 14. Metabolic efficiencies of field sparrows and cardinals for diets of roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower. The energy content (kcal/g kernel) of each seed type and the metabolic efficiency values were obtained in Part III.

| Seed type             | Kcal/g kernel | Metabolic efficiency (%) |           |
|-----------------------|---------------|--------------------------|-----------|
|                       |               | Field sparrows           | Cardinals |
| Roundhead lespedeza   | 4.94          | 1.00                     | 53.85     |
| Thickspike gayfeather | 5.94          | 53.34                    | 76.62     |
| Sawtooth sunflower    | 6.54          | 77.56                    | 81.47     |
| Maximilian sunflower  | 6.92          | 87.60                    | 84.65     |

D.M.R. = daily metabolic requirement (empirically determined constant for each bird type).

$$G \times K \times M.E. = D.M.R.$$

$$G = \frac{D.M.R.}{K \times M.E.}$$

The results of these calculations for all seed types and both bird types are summarized in Table 15. It is immediately apparent that field sparrows cannot survive on roundhead lespedeza. Lesser amounts of sunflower seeds need to be consumed per day than roundhead lespedeza or thickspike gayfeather. A more critical examination of required seed consumption is possible by comparison with actual consumption rates (Table 16). Sawtooth sunflower is consumed in quantities slightly less than those required to sustain body weight. Thickspike gayfeather and roundhead lespedeza are virtually ignored by both bird types even though these seeds are the only food resource available.

A quality index applicable to both field sparrows and cardinals is apparent. Maximilian sunflower is consumed in excess of the quantities necessary to sustain metabolism.

Sawtooth sunflower appears to be the exception. Consumption of sawtooth sunflower by cardinals is approximately the same as consumption of maximilian sunflower. This is evidence that cardinals perceive both seeds to be the same. Field sparrows however consume more than a third less sawtooth than maximilian sunflower. Both cardinals and field sparrows metabolize sawtooth sunflower at 3 and 10 percent, respectively, lower efficiency than maximilian sunflower (Table 14). It is apparent that quality differences do exist in the two sunflower types. The nature of these differences is not discernable from data collected in this study or available in the ecological literature.

The consumption difference between thickspike gayfeather and the two sun-

Table 15. The amounts of each seed type needed to be consumed to meet the daily energy requirements of field sparrows and cardinals.

| Seed type             | Amounts (g) to be ingested to meet<br>the daily energy requirements |           |
|-----------------------|---------------------------------------------------------------------|-----------|
|                       | Field sparrows                                                      | Cardinals |
| Roundhead lespedeza   | ---- <sup>a</sup>                                                   | 12.09     |
| Thickspike gayfeather | 5.47                                                                | 6.86      |
| Sawtooth sunflower    | 3.38                                                                | 6.08      |
| Maximilian sunflower  | 2.83                                                                | 5.48      |

a. Since the metabolic efficiency of field sparrows is less than 1, essentially 0, then it is impossible for field sparrows to eat enough roundhead lespedeza to meet their daily energy requirements.



Table 16. The average consumption of field sparrows and cardinals per day for each of the four seed types. (from Part III, metabolic efficiency).

| Seed type             | Average consumption (g) of seeds per day |          |
|-----------------------|------------------------------------------|----------|
|                       | Field sparrow                            | Cardinal |
| Roundhead lespedeza   | 0.08                                     | 1.33     |
| Thickspike gayfeather | 0.35                                     | 1.47     |
| Sawtooth sunflower    | 2.22                                     | 5.75     |
| Maximilian sunflower  | 3.51                                     | 5.78     |

flower types is unexpected. Cardinals are able to metabolize thickspike gayfeather with efficiency comparable to the sunflowers. Yet when fed a diet of only thickspike gayfeather cardinals consumed only  $\frac{1}{4}$  their apparent capacity as determined by the amount of sunflower seeds consumed (Table 16) and starved (Part III). Field sparrows metabolize thickspike gayfeather with about 20 percent less efficiency than cardinals. Field sparrows consumed proportionally less thickspike gayfeather.

Roundhead lespedeza was useless as a food resource for field sparrows and nearly so for cardinals. Again both bird species consumed much less than their capacity (determined from sunflower consumption) although the alternative was starvation.

An interesting phenomena emerges from this energetic overview. Birds will limit consumption of certain seed types to levels below those required for maintenance. They will continue to do so until death by starvation results. This is not merely preference behavior. Rather it implies some limit to the amount of certain seed types consumed, such as thickspike gayfeather and roundhead lespedeza.

As previously discussed this limit is not foraging or handling time. Nor is it satiation or the volume capacity of the gut. One postulate could be a plant defense compound present in the seed which accumulates according to the amount of seed consumed. The question of consumption limitation is an ecologically important and open one.

From a management standpoint the consumption limitation phenomena is a solid argument for the diversity ethic. It is poor strategy to saturate a management area with a single preferred plant species. Rather the life history, seasonality and "resource diversity requirement" all point to combinations of species as the best habitat management scheme for non-game birds.

A last but important point to be understood is that seeds taken in nature will always be found with alternate choices. High metabolic efficiency, high energy content and high rates of productivity will count for little, if birds refuse to eat them in the presence of some preferred seed (Table 17). The environmental matrix presents wild birds with complex choices. Any management strategy should be preceded by a pilot study to determine if the end results match the goals.

Table 17. Actual consumption of the seed types within seed pairs in grams, number and energy (kcal) consumed by field sparrows. Using metabolic efficiencies of field sparrows for each seed type, energy assimilated (kcal) is determined.

| Seed pairs | Amount Consumed |            |               | Metabolic efficiency (%) | Assimilated energy (kcal) |
|------------|-----------------|------------|---------------|--------------------------|---------------------------|
|            | Number of seeds | Weight (g) | Energy (kcal) |                          |                           |
| Lespedeza  | 1762.2          | 3.0        | 14.8          | 0.0                      | 0.0                       |
| Sawtooth   | 12805.2         | 22.6       | 147.8         | 77.6                     | 114.7                     |
| Lespedeza  | 1879.7          | 3.2        | 15.8          | 0.0                      | 0.0                       |
| Maximilian | 12130.4         | 20.9       | 144.6         | 87.6                     | 126.7                     |
| Lespedeza  | 2467.1          | 4.2        | 20.8          | 0.0                      | 0.0                       |
| Gayfeather | 2903.7          | 4.9        | 29.1          | 53.3                     | 15.5                      |
| Sawtooth   | 6391.2          | 11.3       | 73.8          | 77.6                     | 57.3                      |
| Maximilian | 5525.4          | 9.5        | 65.9          | 87.6                     | 57.7                      |
| Sawtooth   | 13485.1         | 23.8       | 155.6         | 77.6                     | 120.7                     |
| Gayfeather | 1659.3          | 2.8        | 16.6          | 53.3                     | 8.8                       |
| Maximilian | 14568.0         | 25.1       | 173.7         | 87.6                     | 152.2                     |
| Gayfeather | 3200.0          | 5.4        | 32.1          | 53.3                     | 17.1                      |
| -----      |                 |            |               |                          |                           |
| Means:     |                 |            |               |                          |                           |
| Seed Type  | 6564.8          | 12.3       | 74.2          | ----                     | 55.9                      |
| Seed Pair  | 13129.6         | 24.7       | 148.4         | ----                     | 111.8                     |

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Appendix. Table 1. Common and scientific names, status in Kansas and frequency of appearance in study area of 16 species of granivorous birds during the period June 1975-June 1976.

| Granivores <sup>a</sup>                                  |                               |                                                  |
|----------------------------------------------------------|-------------------------------|--------------------------------------------------|
| Species <sup>b</sup>                                     | Status in Kansas <sup>b</sup> | Relative frequency observed in area <sup>c</sup> |
| American goldfinch<br><u>Spinus tristis</u>              | resident                      | rare                                             |
| Cardinal<br><u>Richmondia cardinalis</u>                 | resident                      | common.                                          |
| Cedar waxwing<br><u>Bombycilla cedrorum</u>              | winter                        | rare                                             |
| Clay-colored sparrow<br><u>Spizella pallida</u>          | migrant                       | rare                                             |
| Field sparrow<br><u>Spizella pusilla</u>                 | summer                        | occasional                                       |
| Harris sparrow<br><u>Zonotrichia albicollis</u>          | winter                        | common                                           |
| House sparrow<br><u>Passer domesticus</u>                | resident                      | common                                           |
| House wren<br><u>Troglodytes aedon</u>                   | summer                        | occasional                                       |
| Indigo bunting<br><u>Passerina cyanea</u>                | summer                        | occasional                                       |
| Rose-breasted grosbeak<br><u>Pheucticus ludovicianus</u> | migrant                       | rare                                             |
| Rufous-sided towhee<br><u>Pipilo erythrophthalmus</u>    | migrant                       | rare                                             |
| Slate-colored junco<br><u>Junco hyemalis</u>             | winter                        | occasional                                       |
| Song sparrow<br><u>Melospiza melodia</u>                 | winter                        | occasional                                       |
| Tree sparrow<br><u>Spizella arborea</u>                  | winter                        | occasional                                       |

| Granivores <sup>a</sup>                                 |                                  |                                                       |
|---------------------------------------------------------|----------------------------------|-------------------------------------------------------|
| Species <sup>b</sup>                                    | Status in<br>Kansas <sup>b</sup> | Relative frequency<br>observed in Kansas <sup>c</sup> |
| White-crowned sparrow<br><u>Zonotrichia leucophrys</u>  | winter                           | occasional                                            |
| White-throated sparrow<br><u>Zonotrichia albicollis</u> | migrant                          | common                                                |

a. from Robbins et al, 1966.

b. after Martin et al, 1961.

resident = bird species that are present year-around.

winter = bird species that are present during the winter months  
(usually November-March).

summer = bird species that are present during the summer months  
(usually April-September), breeding here.

migrant = bird species that pass through during the spring (March-May) and the fall (September-October).

c. qualitative ratings based on the number of times that a bird species was sited in the area.

common            more than 150 sitings

occasional        10-150 sitings

rare              less than 150 sitings

Appendix. Table 2. Common and scientific names, status in Kansas and frequency of appearance in study area of 28 species of insectivorous birds during the period June 1975-June 1976.

| Insectivores <sup>a</sup>                             |                               |                                                  |
|-------------------------------------------------------|-------------------------------|--------------------------------------------------|
| Species <sup>b</sup>                                  | Status in Kansas <sup>b</sup> | Relative frequency observed in area <sup>c</sup> |
| American redstart<br><u>Setophaga ruticilla</u>       | migrant                       | common                                           |
| Baltimore oriole<br><u>Icterus spurius</u>            | summer                        | occasional                                       |
| Black-capped chickadee<br><u>Parus atricapilla</u>    | resident                      | common                                           |
| Blue jay<br><u>Cyanocitta cristata</u>                | resident                      | occasional                                       |
| Brown thrasher<br><u>Toxostoma rufum</u>              | summer                        | common                                           |
| Carolina wren<br><u>Thryothorus ludovicianus</u>      | resident                      | rare                                             |
| Catbird<br><u>Dumetella carolinensis</u>              | summer                        | occasional                                       |
| Downy woodpecker<br><u>Dendrocopos pubescens</u>      | resident                      | rare                                             |
| Eastern kingbird<br><u>Tyrannus tyrannus</u>          | summer                        | occasional                                       |
| Eastern wood pewee<br><u>Contopus virens</u>          | summer                        | rare                                             |
| Great-crowned flycatcher<br><u>Myiarchus crinitus</u> | summer                        | occasional                                       |
| Hooded warbler<br><u>Wilsonia sitrina</u>             | migrant                       | rare                                             |
| Mockingbird<br><u>Mimus polyglottus</u>               | resident                      | common                                           |

| Insectivores <sup>a</sup>                                  |                               |                                                  |
|------------------------------------------------------------|-------------------------------|--------------------------------------------------|
| Species <sup>b</sup>                                       | Status in Kansas <sup>b</sup> | Relative frequency observed in area <sup>c</sup> |
| Myrtle warbler<br><u>Dendroica petechia</u>                | migrant                       | rare                                             |
| Orange-crowned warbler<br><u>Vermivora celata</u>          | migrant                       | occasional                                       |
| Orchard oriole<br><u>Icterus spurius</u>                   | summer                        | occasional                                       |
| Red-bellied woodpecker<br><u>Centurus carolinus</u>        | resident                      | rare                                             |
| Red-headed woodpecker<br><u>Melanerpes erythrocephalus</u> | resident                      | rare                                             |
| Red-shafted flicker<br><u>Colaptes cafer</u>               | resident                      | rare                                             |
| Robin<br><u>Turdus migratorius</u>                         | migrant                       | rare                                             |
| Ruby-crowned kinglet<br><u>Regulus calendula</u>           | migrant                       | occasional                                       |
| Starling<br><u>Sturnus vulgaris</u>                        | resident                      | occasional                                       |
| Tennessee warbler<br><u>Vermivora peregrina</u>            | migrant                       | occasional                                       |
| Tufted titmouse<br><u>Parus bicolor</u>                    | resident                      | occasional                                       |
| Wilson's warbler<br><u>Wilsonia pusilla</u>                | migrant                       | rare                                             |
| Wood thrush<br><u>Hylocichla mustelina</u>                 | migrant                       | rare                                             |
| Yellow-billed cuckoo<br><u>Coccyzus americanus</u>         | summer                        | occasional                                       |
| Yellow warbler<br><u>Dendroica petechia</u>                | migrant                       | rare                                             |

## Appendix. Table 2 (continued).

---

a. from Robbins et al, 1966.

b. after Martin et al, 1961.

resident = bird species that are present year-around.

winter = bird species that are present during the winter months  
(usually November-March).

summer = bird species that are present during the summer months  
(usually April-September), breeding here.

migrant = bird species that pass through during the spring (March-May) and the fall (September-October).

c. qualitative ratings based on the number of times that a bird species was sited in the area.

common            more than 150 sitings

occasional        10-150 sitings

rare              less than 150 sitings

Appendix. Table 3. Common and scientific names of plants included in this study.

| Common name <sup>a</sup>   | Scientific name <sup>a</sup>      |
|----------------------------|-----------------------------------|
| American bittersweet       | <u>Celastrus scandens</u>         |
| American elderberry        | <u>Sambucus canadensis</u>        |
| American plum              | <u>Prunus americana</u>           |
| Amur honeysuckle           | <u>Lonicera maacki podocarpa</u>  |
| Arrowhead viburnum         | <u>Viburnum dentatum</u>          |
| Bessey cherry              | <u>Prunus besseyi</u>             |
| Bristly locust             | <u>Robina fertilis</u>            |
| Buckbrush                  | <u>Symphoricarpos orbiculatus</u> |
| 'Cardinal' autumnolive     | <u>Elaeagnus umbellata</u>        |
| Common lilac               | <u>Syringa vulgaris</u>           |
| Cotoneaster species        | <u>Cotoneaster sp.</u>            |
| Indigobush amorpha         | <u>Amorpha fruticosa</u>          |
| Jerseytea                  | <u>Ceanothus americanus</u>       |
| Matrimony vine             | <u>Lycium halimifolium</u>        |
| Maximilian sunflower       | <u>Helianthus maximiliani</u>     |
| Mediterranean salt tree.   | <u>Holomodendron sp.</u>          |
| Multiflora rose x rugosa   | <u>Rosa multiflora x rugosa</u>   |
| Redosier dogwood           | <u>Cornus stolonifera</u>         |
| Red tatarian honeysuckle   | <u>Lonicera tatarica sibirica</u> |
| 'Rem-red' amur honeysuckle | <u>Lonicera maacki</u>            |
| Roundhead lespedeza        | <u>Lespedeza capitata</u>         |
| Russianolive               | <u>Elaeagnus angustifolia</u>     |

Appendix. Table 3 (continued).

| Common name <sup>a</sup>  | Scientific name <sup>a</sup>     |
|---------------------------|----------------------------------|
| Sargent crabapple         | <u>Malus sargentii</u>           |
| Sawtooth sunflower        | <u>Helianthus grosseserratus</u> |
| Shrub lespedeza           | <u>Lespedeza bicolor</u>         |
| Silver buffaloberry       | <u>Shepherdia argentea</u>       |
| Skunkbush sumac           | <u>Rhus trilobata</u>            |
| Smoothstem prairie rose   | <u>Rosa setigera serena</u>      |
| Thickspike gayfeather     | <u>Liatrus pycnostachya</u>      |
| Thornless multiflora rose | <u>Rosa multiflora</u>           |
| Washington hawthorn       | <u>Crataegus phaenopyrum</u>     |
| Wayfaringtree viburnum    | <u>Viburnum lantana</u>          |
| Western chokecherry       | <u>Prunus virginiana</u>         |
| Wichura rose              | <u>Rosa wichuriana</u>           |

a. Common and scientific names are those used by the Manhattan Plant Materials Center, U. S. Soil Conservation Service. (



Appendix. Table 4. Total amount of activity occurring in 32 plant species studied from June 1975-June 1976. Plant species are listed in descending order according to the total amount of activity time observed per species.

| Plant species                     | Total activity (min) |
|-----------------------------------|----------------------|
| Thornless multiflora rose         | 400.80               |
| Multiflora rose x rugosa          | 327.16               |
| 'Cardinal' autumnolive            | 272.48               |
| Manchu cherry 1<br>(North Dakota) | 260.29               |
| Smoothstem prairie rose           | 167.67               |
| Sargent crabapple                 | 154.50               |
| Silver buffaloberry               | 133.25               |
| Russianolive                      | 125.27               |
| Manchu cherry 2<br>(Missouri)     | 118.68               |
| Skunkbush sumac                   | 102.13               |
| Redosier dogwood                  | 90.77                |
| Red tatarian honeysuckle          | 71.08                |
| Western chokecherry               | 52.73                |
| Cotoneaster sp.                   | 35.10                |
| Amur honeysuckle                  | 32.67                |
| Washington hawthorn               | 22.06                |
| Indigobush amorpha                | 20.97                |
| American plum                     | 17.65                |
| American elderberry               | 14.00                |
| Common lilac                      | 12.34                |
| Shrub lespedeza                   | 11.37                |
| 'Rem-red' amur honeysuckle        | 9.68                 |

Appendix. Table 4 continued.

| Plant species           | Total activity (min) |
|-------------------------|----------------------|
| Yellow chokecherry      | 7.36                 |
| Bristly locust          | 4.21                 |
| Jerseytea               | 2.41                 |
| Wichuria rose           | 2.09                 |
| Mediterranean salt tree | 0.62                 |
| Bessey cherry           | 0.57                 |
| American bittersweet    | 0.42                 |
| Buckbrush               | 0.42                 |
| Matrimony vine          | 0.34                 |
| Arrowhead viburnum      | 0.00                 |
| Wayfaringtree viburnum  | 0.00                 |

Appendix. Table 5. Ranks of 14 species of plants from 1 (least used) to 5 (most used) for seasons within major activity categories.

| Plant species                     | Bird type <sup>a</sup> | Foraging <sup>b</sup> |    |    |   | Courtship <sup>b</sup><br>Sp & Su | General activity <sup>b</sup> |    |    |   |
|-----------------------------------|------------------------|-----------------------|----|----|---|-----------------------------------|-------------------------------|----|----|---|
|                                   |                        | W                     | Sp | Su | F |                                   | W                             | Sp | Su | F |
| Russianolive                      | G                      | 3                     | 1  | 4  | 1 | 5                                 | 2                             | 1  | 2  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 4  | 1 |
| Western chokecherry               | G                      | 1                     | 1  | 2  | 1 | 4                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Sargent crabapple                 | G                      | 5                     | 1  | 4  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Silver buffaloberry               | G                      | 5                     | 1  | 1  | 2 | 1                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 2                     | 1  | 5  | 5 | 1                                 | 1                             | 1  | 5  | 1 |
| Cotoneaster sp.                   | G                      | 1                     | 1  | 5  | 1 | 3                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Amur honeysuckle                  | G                      | 2                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Red tatarian honeysuckle          | G                      | 3                     | 1  | 2  | 4 | 1                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| 'Cardinal' autumnolive            | G                      | 1                     | 2  | 5  | 5 | 4                                 | 3                             | 1  | 5  | 5 |
|                                   | I                      | 1                     | 3  | 1  | 2 | 2                                 | 1                             | 1  | 2  | 5 |
| Manchu cherry 1<br>(North Dakota) | G                      | 1                     | 5  | 2  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Manchu cherry 2<br>(Missouri)     | G                      | 1                     | 3  | 1  | 2 | 1                                 | 1                             | 1  | 1  | 1 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 2  | 1 |
| Thornless multiflora rose         | G                      | 3                     | 2  | 1  | 1 | 1                                 | 5                             | 5  | 1  | 5 |
|                                   | I                      | 5                     | 5  | 1  | 1 | 2                                 | 5                             | 1  | 2  | 1 |
| Multiflora rose x rugosa          | G                      | 4                     | 2  | 1  | 5 | 1                                 | 3                             | 5  | 1  | 3 |
|                                   | I                      | 3                     | 1  | 1  | 2 | 5                                 | 1                             | 5  | 1  | 2 |
| Smoothstem prairie rose           | G                      | 3                     | 2  | 1  | 2 | 1                                 | 1                             | 1  | 1  | 2 |
|                                   | I                      | 1                     | 1  | 3  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Redosier dogwood                  | G                      | 4                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 2 |
|                                   | I                      | 1                     | 1  | 1  | 1 | 1                                 | 1                             | 1  | 1  | 1 |
| Skunkbush sumac                   | G                      | 1                     | 1  | 4  | 1 | 1                                 | 1                             | 1  | 1  | 4 |
|                                   | I                      | 1                     | 1  | 4  | 1 | 1                                 | 1                             | 1  | 1  | 1 |

a. Bird type G = bird species predominantly granivorous.

Bird type I = bird species predominantly insectivorous.

(from Robbins et al., 1966)

b. W = winter (December, January, February)

Sp = spring (March, April, May)

Su = summer (June, July, August)

F = fall (September, October, November)

Appendix. Table 6. Time (min) spent in foraging activity by granivorous birds for each season in 14 plant species during the June 1975-June 1976 period.

| Plant species                     | Winter | Spring | Summer | Fall   |
|-----------------------------------|--------|--------|--------|--------|
| Russianolive                      | 44.48  | 32.25  | 2.28   | 1.79   |
| Western chokecherry               | 9.60   | 20.70  | 1.19   | 2.76   |
| Sargent crabapple                 | 80.90  | 30.37  | 2.89   | 4.70   |
| Silver buffaloberry               | 85.61  | 12.45  | 0.74   | 9.01   |
| Cotoneaster sp.                   | 7.01   | 0.00   | 2.97   | 3.25   |
| Amur honeysuckle                  | 24.49  | 0.00   | 0.54   | 0.36   |
| Red tatarian honeysuckle          | 33.45  | 6.75   | 0.86   | 23.15  |
| 'Cardinal' autumnolive            | 15.66  | 51.00  | 3.70   | 37.24  |
| Manchu cherry 1<br>(North Dakota) | 0.34   | 231.00 | 1.32   | 2.34   |
| Manchu cherry 2<br>(Missouri)     | 0.68   | 104.40 | 0.27   | 8.57   |
| Thornless multiflora rose         | 34.53  | 65.77  | 0.70   | 6.88   |
| Multiflora rose x rugosa          | 59.96  | 60.13  | 0.00   | 39.78  |
| Smoothstem prairie rose           | 44.65  | 64.65  | 0.42   | 9.01   |
| Redosier dogwood                  | 55.73  | 3.30   | 0.00   | 5.26   |
| Skunkbush sumac                   | 13.28  | 0.00   | 2.79   | 2.56   |
| Total                             | 510.37 | 682.77 | 20.67  | 156.66 |

Appendix. Table 7. Time (min) spent in foraging activity by insectivorous birds for each season in 14 plant species during the June 1975-June 1976 period.

| Plant species                     | Winter | Spring | Summer | Fall  |
|-----------------------------------|--------|--------|--------|-------|
| Russianolive                      | 0.00   | 0.00   | 0.00   | 0.85  |
| Western chokecherry               | 0.00   | 0.90   | 0.09   | 3.47  |
| Sargent crabapple                 | 2.00   | 0.00   | 1.21   | 19.03 |
| Silver buffaloberry               | 0.00   | 0.00   | 0.12   | 0.37  |
| Cotoneaster sp.                   | 0.00   | 0.00   | 0.57   | 0.10  |
| Amur honeysuckle                  | 0.00   | 0.00   | 0.00   | 0.49  |
| Red tatarian honeysuckle          | 0.00   | 0.00   | 0.08   | 1.56  |
| 'Cardinal' autumnolive            | 0.00   | 12.30  | 0.00   | 5.05  |
| Manchu cherry 1<br>(North Dakota) | 0.00   | 2.10   | 0.00   | 0.24  |
| Manchu cherry 2<br>(Missouri)     | 0.00   | 0.15   | 0.21   | 0.76  |
| Thornless multiflora rose         | 7.01   | 22.40  | 0.03   | 3.50  |
| Multiflora rose x rugosa          | 3.69   | 0.00   | 0.00   | 7.52  |
| Smoothstem prairie rose           | 0.34   | 0.00   | 0.61   | 0.56  |
| Redosier dogwood                  | 0.00   | 0.00   | 0.24   | 0.40  |
| Skunkbush sumac                   | 0.00   | 4.05   | 0.83   | 0.40  |
| Total                             | 13.04  | 41.90  | 3.99   | 40.53 |

Appendix. Table 8. Time (min) spent in general activity by granivorous birds for each season in 14 plant species during the June 1975-June 1976 period.

| Plant species                     | Winter | Spring | Summer | Fall   |
|-----------------------------------|--------|--------|--------|--------|
| Russianolive                      | 13.64  | 5.55   | 2.04   | 5.54   |
| Western chokecherry               | 1.48   | 1.65   | 0.96   | 0.00   |
| Sargent crabapple                 | 5.29   | 6.45   | 0.13   | 0.73   |
| Silver buffaloberry               | 10.42  | 2.95   | 0.71   | 5.90   |
| Cotoneaster sp.                   | 2.68   | 0.45   | 0.68   | 8.48   |
| Amur honeysuckle                  | 1.30   | 0.00   | 0.35   | 4.86   |
| Red tatarian honeysuckle          | 0.04   | 0.22   | 0.69   | 4.11   |
| 'Cardinal' autumnolive            | 7.48   | 3.15   | 9.41   | 101.14 |
| Manchu cherry 1<br>(North Dakota) | 0.00   | 0.00   | 1.94   | 20.91  |
| Manchu cherry 2<br>(Missouri)     | 0.00   | 0.00   | 0.09   | 2.66   |
| Thornless multiflora rose         | 57.67  | 36.73  | 0.63   | 121.21 |
| Multiflora rose x rugosa          | 24.49  | 36.15  | 0.00   | 62.98  |
| Smoothstem prairie rose           | 0.00   | 0.00   | 0.00   | 47.43  |
| Redosier dogwood                  | 0.79   | 0.00   | 0.00   | 24.53  |
| Skunkbush sumac                   | 0.93   | 0.00   | 0.06   | 77.11  |
| Total                             | 126.21 | 93.25  | 17.69  | 487.59 |

Appendix. Table 9. Time (min) spent in general activity by insectivorous birds for each season in 14 plant species during the June 1975-June 1976 period.

| Plant species                     | Winter | Spring | Summer | Fall  |
|-----------------------------------|--------|--------|--------|-------|
| Russianolive                      | 0.50   | 0.00   | 1.05   | 0.00  |
| Western chokecherry               | 0.00   | 0.00   | 0.19   | 0.00  |
| Sargent crabapple                 | 0.25   | 0.00   | 0.13   | 0.00  |
| Silver buffaloberry               | 1.03   | 0.00   | 1.44   | 0.21  |
| Cotoneaster sp.                   | 0.00   | 0.00   | 0.05   | 0.00  |
| Amur honeysuckle                  | 0.00   | 0.00   | 0.23   | 0.00  |
| Red tatarian honeysuckle          | 0.00   | 0.00   | 0.02   | 0.10  |
| 'Cardinal' autumnolive            | 0.00   | 0.00   | 0.43   | 6.55  |
| Manchu cherry 1<br>(North Dakota) | 0.00   | 0.00   | 0.10   | 0.00  |
| Manchu cherry 2<br>(Missouri)     | 0.00   | 0.00   | 0.33   | 0.56  |
| Thornless multiflora rose         | 30.19  | 0.30   | 0.48   | 6.83  |
| Multiflora rose x rugosa          | 5.09   | 4.60   | 0.00   | 2.42  |
| Smoothstem prairie rose           | 0.00   | 0.00   | 0.00   | 0.00  |
| Redosier dogwood                  | 0.00   | 0.00   | 0.00   | 0.52  |
| Skunkbush sumac                   | 0.00   | 0.00   | 0.00   | 0.00  |
| Total                             | 37.06  | 4.90   | 4.45   | 17.19 |



Appendix. Table 10. Time (min) spent in reproductive activity by granivorous birds for spring and summer (combined) in 14 plant species during the June 1975-June 1976 period.

| Plant species                     | Spring & Summer |
|-----------------------------------|-----------------|
| Russianolive                      | 15.35           |
| Western chokecherry               | 9.74            |
| Sargent crabapple                 | 0.42            |
| Silver buffaloberry               | 2.29            |
| Cotoneaster sp.                   | 8.86            |
| Amur honeysuckle                  | 0.09            |
| Red tatarian honeysuckle          | 0.05            |
| 'Cardinal' autumnolive            | 12.07           |
| Manchu cherry 1<br>(North Dakota) | 0.00            |
| Manchu cherry 2<br>(Missouri)     | 0.00            |
| Thornless multiflora rose         | 0.14            |
| Multiflora rose x rugosa          | 1.35            |
| Smoothstem prairie rose           | 0.00            |
| Redosier dogwood                  | 0.00            |
| Skunkbush sumac                   | 0.00            |
| Total                             | 50.36           |

Appendix. Table 11. Time (min) spent in reproductive activity by insectivorous birds for spring and summer (combined) in 14 plant species during the June 1975-June 1976 period.

| Plant species                     | Spring & Summer |
|-----------------------------------|-----------------|
| Russianolive                      | 0.00            |
| Western chokecherry               | 0.00            |
| Sargent crabapple                 | 0.00            |
| Silver buffaloberry               | 0.00            |
| Cotoneaster species               | 0.00            |
| Amur honeysuckle                  | 0.00            |
| Red tatarian honeysuckle          | 0.00            |
| 'Cardinal' autumnolive            | 7.30            |
| Manchu cherry 1<br>(North Dakota) | 0.00            |
| Manchu cherry 2<br>(Missouri)     | 0.00            |
| Thornless multiflora rose         | 5.80            |
| Multiflora rose x rugosa          | 19.00           |
| Smoothstem prairie rose           | 0.00            |
| Redosier dogwood                  | 0.00            |
| Skunkbush sumac                   | 0.12            |
| Total                             | 32.22           |

Appendix. Table.12. Composition of Co-op Chick Starter. Values and components were obtained from the Feed Franchise Mixer Manual for Poultry Feeds, pg 1, 1973.

| Components           | Percent of total weight |
|----------------------|-------------------------|
| Corn or milo         | 70.29                   |
| Soybean meal 44      | 21.50                   |
| Wheat middlings      | -----                   |
| Dehy alfalfa 17      | 1.00                    |
| Meat and bone meal   | 1.00                    |
| Animal fat           | 0.60                    |
| Mixing salt          | 0.40                    |
| Dical phos 21        | 1.50                    |
| Ground limestone     | 1.00                    |
| Methionine HA        | 0.10                    |
| Aniprol plus         | 0.05                    |
| Bacitracin 4g        | 0.01                    |
| Lysine 80%           | 0.05                    |
| Poultry fort #1 6810 | 2.50                    |
| -----                |                         |
| Nutrient analysis    | Percent composition     |
| Crude protein        | 17.00                   |
| Fiber, max.          | 4.00                    |
| Calcium              | 0.77                    |
| Phosphorous          | 0.70                    |
| Meth-Cystine         | 0.60                    |
| Lysine               | 0.90                    |
| -----                |                         |

Metabolic energy = 2.7 kcal/g

HABITAT UTILIZATION BY NON-GAME BIRDS

by

NANCY BROWNING TAYLOR

B. S., University of Oregon, 1974

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An Abstract of a Master's Thesis

submitted in partial fulfillment of the

requirement for the degree

MASTER OF SCIENCE

Division of Biology

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Selected plant species currently being evaluated for potential conservation use by the Plant Materials Center, U. S. Soil Conservation Service, Manhattan, Kansas, were evaluated with respect to habitat quality for non-game birds. Evaluation of habitat quality involved four approaches: 1) seasonal activity determinations for all species of birds that utilized any of the plant species, 2) seasonal availability of roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower seeds, 3) metabolic efficiencies of field sparrows and cardinals associated with ad libitum diets of roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower seeds, and 4) preference of field sparrows and cardinals for roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower seeds.

A plant quality index based on the behavioral observations of Part I was formulated which rated plant species for seasonal quality (fall, winter, spring and summer) with respect to the functional categories of bird activity (foraging, reproduction and general activities). This method of data summary enables the conservation manager to choose a combination of plants which can satisfy the requirements of resident or migratory non-game birds for the entire annual cycle.

Roundhead lespedeza, thickspike gayfeather, sawtooth sunflower and maximilian sunflower are slated for early release in conservation programs by the U. S. Soil Conservation Service. For this reason these seed types were investigated with respect to seasonal availability (2), associated metabolic efficiency (3), and preference (4). Both roundhead lespedeza and thickspike gayfeather showed little difference in seasonal abundance of seeds on the ground, while the densities of both species of sunflower seeds were continually diminished after an autumn peak. This result is consistent with the metabolic and preference

study conclusions that roundhead lespedeza is unsuitable as a food resource for non-game birds and both species of sunflower seeds are much superior to thickspike gayfeather seeds.

Field sparrows and cardinals were chosen as representative species of eastern Kansas.