Breeding Habitat for the Loggerhead Shrike (*Lanius ludovicianus*) in South-Western Manitoba

by

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BREEDING HABITAT FOR THE LOGGERHEAD SHRIKE

(<u>Lanius ludovicianus</u>) IN SOUTH-WESTERN MANITOBA

BY

SHERYL LYNN HELLMAN

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

ABSTRACT

The Loggerhead Shrike (*Lanius ludovicianus*), a bird indigenous to the North American Prairies, is considered endangered under the Manitoba Endangered Species Act. The purpose of this study was to describe the most suitable Loggerhead Shrike breeding habitat with respect to site selection and reproductive success. Habitat at 43 nest sites was examined within Albert and Edward municipalities in southwestern Manitoba from May to August, 1992. Variables at each nest site and territory were measured and compared to random sites. Nest territories had a significantly higher percentage of pasture, less trees, and more perching substrata than random territories. Furthermore, the understory index was significantly shorter at the nest sites than random sites. Nest territories were further examined to determine if they were similar in terms of habitat variables, or if they could be classified into separate groupings. Correspondence analysis grouped nest territories into three distinctive groupings: nest territories strongly associated with pasture, territories strongly associated with cropland and territories associated with smaller proportions of pasture and cropland, with a mixture of other land use types. Comparisons of reproductive success among these groupings found that the pasture grouping had the highest reproductive success. Reproductive success was also found to be high in nest sites associated with a lower understory index.

Findings from this study and previous research were used to develop management recommendations which may promote the conservation of suitable Loggerhead Shrike breeding habitat.

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CHAPTER 1
INTRODUCTION

1.1 Background:

The Loggerhead Shrike (*Lanius ludovicianus*) is indigenous to North America, ranging from southern Canada to Mexico (Cadman 1985). Its historical breeding range on the prairies extended from northcentral to southern Alberta, through central and southern Saskatchewan and into Manitoba (south and west of Lake Winnipeg) . Changes in population size and ranges have been documented in southern Canada (Cadman 1985, Telfer 1992). The most severe population and distribution declines began in the 1940's. Experts are most concerned with the diminishing eastern subspecies occuring in Ontario, Quebec, and Manitoba populations (Cadman 1990, Robert and Laporte 1991). Western populations are less vulnerable in the western population, however, their distribution in Manitoba and Alberta has retracted to areas adjacent to the borders of Saskatchewan, with 250 and 400 pairs respectively (Telfer et al. 1992). The last remaining stable populations remain in portions of southwest Manitoba, southern Saskatchewan and southeastern Alberta. Based on these findings, the Loggerhead Shrike was placed on the Canadian Threatened Species List (Cadman 1985) and was recently included in Manitoba's Endangered Species Act (Government of Manitoba 1990).

Historically, Loggerhead Shrike populations have extended across southern Manitoba (Cadman 1985). Extensive surveys since 1987 have revealed that the shrike population has retracted to the extreme southwest of the province. De Smet (1992) found that 85-95 percent of Loggerhead Shrikes in Manitoba occur within the extreme southwest of the province. Recent surveys suggest that Loggerhead Shrikes have decreased by 33 percent within the last five years within northern portions of their southwestern Manitoba stronghold. Causes of Loggerhead Shrike population decline remain unclear (Telfer et al.

1992). A combination of factors may have lowered reproductive success and increased mortality. These factors include habitat changes on the breeding and wintering ranges (Brooks and Temple 1990, Telfer et al. 1992), pesticides (Anderson and Duzan 1978), post-fledgling mortality, vehicle collisions, and changes in weather patterns (Telfer et al. 1992).

This project focused on quantifying Loggerhead Shrike habitat needs within primary nesting range in southwestern Manitoba. It should be seen as a preliminary step in determining if this species is limited by its habitat in this area. Although surveys report ample apparently suitable habitat for Loggerhead Shrike breeding in Canada, recent studies suggest that optimal habitat possesses unique features which may have been overlooked (Brooks and Temple 1990, Prescott and Collister 1992). Determining optimal characteristics of the Loggerhead Shrike's breeding habitat, and quantitatively describing and comparing occupied and apparently suitable unoccupied areas, was recommended as a priority in the National Recovery Plan for Loggerhead Shrikes (Telfer et al. 1992). Quantitative studies may reveal "previously unknown factors contributing to shrike declines."

1.2 Problem Statement

Within the past 50 years, agricultural practices in North America have altered the natural habitat for Loggerhead Shrikes, replacing most of mixed grass prairie within southwestern Manitoba with agricultural fields and pasture. In order to preserve the species for the future, it is necessary to determine suitable breeding habitat for the Loggerhead Shrike within this altered habitat.

1.3 Objectives

The purpose of this study was to describe the most suitable Loggerhead Shrike breeding areas with respect to site selection and reproductive success. Management recommendations were then implied from these results and other recent research. Specific objectives were to:

(1) quantify nesting habitat characteristics of the Loggerhead Shrike in southwestern Manitoba, and to test the null hypothesis that nest territories were similar to randomly chosen locations;

(2) determine if nest territories were similar in terms of habitat variables, or if they can be classified into separate groupings;

(3) determine if the resulting nest habitat groupings differed in reproductive success; and

(4) recommend land management, administration and policy implications from the results of this study which may promote the conservation of Loggerhead Shrike habitat.

1.4 Scope and Constraints

This study encompassed only a sample of the Manitoba Loggerhead Shrike population. Shrike pairs were found by travelling and scanning from roadsides, thus the sample of breeding sites may be biased towards roadside sites. Because some habitat variables may be related to the distance to roads, the randomly chosen points approximated the frequency distribution of distances to roads in the breeding site sample.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review covers historical and present Loggerhead Shrike distribution, possible reasons for population declines, as well as Loggerhead Shrike biology related to habitat use. Current national and provincial conservation efforts are also discussed.

2.2 Description

2.21 Characteristics

The Loggerhead Shrike (*Lanius ludovicianus*) is a medium-sized passerine (songbird), slightly smaller than a robin. The head appears somewhat large in proportion to the rest of the body, hence the name "loggerhead" (Ohlinger 1898).

Coloration in *L. ludovicianus* is similar to a mockingbird. The upper parts of the body are mouse grey, the breast, sides and flanks are white and the wings and tail are in proportions of black and white. A wide black bar extends horizontally from behind each eye forward and meets above the bill and at the base of the upper mandible. Loggerhead males and females are indistinguishable in size and color (Miller 1931). Juveniles are also similar in color pattern, however, colors are more drab and dusky. The beak is raptor-like in appearance with a hooked upper mandible extending beyond the lower. However, the legs and claws are that of a songbird. As it lacks talons, it impales its prey on sticks, thorns or barbed wire fence, anchoring the object in order to tear its prey apart . Other reasons for this behavior include caching and territorial markings (Smith 1972). The shrike has a diet of beetles, grasshoppers and insects, with the occasional mouse or small bird.

2.3 North American Distribution and Population Trends

Historically, Loggerhead Shrikes extended from Nova Scotia into central Mexico and from the Atlantic to Pacific Oceans; they spread into northeast range with settlement (Bent 1950, Cadman 1985) . Despite its wide range, Loggerhead Shrike populations have declined over much of the United States and Canada over the past several decades (Morrison 1981, Robbins et al. 1986). The most important population changes have almost certainly taken place in the last 25 years (Arbid 1978). In the northeast, the population seems to have peaked during the past few decades of the 1800's (Bull 1974). Populations remained high through to the mid-1900's, when some authors began to note declines (Mayfield 1949). Peterson (1965) commented on the continued decline in numbers in the mid-western prairie region. The Loggerhead Shrike has been included on the American Bird's "Blue List" of declining birds in every year since 1972 (Tate 1986). Arbib (1978) considered shrikes to be among the most critically declining species, noting particular concerns among the *L. l. excuitorides* and *L.l. migrans* subspecies.

Analysis of the U.S. Fish and Wildlife Service Breeding Bird Survey data also indicated that Loggerhead Shrikes have exhibited a significant decline throughout North America, but it has been most severe in the central U.S. (Bystrak 1981). Loggerheads have been reported on BBS routes in 40 States and seven provinces. Since 1966, declines have been evident in 31 of these states and five provinces (Cadman 1985). Cadman (1985) documented continual decline throughout their range according to data collected between 1966 and 1983, noting that the decline varied from five to 100 percent in different areas. Christmas Bird Count data confirmed that shrikes have declined in numbers (Morrison 1981). Luukkonen (1987) analyzed BBS routes and found a significant overall continental decline of 3.7 percent yearly ($p<0.01$).

2.31 Population Trends in Canada

After reviewing the Loggerhead Shrike's distribution and population trends, Cadman (1985) recommended that this species should be assigned to the Canadian Threatened Species List. COSEWIC (The Committee on the Status of Endangered Wildlife in Canada) designated it as a threatened species in 1986. Cadman (1985) concluded that the species was in danger of extirpation in the Canadian maritime provinces and Quebec, endangered in Ontario, and threatened in the prairie provinces. Figure 1 illustrates how the breeding range of Canadian populations has retracted in recent times.

In Manitoba, Loggerhead Shrikes historically extended north to Riding Mountain National Park, angling down to east of Winnipeg (Cadman 1985). However, surveys conducted from 1987-1991 revealed that the shrike population has retracted to the extreme southwest of the province. Approximately 250 pairs were found annually with 85-95 percent of these occuring in the extreme southwest (De Smet 1991, 1992). Within the last five years, numbers in the northern portion of this area alone have declined by 33 percent. BBS routes from Manitoba show a definite decrease in numbers from 1967 to 1983 (Cadman 1985). Figure 2 illustrates the distribution of the breeding population from 1987- 1991 (De Smet 1992). The western subspecies (*L.l. excubitorides)* is designated as threatened in Manitoba, while the eastern population (subspecies *L. l. migrans)* has been designated by COSEWIC as endangered (Cadman 1990, Manitoba Environment 1993).

2.4 Possible Reasons for Decline

2.41 Land Use Change on the Breeding Grounds

One possible factor contributing to the decline of the Loggerhead Shrike is modification of optimal breeding habitat (Cadman 1985, Telfer 1992). The North American prairies have been drastically transformed within the past century. In all Canadian regions, the area of cultivated land increased steadily and substantially from 1946 to 1986. In the Canadian Prairies, less than 15 percent of native short grass, mixed grass,

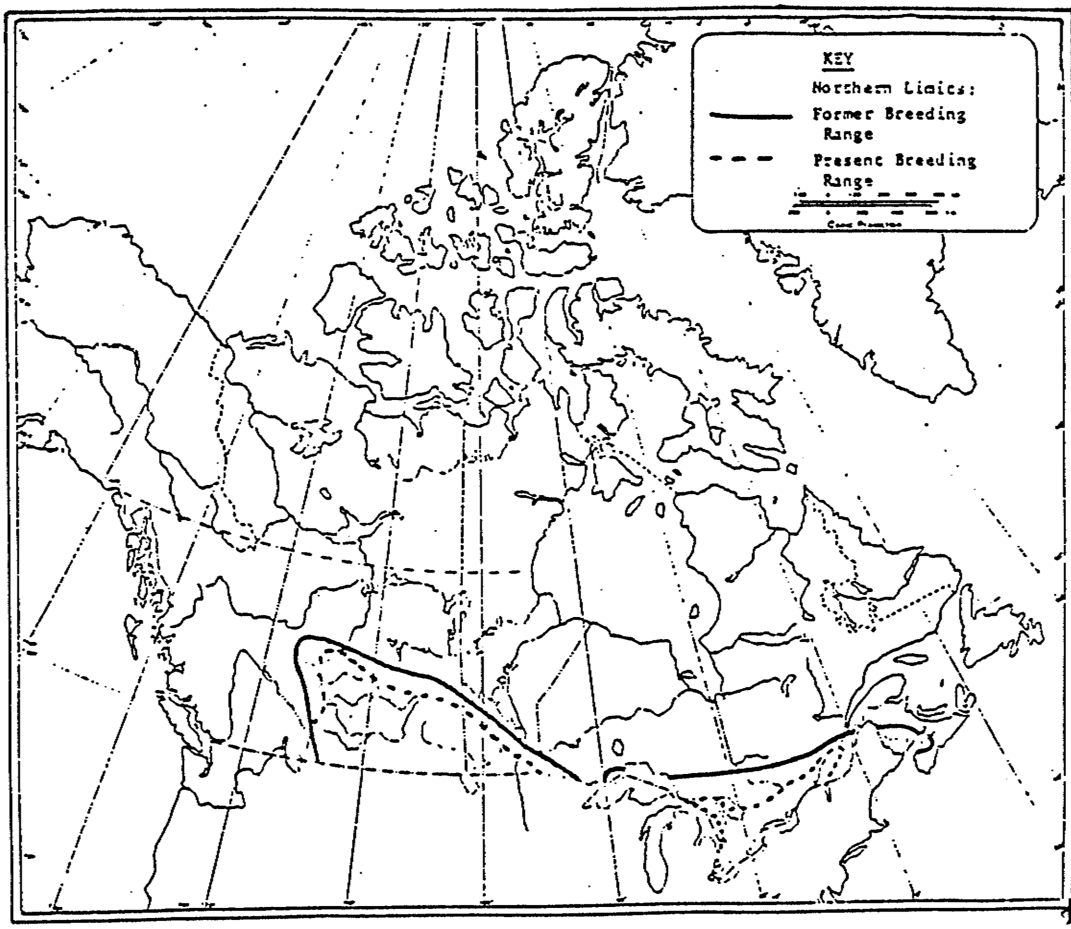

Figure 1. Present and Former Breeding Limits of the Loggerhead Shrike in Canada (From Cadman 1985)

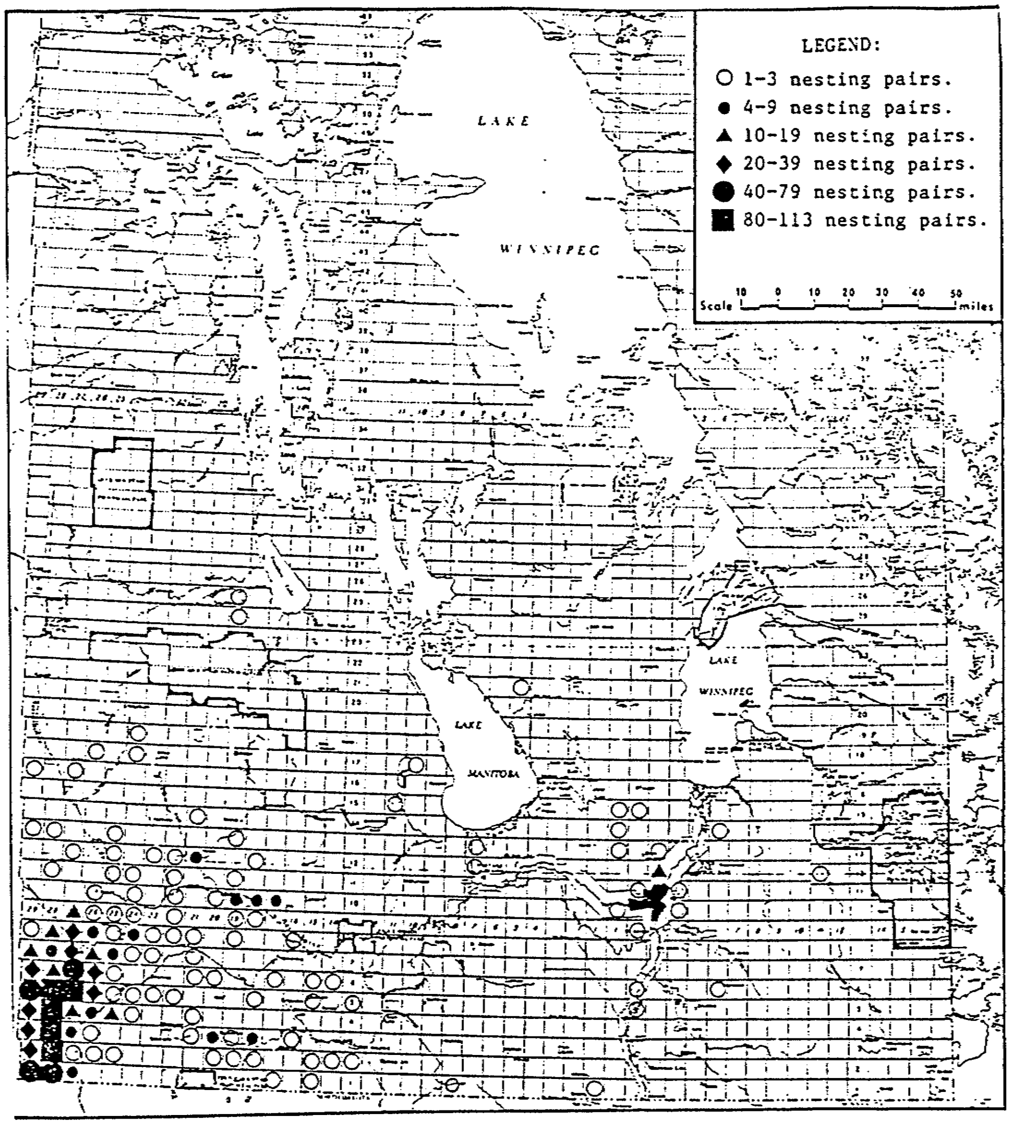

Figure 2. Distribution of Loggerhead Shrikes in Manitoba During 1987-1991 Based on the Total Number of Nesting Pairs or Territorial Adults per Township. (from De Smet 1992).

and aspen parkland remain unaltered (Manitoba Environment 1993). In Manitoba, 88 percent of the land in agricultural use is cropland, and there is less than five percent of the natural prairie remaining. Rounds (1982) documented a 42 percent reduction in the amount of pasture from 1948 to 1970 in southwestern areas of Manitoba.

Government subsidy and tax programs based upon the amount of acreage that is cultivated has motivated cultivation of marginal lands and pasture (Girt 1990, Thornton et al. 1993 a and b). Marginal land, such as field borders, bushes and shelterbelts, are all at risk of being diminished in order to increase cropland acreage.

The prairies were not only modified by increase in cultivation and planting of forage. Limiting fire, a natural agent for maintaining native prairie, as well as allowing heavy grazing practices tend to promote tree and shrub invasion on the prairies. Heavy grazing increases a replacement of native prairie with weeds, and fires prevent the encroachment by trees. Walter (1973) indicated "that the normal rate of encroachment in the absence of fire was one meter every three to five years." In Manitoba, much of the prairies were invaded by wood cover between the years 1885 and 1956 (Thompson 1891, Bird 1961, Soprovich and Shea 1986).

Recent studies focusing on Loggerhead Shrike habitat at a regional level have found that the decline of shrike populations is correlated with the loss of pasture (Luukkonen 1987, Telfer 1992). The transformation of the prairies affected shrike populations and those of upland prairie birds as a whole (Knapton 1979, Kantrud and Kologiski 1982, Cadman 1985, Telfer 1992). Cadman (1985) reported that in regions where shrike numbers have declined most severely, native pasture and other suitable habitat was 61 percent of its 1945 level, while in regions retaining reasonable numbers of shrikes, native pasture had only declined to 88 percent. Telfer (1992) utilizing Canada Land Use data found that areas of Saskatchewan and Alberta which had experienced the most severe declines in shrike numbers had a 39 percent decline in unimproved pasture between 1946 and 1986, compared to a 12 percent decline in regions that retained substantial numbers of nesting shrikes. Total area of unimproved pasture was also much less in 1986 in areas of severe declines (3.3 million hectares compared to 8.7 million hectares in areas retaining substantial populations). De Smet (1992) documented a decline of 33 percent in suboptimal habitats of southwestern Manitoba, whereas declines were not evident in prime breeding habitat.

Cultivation, overgrazing, and fragmentation of land have threatened many other indigenous prairie species including Baird's Sparrows (*Ammodramus bairdii)*, Burrowing Owls (*Athene cunicularia*) and Ferruginous Hawks (*Buteo regalis*) (Ratcliff 1987, De Smet 1991, 1992).

2.42 Winter Mortality and Habitat Loss in the South

Limiting factors of the population may also occur on the Loggerhead Shrike's wintering grounds. Burnside and Shepherd (1985) suggested that recent land use changes have eliminated prime shrike habitat in Arkansas. Kridelbaugh (1982) attributed the decline of Loggerhead Shrike in Missouri to conversion of pasture and hayfields to row crops. Luukkonen (1987) found that farmland in Virginia decreased by 40 percent and cropland increased by 26 percent of the measured area from 1969 to 1982. The extensive conversion of pasture and old fields to cereal crops has resulted in the elimination of large areas of grassland habitat throughout the gulf coast and adjacent areas (Neff and Meanly 1957, USDA 1986). There is evidence indicating that these habitat changes have impacted populations of birds that winter in the region. The best documented responses have been dramatic increases in species that feed on grain, notably members of the family Icteridae (Stepney 1975). Because these wintering blackbirds feed primarily on cultivated grain, their populations have steadily increased over the same 50 year period that the shrike population, sharing the same wintering areas, have steadily decreased (Brittingham and Temple 1986). With habitat alterations in the gulf coast region and adjacent states having reduced habitat for resident shrikes, wintering shrikes may be forced to occupy suboptimal habitat.

2.43 Post Fledging Mortality

Another factor which may be restricting populations of shrikes may be high post-fledging mortality. Luukkonen (1987) found that much lower numbers of shrikes migrate south than what were produced and hypothesized that there may be a high post-fledging mortality in the breeding grounds. This factor was also addressed as a major concern in Manitoba (De Smet and Conrad 1991, De Smet 1992) but has never been studied on the northern breeding grounds.

2.44 Pesticide Use

A direct relationship exists between the amount of various pesticides in the environment and declines in several species of birds (World Wildlife Fund 1991). Birds most severely affected are members of the Falconiformes and Pelicaniformes. The members of these two groups are upper level predators and because organochlorines are fat soluble and biologically magnified, predatory birds accumulate high pesticide dosages. Loggerhead Shrikes are also predatory, although the prey is smaller. The decline in the Loggerhead Shrike is also widespread and coincides with use of organochlorines that began in the late 1940's and increased until the 1970's (Morrison 1981, Robbins et al. 1986, Tate 1986). Studies report that organochlorines have been found in high concentrations in some shrikes reducing eggshell thickness and inhibiting the behavioral development of the young (Busbee 1977, Anderson and Duzan 1978, Morrison 1980). Nevertheless, Anderson and Duzan (1978) concluded that a slight 2.5 percent decrease in eggshell thickness from 1895-1972 was not decreasing reproduction. Furthermore, wide scale use of organochlorines was curtailed in the early 1970's, yet Loggerhead Shrikes have continued to decline (Brooks and Temple 1990).

There are, however, other pesticides utilized on croplands today that may negatively effect bird populations. Carbofuran (2,3 dihydro-2,2-dimetryl-7-benzifuranyl metrylobamate) is a pesticide commonly utilized in this area and across the prairies. It is sold under the trade name Furadan, in liquid or pellet form. Liquid forms are sprayed in wheat, alfalfa, in selected prairie crops, and in pasturelands and ditches. Granules are incorporated into the soil at seeding time, mainly to control flea beetles which attack canola seedlings. Studies on the Burrowing Owl, another predatory bird that relies largely on grasshoppers suggest reduction in broods and a sharp decline in nesting success in areas sprayed with carbofuran (Baril 1993).

2.45 Automobile Collisions

Where shrike numbers are low and suitable habitat limited, losses due to automobile collisions may be serious. Highway banks and ditches are often grassed over and are mowed providing excellent feeding habitat for shrikes (Telfer et al. 1992). The presence of good habitat attracts them to roadsides where collisions can take place. Some roadside mortality of shrikes has been recorded in Manitoba, however, rates did not appear to be unusually high (De Smet and Conrad 1991).

2.46 Depredation

Depredation may be a major cause of Loggerhead Shrike declines in certain areas. Blumton (1989) in Virginia found that the major source of mortality for Loggerhead Shrikes was raptor depredation, accounting for 57 percent of shrike mortality. In this area, Red-tailed hawks (*Buteo jamaicensis*) and Cooper's hawks (*Accipiter cooperi)* were common. In the winter, raptors and shrikes tend to seek out shrub-forest habitats during inclement weather for shelter and prey. Blumton (1989) found that the shrikes' susceptibility to depredation increases when these areas overlap.

In southwestern Manitoba, incidences of depredation also appears to be quite common as evidenced by unturned or torn nests, and/ or eggshells or pecked young (De Smet and Conrad 1989). Brown-headed Cowbird parasitism has also been observed in two clutches (De Smet and Conrad 1989, K. De Smet pers. comm., 1993).

2.47 Changes in Weather Patterns

The Red-backed Shrike (*Lanius collurio*) is a declining species in Great Britain. Bibby (1973) found a dramatic decline in the population from 1960 (235 pairs) to 1971 (81 pairs). He cited this decline as having accelerated since the 1950-1959 decline. Correlations were found between the decline of the shrikes with cooler, wetter summers, and habitat fragmentation . As well, Kridelbaugh (1982) found that particularly inclement weather during nesting season can cause mortality in young, thereby reducing production. In 1991 and 1992, cool, wet weather during some breeding seasons in Manitoba contributed to many partial and complete brood losses among shrikes (De Smet 1991, 1992).

2.5 Habitat Requirements of the Loggerhead Shrike

Although there are many possible factors of the Loggerhead Shrike's decline, this study focuses on the limitation of habitat on the breeding range. This section reviews literature on the Loggerhead Shrike's habitat requirements from different perspectives, how they are related to its hunting and foraging behavior, and how reproductive success may be related to habitat.

2.51 Territorial Perspective

Although there is accumulating evidence of the importance of pasture for the Loggerhead Shrike on a regional scale, it is also useful to understand its habitat needs from a different perspective. Important habitat variables, indistinguishable at one level may be determined by focusing on habitat characteristics at another (Wiens et al. 1987).

A territory is a defended, exclusive area maintained by an individual or social unit occupying it (Smith 1980). There are several types of territories which may be classified according to the activities which take place in them (Nice 1941). Shrikes hold a general purpose territory in which all activities take place within its boundaries. Past studies have indicated that nesting territories may be repeatedly used from year to year (Kridelbaugh 1982, De Smet 1992).

Territories are established and defended aggressively by pairs during the breeding season. Porter (1975) observed the limits of foraging behavior and defense around the nest, and found that the minimum distance between nests was 400 meters. Kridelbaugh (1982) observed that the size of the territory changed with the stage in the reproductive cycle; the area occupied during incubation was much larger than during the nestling stage, but increased significantly again after fledging. Kridelbaugh (1982) also found that territory size was positively correlated with the percent of row crop within the territory and negatively correlated with the percent of grasslands, lawn, hay and pasture. This difference in size may be attributed to the fact that with suboptimal foraging areas, less food will be found and therefore, the territory must be large to find enough food. Reduced productivity in shelterbelt areas of southwestern Manitoba verses typical grassland areas was hypothesized as being related to suboptimal foraging conditions (De Smet and Conrad 1991).

Studies at the territory level have also indicated the importance of pasture and ample perching sites for higher reproductive success (Luukkonen 1987, Gawlik 1988). Brooks and Temple (1990) described optimal breeding range for Loggerhead Shrikes in Minnesota as primarily open, agricultural areas interspersed with grassland habitat. Other studies have also reported the importance of open habitat types, specifically improved pastures, grasslands and hayfields, within shrike breeding areas (Porter et al. 1975, Siegel

1980, Luukkonen 1987, Gawlik 1988). Favored use of areas with shorter grass may be due to the shrikes' feeding strategies. Some studies conclude that suitable habitat availability is not limiting the population (Luukkonen 1987, Brooks and Temple 1990) and that much apparently suitable habitat remains unoccupied (Telfer 1992). Conversely, other studies suggest that there may be intrinsic characteristics of nest sites that are being overlooked and "apparently suitable habitat" may indeed not be optimal breeding habitat. Prescott and Collister (1993) quantified nest sites and apparently suitable unoccupied sites in southwestern Alberta, providing evidence that there was a significant difference between occupied and unoccupied sites. Most nest sites harbored tall grass compared to unoccupied sites. They surmised that in their heavily grazed study area, the taller grass would possess higher densities of invertebrate prey. Mills (1979) supports this, noting that shrikes selected shorter grass to hunt but they hunted in taller substrata if prey density was higher. Prescott and Collister (1993) suggested that their results could be interpreted in two different ways: 1) lack of tall grass habitat was limiting shrike populations in this area; and 2) decline of the wintering population in the south left fewer shrikes to occupy all suitable areas on the breeding grounds. The shrikes which nested in their study area occupied the most optimally suitable sites first. The major conclusion was that shrikes nested in unique areas with taller grass in southeastern Alberta and that this "higher quality" habitat was scarce.

2.52 Nest Site Perspective

In some studies, Loggerhead Shrikes have been known to show a high degree of nest site fidelity and therefore, specific characteristics of the nesting site itself may be important for optimal breeding. Kridelbaugh (1982) found a 54 percent reuse rate of nesting territories from one year to the next year. However, he found a difference in site fidelity between males and females; 47 percent of the males banded in 1980 returned to the same site the following year, while none of the females returned to the banding site. Other studies have found that site fidelity by banded adults was low (Haas and Slone 1989, De Smet 1992), but shrikes may be attracted to previously used sites by " fidelity, intrinsic characteristics of the nest site, or by evidence of previous occupation" (Telfer et al. 1992).

Nest site selection is believed to be influenced more by the degree of cover provided than the specific plant species utilized (Porter et al. 1975). Dense foliage on the nest tree would be expected to reduce detection of nests by predators and losses due to inclement weather. Nests are often built in the most dense part of the shrub, tree or hedgerow, between 3 and 25 feet off the ground (Miller 1931).

Luukkonen (1987) found that the area immediately surrounding the nest site had significantly less vegetation height and density than random samples. However, in shorter grass areas, such as what exists in southeastern Alberta, denser foliage may be needed in shorter grass areas to provide cover and food for the prey (Prescott and Collister 1993).

2.53 Hunting and Foraging Behavior Related to Habitat Requirements

Shrike hunting behavior must be considered when trying to determine their optimal foraging range. Loggerhead Shrikes are predatory and take a wide variety of food. Miller (1931) found shrikes to take almost any type of prey as long as it could be detected and overcome. Small mammals, birds, reptiles, amphibians and a variety of invertebrates are common shrike food (Judd 1898, Miller 1931). However, invertebrates (grasshoppers; beetles) are the most common food during the nesting period (Prescott and Collister 1993).

Shrikes hunt by plunging vertically from a perch to the ground. This may result in a "direct hit, or the shrike may just hover above the ground continuing to search for its prey. It will pursue flying prey and will persist in attack until the prey is successfully captured" (Miller 1931). Small insects may be captured in flight or by hopping along the ground (Morrison 1980). Miller (1931) described the method of kill as a blow to the head with the bill, as well as rapid, repeated snips to the head of the prey.

Two types of hunting methods are utilized by Loggerhead Shrikes: active and passive (Morrison 1980). Active hunting takes place during the early morning and at dusk. It is characterized by frequent trips to the ground from a perch. Perch height may range from 15.2 cm to 9.15 m (Morrison 1980). If no prey is detected in a certain period of time, the bird moves on, searching within its territory. Passive hunting is conducted throughout most of the rest of the day. The shrike perches at a much higher height and can detect prey from 3.05-47.75 m. During passive hunting, no prey may be taken for intervals of 10-30 minutes while the bird sits and waits.

In selecting breeding territories, shrikes may choose areas which would best suit characteristics of their hunting and foraging behavior. Since shrikes hunt from a perch, they may favor territories with an abundance of food, perches, open space, and short vegetation. Mills (1979) studied Loggerhead Shrike foraging patterns during the fall and winter. Shrikes usually avoided hunting in areas of tall grass, but if higher prey availability or greater prey size occurred in tall grass areas, shrikes selected these lower visibility areas over short grass habitat.

Studies of raptors, which feed similarly to shrikes have emphasized the importance of plant cover in relation to prey accessibility. Toland (1987) reported that American Kestrels (*Falco sparverius)* were attracted to pastures and fields with low vegetation that allowed good visibility of insects and mammals. He found that kestrel hunting success declined with increasing vegetation height and density. Craighead and Craighead (1956) found higher hawk densities in habitats with shorter vegetation height and sparser ground cover. Vegetation cover has also been found to be more important than prey abundance in the selection of hunting sites by Swainson's Hawks (Bechard 1982).

2.54 Habitat Requirements Related to Reproductive Success

In Manitoba, Loggerhead Shrikes initiate nesting in mid-May and nests with eggs can be found until mid-July (De Smet 1991, 1992). Average complete clutch size is 6.3 eggs (early clutches= 6-7 eggs, and late clutches= 5-6 eggs). Incubation is performed by the female. During this time, and for most of the nesting period, food is provided by the male (Porter et al. 1975). Reproductive success (ie., young produced to fledgling age) has been found to be quite high relative to other passerine birds (Porter et al.1975, Kridelbaugh 1982, Cadman 1985, Gawlik 1988, De Smet 1992). However, nesting success has been found to vary with habitat (Luukkonen 1987, De Smet and Conrad 1991) . Although nesting success may be high in certain areas, reduction in optimal habitat may reduce or limit the number of shrikes that are able to nest (Telfer et al. 1992).

During the nesting season, shorter vegetation structure in foraging areas may be especially important for reproductive success. Several authors have associated higher reproductive success among shrikes in pastures and shorter grass. Studies by Luukkonen (1987) and Gawlik (1988) have shown that shrikes selecting active pasture (ie., areas grazed by cattle throughout the shrike's breeding season) had higher reproductive success than those that selected other habitats. Luukkonen (1987) hypothesized that active pasture provided consistently shorter vegetation and therefore prey was easier to detect. Gawlik (1988) reported that shrikes foraged in recently mowed fields and that higher nesting success occurred when birds nested within 100 m of these habitats. Gawlik concluded that increased hunting efficiency due to shorter vegetation would be especially important when adults are providing insects to nestlings.

De Smet and Conrad (1989, 1991) found that reproductive success was higher in pasture than in shelterbelt and cropland situations. They postulated that this difference was due to parents having to fly further to obtain food in cropland, and therefore wasting energy and increasing chances of depredation. They also suggested that shrikes nesting in cultivated land experienced ideal crop heights during early nesting stages. During the nestling period,however, crop heights often made it difficult for adults to find food when energy was most needed. Foraging rates (time it takes to bring food back to the young) as well as distances travelled in these separate areas have never been compared. Morrison (1980) found that shrikes hunted more frequently in the nesting season as compared to the non-breeding period; hypothesizing that the distance to prey could be an important part of the shrike's energy expenditure especially during nesting periods.

2.6 Current Recovery and Protection Efforts

2.61 Protection

The Loggerhead Shrike is a migratory bird protected under the Migratory Birds Convention Act (Telfer et al. 1992). In Manitoba, this species is protected under the Endangered Species Act (Government of Manitoba 1990). It is not officially listed as endangered in the United States because of adequate population densities west of the Rocky Mountains and in portions of the southern states. However, individual states in the Great Lakes region and the northeast have listed it a endangered (Fruth 1988). Since the breeding distributions of both *L.l migrans* and *L.l excubitorides* are considered to extend from Canada into the southern States where substantial populations remain, neither of these subspecies can be considered threatened from a North American national standpoint (Fruth 1988). Canadian efforts to recover the Loggerhead Shrike will therefore lack the advantage of official U.S. participation.

2.62 National Recovery Program for the Loggerhead Shrike

The Canadian National Recovery Plan (Telfer et al. 1992), is a program specifically focused on the recovery of the Loggerhead Shrike, through the collaborative efforts of the Quebec, Ontario, Manitoba, Saskatchewan and Alberta provincial governments and the Canadian Wildlife Service. The plan outlines the major reasons for the Loggerhead

Shrike decline, the recovery potential, goals, and objectives. It then details strategies which will be implemented to fulfill the objectives.

The plan attributes the major cause of the decline to the long-term modification of the prairies from native grassland and pasture to cropland and bush. As well, it cites "intensive management of these grasslands, including the use of pesticides" and "dissection of these areas by roads" as increasing the mortality of migratory shrikes. The program established that the major problems pertaining to the population decline include "quantitative information on breeding habitat, productivity in relation to habitat quality on the breeding range, knowledge of populations that breed in Canada, survival rates of adults and juveniles, causes of mortality and how to monitor changes in status and distribution" (Telfer et al.1992).

The program objectives acknowledge and are based upon these information gaps. The strategies, which will address the objectives include: "determination of population status and distribution; determination of the cause of the species decline; determination of the habitat requirements of the species; techniques such as capture and release; establishment of working groups (including government , nongovernment organizations, as well as landowners) for both western and eastern populations; and establishment of cooperative programs to protect existing grasslands, especially native prairie."

Presently, research on the species is underway from Alberta to Quebec. Populations are being monitored in order to detect limiting factors and further changes in the populations (Telfer et al. 1992). Young have been banded in most jurisdictions, supplying information on the distance and areas to which northern populations migrate, mortality rates, adult and natal site fidelity and other aspects of population dynamics.

2.63 Threatened and Endangered Grassland Birds Recovery Program

In Manitoba, the Loggerhead Shrike population has been monitored since 1987 (De Smet and Conrad 1989, 1991; De Smet 1991, 1992). Distribution, nesting, habitat limiting factors and productivity are being monitored. This information will provide long-term data of population dynamics so that effective management can be carried out . This program also involves ongoing efforts to educate the public and to include landowners in conserving the shrike and other declining grassland birds. The public is informed through newspaper articles, pamphlets, television and radio coverage. Landowners and interested groups are involved in monitoring and banding programs. There has been regular meetings with landowners and local conservation groups to increase their involvement and obtain their input. This program also encourages farmers to lease their land through the Critical Wildlife Habitat Program.

2.7 Conclusion

This chapter has focused on Loggerhead Shrike breeding and foraging ecology and habitat needs, possible reasons and for its decline and existing programs relating to its conservation. The continuing decline of the Loggerhead Shrike across North America and the prairies is an enigma. Several contributing factors, such as changing land use practices on the wintering and breeding grounds, pesticides, predation and changes in weather may all contribute to the continued demise of this species. This study focuses on delimiting optimal breeding habitat in southwestern Manitoba and is a step towards determining whether or not loss of habitat in this area is a prevalent limiting factor.

CHAPTER 3

METHODS

3.1 Study Area

Shrike breeding habitat was studied from May to August 1992. The study area (Townships 1-5, Range 28-29) included portions of two municipalities in southwestern Manitoba, including all eight townships in Edward municipality and two townships in adjoining Albert municipality (Figure 3). In order to obtain a suitable sample size, the study area included what is considered to be a "core shrike breeding area" (De Smet and Conrad 1989, 1991). The area represents a cross section of many land use types in southwestern Manitoba. Townships 1-28 and 2-28 are dominated by cropland with abundant maple, ash and caragana shelterbelts. Typical crops of the area included sunflowers, canola, flax, oats, barley, rye, wheat, corn and millet. Townships 3-28 and 4-28 are dominated by pasture. This area encompasses the "Poverty Plains", one of the most extensive grassland areas remaining in southwestern Manitoba. Townships 4-29 and 5-29 includes more cropland, aspen bluffs and willow-lined lowlands (Aspen Parkland habitat). Table 1 provides a breakdown of the various land use types in Edward and Albert municipalities. It illustrates that cropland is the dominant land use type throughout, but the area retains a variety of other land use types including a substantial amount of pasture. Table 2 provides definitions for the main land uses found in the study area.

3.2 Locating Shrike Pairs and Nests

Shrikes were found by travelling a predetermined road route (215 km) within the study area (selected using forestry inventory maps of each township). Three randomly chosen points (road corners) were chosen in each township and connected to create the

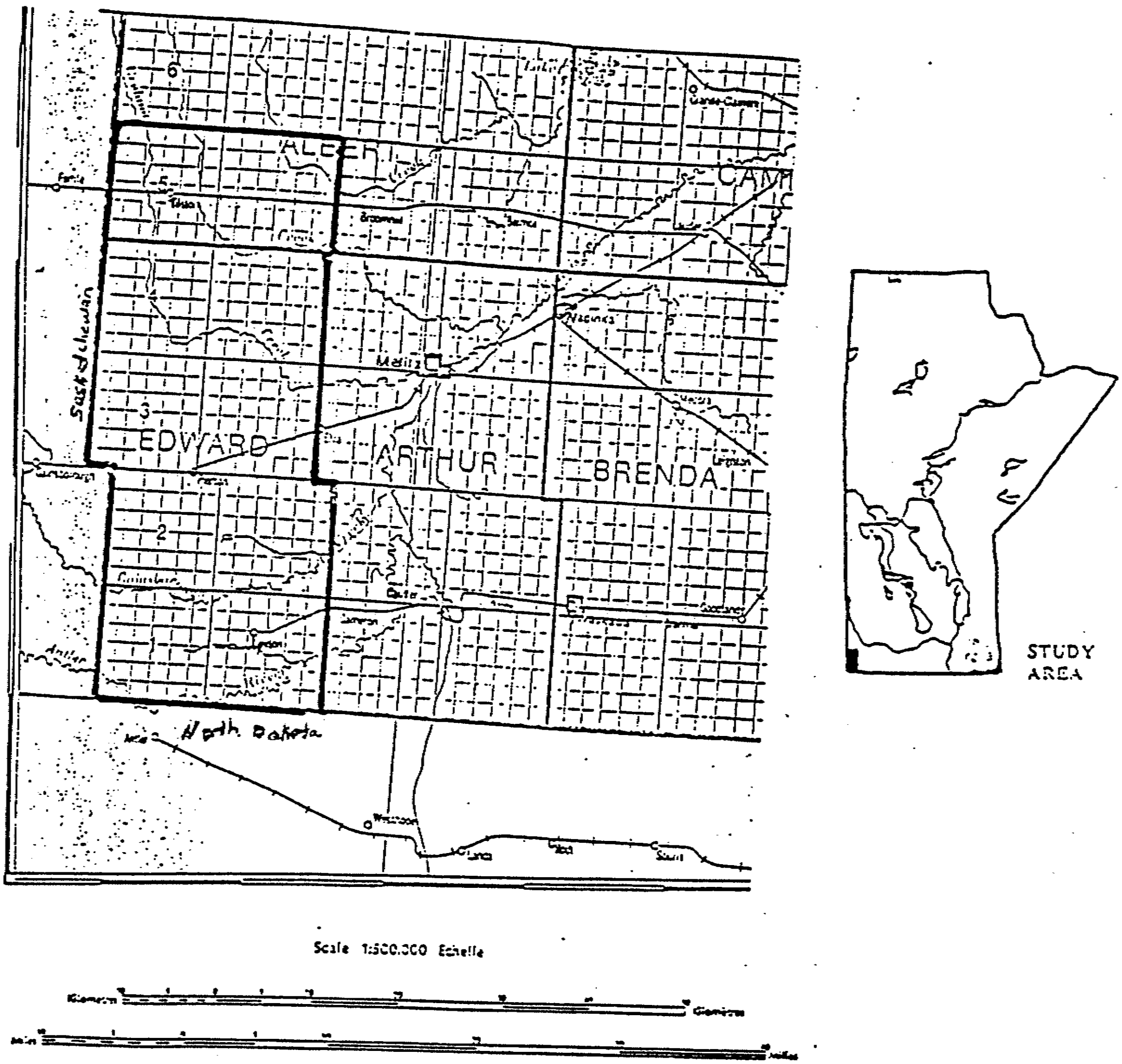

Figure 3. Study Area in Edward and Albert Municipalities of Southwestern Manitoba.

Table 1. Proportions of Land Use for Edward and Albert Municipalities in 1991 (Statistics Canada, 1991).

Land Use	**Edward**	%	**Albert**	%
Cropland	45895.8	66.7	40000.9	64.7
Summerfallow	6009.4	8.7	4056.3	6.6
Improved Land	2968.5	4.3	4176.1	6.8
Unimproved	10599.9	15.4	9457.0	15.3
Yards	3318.9	4.8	4127.3	6.6
Total	**68792.5 ha**	100.0	**61817.5**	100.0

Cropland= Wheat, oats, barley, mixed grains, rye, corn, canola, flax, sunflower, mustard and millet.
Summer Fallow= Cultivated land not in use
Improved Land= Alfalfa, tame hay (ie. brome, alfalfa), improved pasture
Unimproved= pasture with native prairie

Table 2. Classification of Major Habitat Uses in the Study Site

% Trees	Percentage of all trees and bushes, including willow bushes, aspen stands and shelterbelts.
% Pasture	Percentage of land consisting of native prairie, to improved grass, such as brome which is grazed during the summer. Surrounded by fence.
% Hay	Percentage of any area, usually consisting of improved, and/or native grasses, which are hayed in late June and August.
% Cereal	Percentage of area growing wheat, barley, oats, or rye. These crops generally reach a height of 70-80 cm by early July, with much thicker and denser stands than native.
% Oil Seed	Percentage of area of canola or flax. These are broad leafed, flowering plants which can grow to be a very dense crop by July.
% Sunflower	Percentage of area growing sunflowers. They are relatively tall standing plants (reaching 1-1.5 m by July) which are grown in rows.
% Lowland	Percentage of any low lying area. These are temporary wetlands surrounded by willow bushes. These areas usually grass covered , with little or no management practices such as grazing or haying.
% Road	Percentage of any route utilized for vehicle travel.
% Ditch	Percentage of area running along the side of roads; measured from the edge of the road to fence line, border of private land or Crown land. The edge of the ditch is usually hayed.
% Miscellaneous	Percentage of lawn in farm yards.
% Summer Fallow	Cultivated land which is not being utilized for crop growing in a summer.

route. The connections (how the points were joined) were also randomly selected but were limited to roads that could be travelled by car. If the roads were impassible, another random selection was made connecting this portion of the route. Random selections were made by using a number randomizer on a calculator (if the number was even, turn right from the point, if odd, turn left). Roads consisted mostly of gravel farm roads, some were grass, and a small portion were highway. The route represented a stratified random sample of the study area. The route was travelled from sunrise to 1:30 pm and from 4:00 pm until dusk as shrikes are most active and can be more readily seen at these times. Surveys were not conducted during rains, or if the winds increased above 35 km/hr. Surveys were initiated at the north, middle and south end of the route; the starting point was successively alternated every day as it was observed that shrikes are most active at sunrise and sampling would be biased if it was initiated at the same point every day. The entire route was travelled at 40 km/hr (5 days a week) from May 13 to the first week of July. Stops were made every 0.5 km and the surrounding area was intensively scanned for one minute.

When a shrike was spotted, it was watched for several minutes and followed in order to find its nest. Most bushes and trees of nest-holding size within 200 m were searched checked. If the actions of the shrike were indiscriminate, a high pitched squeaking noise often prompted adults to come closer and become aggressive if I was in the vicinity of its nest. The majority of the nests were found from mid-May to the end of June. The nest was marked by tying florescent tape on nearby barbed wire or trees (at least 15 m away) with florescent tape which could be seen from the road, allowing later nest checks.

Nests were checked twice weekly until fledging in order to obtain reproductive data (Mayfield 1968). The number of eggs, number of young hatched and number of fledglings was noted for the nest. Care was taken to spend as little time as possible at the nest, ensuring that no branches around the nest were broken, and few trails were left that would cue the nest to predators.

3.3 Habitat Measurements

Both the microhabitat (near the nest) and macrohabitat (to within 282 m of the nest) were measured and compared against random points. I tested the null hypothesis that nest sites are randomly chosen from available habitats. Forty-three nests were found and used in the analysis.

3.31 Macrohabitat

The null hypothesis that shrike nesting territories were similar to random sites was also tested at the macrohabitat level. Measurements encompassed habitat characteristics within a 282 m radius (25 ha) around the shrike's nest (based upon Brooks and Temple 1990). A 25 ha circular plot generally encompasses the territory home range used by nesting pairs (Luukkonen 1987). Cover maps of each 25 ha circular plot were constructed on aerial photographs centering on each nest site. The aerial photographs were ground truthed from May through to August to monitor any land use change during the field season. Loggerhead Shrikes use elevated perches (hydro wires, fence wires) during hunting (Bildstein and Grub 1980, Bohall-Wood 1987). The length of these perches may be a factor in site selection. Therefore, lengths and positions of these perches within the territory were drawn directly onto the photo. Current land uses were also identified and noted directly on the photo. A known distance on an aerial photo was found by pacing off 200m with a meter stick on a gravel road and marking it on the photo (required for calibration of the photo on the computer).

Aerial photos of the territories were then scanned onto computer using an Abaton Computer scanner and Image Studio application on a Macintosh II computer. The image was scanned and saved onto the computer in TIFF format. The image was then imported into the Image 1.41 application (used to analyze and measure objects of any shape or size in the aerial photograph). The application has "tools" which may be used for drawing lines, circles or polygons on the photo image. A circle was drawn around the nesting territory (the 282 m radius circle was already drawn directly onto the aerial photo and could be seen on the computer image), by bordering the drawn circle by right corner angles at the left top corner and the bottom right corner, and dragging the circle application from the top left to bottom right corner. The circle was then copied and shown on the computer clipboard. The resulting image showed only the shrike territory. The photo image was then calibrated using the known distance from one of the aerial photos using the calibration function. The function read the number of "pixels" (computer units) equaling 200 meters, and then computed the number of pixels which equaled 1 meter (0.88 pixels=1m). Once the image was scaled, the measurements on the aerial photo image could be taken. Objects could be measured on the image using the polygon tool. The tool could be used to exactly outline the object to be measured. An application would measure the area of the outlined shape as well as the perimeter of the shape. Once the object was measured, it would be blackened using the delete key in order to prevent measuring objects twice. All areas were measured until the circle was completely blackened. The territory circle itself was outlined and measured. The areas measured could then the converted into percentages which made up the circle. Percentages of the following habitat features were measured within 25 ha of the nest from the aerial photos: Percentage area, percentage cropland including cereal crops, oil seeds (canola, flax), sunflowers, summerfallow, pasture (well grazed and moderately grazed), hayland, lowland, road, ditch and percentage miscellaneous. Linear length of continuous perch sites (high wires, hedgerow and forest edges) and distance from the nest site to the nearest fence, utility wire and road were also calculated.

Thirty randomly located points were chosen within the study area and mapped to within 25 ha. Three random locations were chosen for each township in the study area by

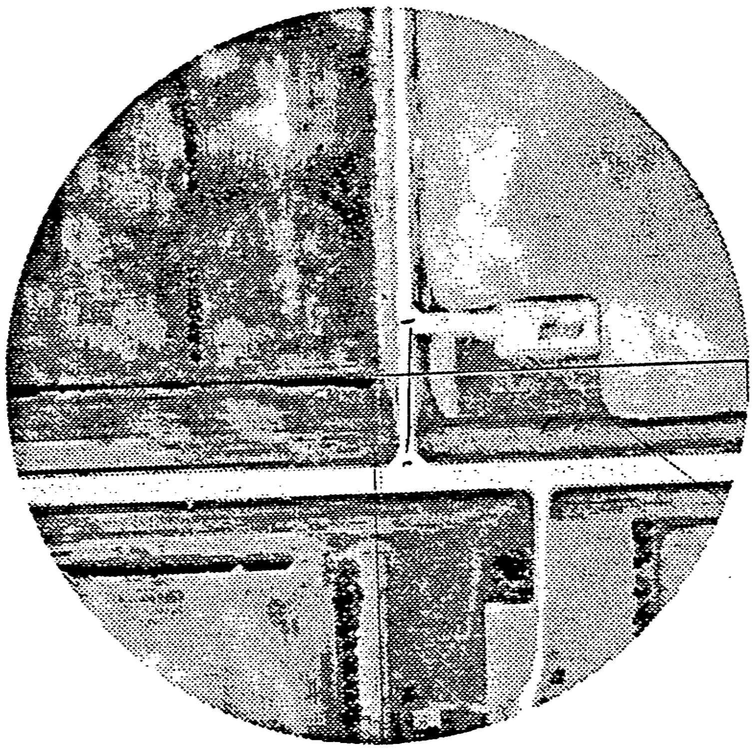

Figure 4. Circular approximation (282m radius) of nesting territory of a Loggerhead Shrike (0.88 pixels=1m). Aerial photographs were scanned onto computer and imported into a program which enabled measurement of the area of land use types, the area and perimeter of trees, and the lengths of hydro wires and fences.

gridding a map of the area numbering the grids and randomly selecting numbers. The locations were skewed to within 300 m of the road, as nest sites were biased in this way. All measurements taken at the nest sites were undertaken on these random sites as well.

3.32 Microhabitat

Microhabitat measurements were taken within three days after the nest had been vacated. Important habitat variables that were measured at the nest site included those designated by several authors (Porter 1975, Luukkonen 1987, Gawlik 1988). Microhabitat nest site measurements included the nest tree and the habitat within 10 m of the tree, as this was classified as microhabitat in other recent studies (Porter 1975, Luukkonen 1987). A randomly chosen tree minimum height of 1.5 m (lowest known tree harboring a nest in the area based on 1991 nesting data) within 200 meters of the nest tree was paired for comparison. Random trees were chosen by establishing a random point > 200 m from the nest tree, as most nests are minimally separated at this distance and would approximately constitute a territory separate from nesting territory (personal obs., Kridelbaugh 1982).

The nest tree itself was identified to species and measured for diameter, height, height of nest, canopy width, horizontal distance of nest from edge, percentage coverage, height of the lowest branch, as well as percentage of the tree alive, number of base branches. Tree diameter was measured with a meter stick at one meter height (James and Shugart 1970). Basal branches included all branches emerging from the ground at the base of a tree or shrub; the diameter of the largest basal branches was recorded. Tree height and nest height were measured with a clinometer. By standing 15 m directly in front of the tree, the clinometer was pointed at the base of the tree and triggered. A reading was taken. The same was done for the top of tree and top of nest (for nest height) and the two readings were added to obtain the correct height. Canopy width was measured with a meter stick at nest height (Luukkonen 1987). Distance from the nest to the edge was measured with a meter stick, from the lip of the nest to the closest outer edge of the tree. Coverage was measured by estimating the percentage of nest that was hidden at a distance of one meter (from two sides and the bottom of the nest and averaging the three readings) (Luukkonen 1987). The height of the lowest branch was measured with a meter stick. Percentage of the tree alive was estimated by looking at the number of branches with leaves compared to dead branches. The same measurements were taken on the random trees, except nest height and the horizontal distance of the nest to edge.

A 10x10 m quadrant was centered around the tree to sample vegetation. The number, and species of trees and shrubs greater than 1 meter tall in each of two height classes (1-2m and > 2m) were noted and counted (Luukkonen 1987). Five 2x2m quadrants were randomly placed (by picking numbers one to ten from a hat and pacing the chosen number from the nest tree, starting from five different locations at the nest tree) within the large quadrant. Percentage of vegetation covering the ground was estimated by dividing the small quadrant into four and averaging the estimated cover of the four smaller portions (Smith 1980). A transect was placed across the small quadrant and the average of five height measurements (cm) were taken from herbaceous plants that it touched. The product of vegetation cover and plant height represents the understory index.

3.4 Analytical Techniques

3.41 Macrohabitat

Analyses were undertaken to test the null hypothesis that individual shrikes selected breeding areas similar to random sites at the macrohabitat scale. Occupied and random variables were compared using standard t-tests with a pooled variance to detect any difference in land use characteristics.

Secondly, it was determined whether or not nest sites were similar in terms of habitat variables or if they could be classified into separate groupings relative to habitat variables. Because 11 macrohabitat variables were measured at each nest location, it was important to understand multivariant interrelationships in quantifying nest characteristics and for determining trends among the sites. Correspondence Analysis (CA) ordination was performed to examine these multivariant trends. This method, which is also known as reciprocal averaging (Pielou 1984), is an eigenvector method of ordination related to principal components analysis. In CA, the data structure is treated as a contingency table. Successive linearly uncorrelated ordination axes are extracted from the data so as to maximize the correspondence between the scores of the macrohabitat variables and locations. The method results in a biplot of the variables and locations in a single ordination diagram.

The resulting graph of the ordination illustrates the relationships among the territories and variables, as well as the variables themselves. Both the nesting locations and the macrohabitat variables are plotted in the same ordination space, permitting a graphical assessment of the relationship between variables and individuals. The eigenvalues represent the degree of linear variation which can be represented on axis 1 and axis 2.

The variables and individuals are plotted relative to one another. For example, a nesting location with a high percentage of pasture and a low percentage of cropland will be associated closely with the plotted pasture variable and will be plotted further away from the cropland variable). Furthermore, the variables are plotted in regard to each other. For example, the cropland variable may be plotted further away from the pasture variable, if some nesting territories have a high proportion of cropland and a low proportion of pasture, while other territories have the reverse). As a result, definite groupings may occur on the canonical graph with respect to habitat composition.

In order to minimize the problem of outliers, the macrohabitat variables were grouped into five broad categories, and log-transformed to render the variables normal. The following macrohabitat classifications used were (See Table 3 For classifying criteria).:

Table 3. Classification of Macrohabitat Variables

Hayland = %hayland+ % lowland + % ditch +%miscellaneous

These areas are similar in vegetative cover with usually a brome mixture. The vegetation in these areas are not always kept low continuously such as in pasture areas, but some are occasionally hayed (once in late June and/or once in August).

Cropland= % Cereal crops + % Oil Seed + % Sunflower

These are planted areas that are generally bare in early spring (May). By mid-summer, they can grow from 70 cm to 1m depending on the crop. They are usually more course, straight standing and denser than natural vegetation.

Pasture= %Pasture

Pastureland is continuously grazed in this area. Therefore, the vegetation is usually constantly lower than hayland areas. The vegetation in most of this area has native mixed grass prairie components which are usually lower growing than Eurasian vegetation.

Bare Ground= %Summerfallow+ %Road

These areas are kept relatively free from vegetation entirely throughout the summer .

Trees= % Trees, Shrubs

All trees and shrubs including lone and shelterbelts.

1) Hayland =% hayland+%lowland + %ditch+ %miscellaneous;

2) Pasture=%well grazed pasture+%moderately pasture;

3) Cropland=%cereal +% oil seed crops + %sunflower;

4) Trees=% trees;

5) Bare Ground=%road+ %summerfallow.

Habitat variables were grouped in the same way for the random variables.

The nest sites were grouped into three site classes (Pasture, Cropland and Mixture), based on the results of the CA ordination. These three groups were confirmed using cluster analysis. Analysis of variance was used to test for significant differences among these groups.

The lengths measured at nest and random sites, as well as distances of perches from nests were compared by t-tests (pooled variance) and box plots.

3.42 Microhabitat Analysis

The null hypothesis that Loggerhead Shrikes choose their nesting sites randomly was also tested using the microhabitat data. Paired t-tests were performed on occupied verses random microhabitat variables to test significant difference between groupings. Correspondence analysis was subsequently performed on occupied and random data combined in order to distinguish differences between these two groups on a multivariant level. The various microhabitat variables were also compared among the three macrohabitat classes, (Pasture, Cropland and Mixture) via the ANOVA test of significance in order to characterize microhabitat differences among the three macrohabitat groupings.

3.43 Relationship Between Habitat and Productivity

Nest success was analyzed via the Modified Mayfield Method (Mayfield 1968, Johnson 1979). Nests were considered successful if one or more young fledged. The nesting cycle was split into egg laying through hatching and nestling through fledging periods. Probabilities of survival were calculated separately and the overall success was calculated by multiplying the two probabilities. Standard errors of survival probabilities were estimated according to Johnson (1979).

Clutch initiation dates for shrike nests were estimated by interpolating laying dates between visits or backdating from hatching or fledging dates. Laying dates were calculated using 16 days for incubation and 17 days from hatching to fledging (Kridelbaugh 1983, Luukkonen 1987).

Clutch size is defined as the total number of eggs divided by the number of nests (of those nests found at egg stage). Hatchability is defined as the average percentage of eggs surviving until hatching which hatched young (Luukkonen 1987). Average brood size is defined as the number of young divided by the number of nests found and monitored from egg and nest stage with >1 young. The number of young fledged refers to the number of young per nest surviving that are able to leave the nest after the nestling period.

Reproductive success between high amount of perch lengths (>2000 m) and lower amounts of perch lengths (<2000 m) were compared via the Mayfield Method.

The reproductive success of the Pasture, Cropland and Mixture groupings from the macrohabitat correspondence analysis was compared via different reproductive parameters: clutch size, young fledged per nest, young fledged per successful nest, young hatched per successful nest (all tested for significance via ANOVA) and nest success using the Mayfield Method (tested for significance using a Chi-square contingency table).

Understory indexes were found to be important when choosing a nest site and may be an important factor of reproductive success . Therefore, understory indexes were divided into four groupings from high to low (< 10 cm, 10-30 cm, >30 -50 cm, > 50 cm) and the measures of reproductive success and significance tests as defined above were analyzed for each category.

CHAPTER 4

RESULTS

Forty-three nests were located within the southwestern Manitoba study area from May 12 to August 1, 1992. All of the nests were checked at least twice a week in order to obtain reproductive data. No shrikes were located at the chosen random points.

4.1 Breeding Biology

Shrikes lay one egg per day; females begin incubation before the entire clutch has been laid, usually on the second to last egg (Kridelbaugh 1982, Luukkonen 1987). During this study, shrikes averaged 16 days of incubation before hatched eggs were found (n=13; range 15-17). Nestlings left the nest (fledged) an average of 17 days after hatching (n=13; range 15-18).

Clutch initiation dates ranged from May 11 to June 17, with the majority of nesting beginning in mid-May. Three pairs renested within 400 m of their previous nests, after their initial nest failed. Others may have renested, but their renest attempt was not found.

4.11 Reproductive Rates

Twenty-two of 43 nests, or 51.2 % of the nests fledged at least one young (were successful). Nesting success was lower (probability of success=0.43 SE= 0.000067) using the Modified Mayfield Method (Mayfield 1968, Johnson 1979) (Table 4). The daily survival rate of nests at the incubation stage x=0.97 (SE=.0085) was similar to the daily survival rate of nests with young was x= 0.98 (SE=0.0067).

Shrike total clutch sizes ranged from 2 to 8. The average clutch size of nests found at the egg stage was 5.66 (N=38; S.E.=1.8). [(Three clutches had 2-3 eggs per nest and did not produce young. By eliminating these nests from calculations, the average clutch size was 5.95 (S.E.= 1.0)]. Of nests found at the egg stage, 161 of 215 eggs survived to

Table 4. Loggerhead Shrike Nesting Success Data in Southwestern Mb, 1992.

Total number of nests monitored	43		
Number of eggs*	215	(N=38)	
Average Clutch Size*	5.66	(N=38)	(S.E.=1.8)
Number of eggs which* survived to hatching	161	(N=27)	
Number of young which hatched*	130	(N=27)	
Hatchability	81.%	(N=27)	(S.E.=1.3)
Mayfield Nest Success	0.43	(N=43)	(S.E.= 0.00067)
Number of young**	159		
Average brood size > 1young**	4.98	(N=32)	(S.E.=1.2)
Number of young which fledged**	79	(N=22)	
Average fledgling brood size per successful nest	3.59	(N=22)	(SE=1.2)
Average brood size of fledglings (all nests)	1.84	(N=43)	(SE=2.2)

* nests found at egg stage ** nests found at both egg and nestling stages

S.E.= standard error

N= number of nests

hatching, and 130 of these produced young (N=27). The number of eggs failing to hatch was 31 (N=11). Therefore, percent hatchability was 81% (N=27; S.E.=1.3).

Of nests found and monitored from egg and nestling stages, 32 had > 1 young; 159 young were produced from these nests. Therefore, an average of 4.97 (S.E.=1.2) young were produced per brood.

Twenty-two nests produced at least one fledgling; a total of 79 fledglings were produced. Hence, the average brood size fledged per successful nests was 3.59 (N=22; S.E.=1.3). The average brood size fledged from all nests was 1.84 (N=43; S.E.=1.4).

4.2 Macrohabitat Selection

The correspondence analysis (log-transformed) depicted each nest location in one of three groups; Mixture (high percentage of Hayland+ Bare Ground + Trees), Pasture (high percentage of pasture), and Cropland (high percentage of Cropland) (Figure 5). The nest locations associated with the pasture variable (B) are composed of a large proportion of pasture with a small or negligible amount of cropland. Conversely, nest locations associated with the cropland variable (C) on the graph, have a negligible amount of pasture. The final nest territory grouping (Mixture) is associated with (A) Hayland, (R) Bare Ground, (T) trees with a moderate affinity for (C) cropland and (B) pasture. Each nest location on the graph was plotted relative to all of the macrohabitat variables and the other nesting locations (Figure 5). A nest site with a higher proportion of pasture than another nest site is situated closer to the variable (B) (pasture) on the graph. Similarly, if the nest site has a low proportion of hayland, it will be farther away from the A variable than another site with more hayland.

ANOVA tests of significance of the average percentage of land use for each grouping verifies that the land use composition among grouped locations are significantly different (Table 5). The group associated with cropland had significantly higher percentages of cropland while the locations associated with pasture did in fact have a

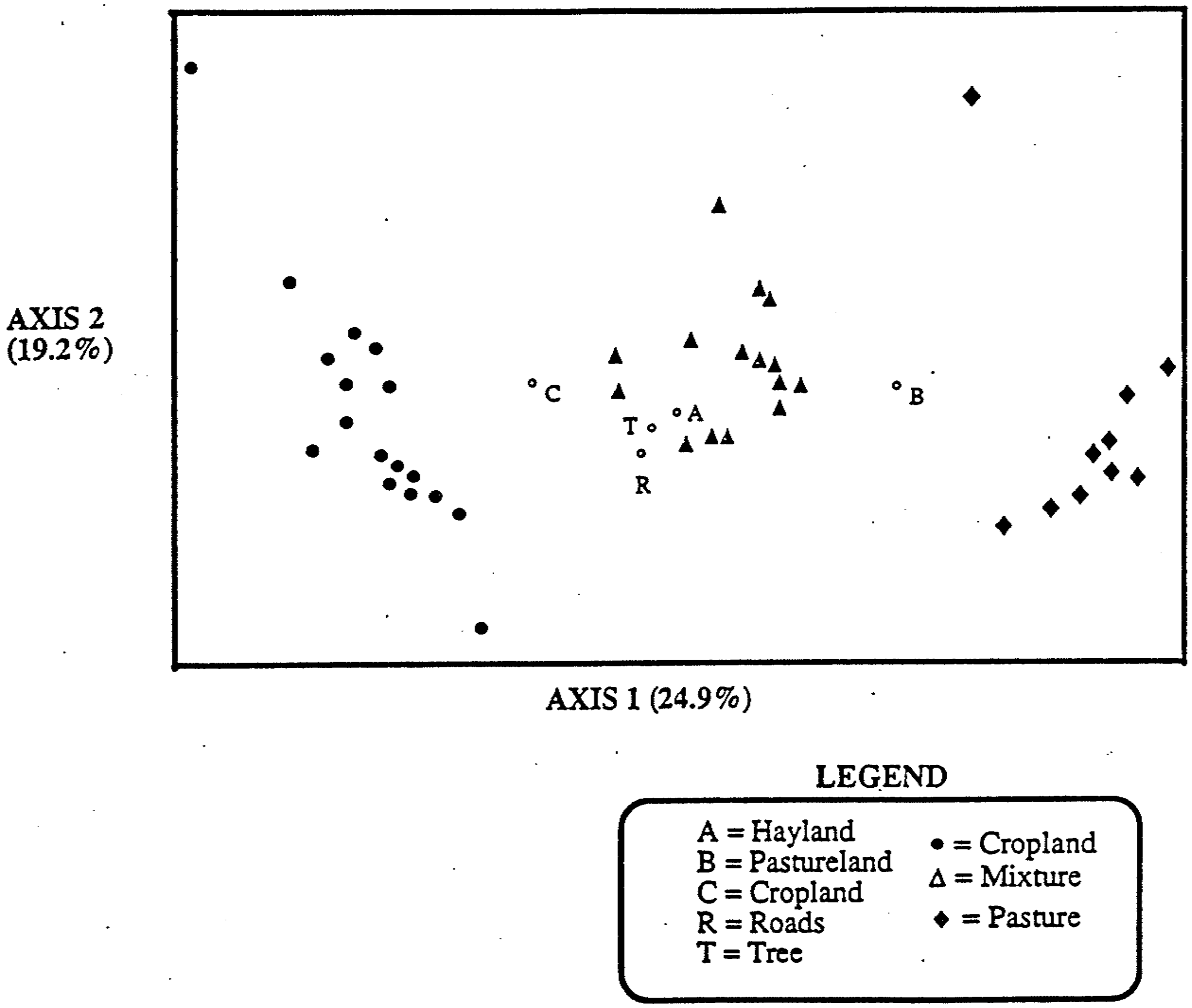

Figure 5. Correspondence Analysis of 43 Loggerhead Shrike Nest Locations

Table 5. Comparisons of Percentages of Land Types Among Mixture, Pasture, and Cropland.

Variable	Mixture (n=15)	Pasture (n=10)	Cropland (n=18)	P. (P value)	F-Ratio
% Trees	4.03 (2.82)[1]	2.58 (1.18)	4.57 (3.62)	0.242[2]	1.49
% Road	11.51 (6.63)	2.16 (1.79)	4.97 (16.33)	0.091	2.54
% Hayland	13.53 (5.92)	13.03 (5.14)	13.50 (15.28)	0.31	1.21
% Crop	40.80 (22.22)	5.33 (12.57)	70.37 (23.98)	<.05*	29.93
% Pasture	36.24 (20.75)	76.90 (24.75)	0.00 (0.00)	<.05*	84.53

1=Standard Deviation
2=ANOVA test of Significance
*=Significant difference among groups

significantly higher percentage of pasture in its composition. Furthermore, cluster analysis again separated the nest locations into three definite land use groupings.

The cumulative percentage variance for nesting sites was 24.9% on the first and 19.2% on the second axis. This is the percentage of the data variation that could be represented on the first two rotated ordinal axes. The nest territory habitat therefore shows a high degree of structure and is trended.

The average percentage of each land use classification for occupied and random sites are summarized and compared in Table 6. Nest sites have significantly higher percentages of pasture than random sites, and significantly lower percentages of trees.

Perch lengths of nest sites and random sites were also compared. Lengths of fences and total lengths were significantly higher in nesting areas (Table 7). Analysis of the differences of total lengths among the pasture, crop and mixture land classifications proved to be insignificant ($p>.05$ (.17) ANOVA). As well, percentage of trees among groups were similar ($p>.05$ (.23) ANOVA). Distances of fence, road and utility wires were similar between nest and random sites and between the groups ($p>.05$ (.14) ANOVA).

Table 6. Macrohabitat Characteristics Measured at Random Points and Loggerhead Shrike Occupied Sites.

Variable (Percentage)	Significance (t-Test)	Occupied Sites (N=43)	Random Points (N=30)
Trees	-2.32* (0.023)**	3.93 (2.93)[1]	6.70 (7.30)
Road	0.64 (0.52)	3.20 (3.35)	2.76 (1.93)
Lowland	0.53 (0.60)	4.92 (6.54)	4.16 (5.29)
Hayland	-0.70 (0.48)	4.37 (12.09)	6.48 (13.36)
Ditch	-0.59 (0.55)	4.81 (3.84)	5.37 (4.04)
Cereal	-1.66 (0.10)	36.53 (29.69)	48.91 (33.55)
Pasture	2.10* (0.04)	30.53 (33.64)	15.07 (26.45)
Miscellaneous	-1.13 (0.26)	0.041 (0.174)	0.13 (0.44)
Summerfallow	-1.51 (0.14)	3.65 (11.42)	8.81 (17.10)
Canola	1.53 (0.13)	6.87 (20.11)	1.09 (5.98)
Sunflower	0.63 (0.26)	1.16 (5.37)	0.49 (0.49)

* Reject Hypothesis that % of area is the same (t-test with pooled variance) $\alpha=0.05$
1= standard deviation
**= p-values

Table 7. Comparison of Perching Substrata Between Random Points and Loggerhead Shrike Occupied Sites.

Variable	Significance (t-Test)[1]	Occupied sites (N=43)	Random sites (N=30)
Tree Lengths (m)	0.12 (0.91)	1125.50 (669.30)[2]	1104.10 (917.80)
Fence Length (m)	3.74* (0.0004)**	747.20 (632.40)	258.50 (398.71)
Utility Wire Length (m)	0.33 (0.75)	430.60 (472.81)	395.50 (421.22)
Total Length (m)	2.00* (0.49)	2303.40 (1021.70)	1758.00 (1185.50)
Distance to fence (m)	0.56 (0.58)	47.96 (57.81)	40.01 (62.30)
Distance to road (m)	-0.59 (0.56)	85.07 (64.40)	93.17 (46.51)
Distance to utility wire(m)	-0.86 (0.39)	46.17 (71.90)	60.75 (69.42)

* Reject Hypothesis that the lengths or distances are similar.
1=(Pooled variance) α=.05
2=Standard Deviation
**= p-value

4.3 Microhabitat Selection

In comparing microhabitat at occupied and random sites, the understory index (ground cover and vegetation height) was the major factor discriminating between the two groups, with occupied sites possessing a significantly lower understory index verses randomly selected sites (Table 8).

The correspondence analysis performed on the nest and random data illustrated the understory index as the most predominant factor discriminating between the two groups. 28.9% and 24.7% cumulative variability was accounted for on the first 2 axes. However, the understory index accounted for 24.7% of the variation on the second axis, with the random understory clearly higher and separated from the lower, nesting understory index.

Shrikes selected a wide variety of different species of trees for nesting but no trees were utilized more than expected based on availability (X^2=8.85, $p>0.05$, df=5). However, there were two basic tree types within the study area which were utilized by the shrike: willow shrubs which grew lone or in scattered clumps, and deciduous trees (mostly in one row shelterbelts). When compared with the deciduous tree nests, willow nest and tree height was significantly shorter, had significantly higher number of branches lower branches and more coverage (Table 9). However, no difference in measures of reproductive success was found between the two groups.

Differences within the microhabitat feature were also found among the three macrohabitat groupings. Fifty percent of the nest trees in cropland, 100% of the nest trees in pasture and 80 % of the trees in mixture were willows. The pasture group had significantly more willow bush used as nest trees than the other groupings (X^2 =9.31 2df ,$p<0.05$). The groups differed in other respects as well (Table 10). Nest trees within cropland tended to be more alive and have less shrubs < 2m surrounding them. Nest trees in pasture tended to have a wider canopy and diameter, as well as less trees >2m surrounding them as compared to the other groups.

Table 8. Comparisons of Occupied Sites and Random Microhabitat Variables.

Variable	Significance (t-test)	Occupied (N=43)	Random (N=43)
Tree Height (m)	0.17 (0.43)**	3.64 (1.88)***	3.57 (1.84)***
Alive (Percent)	0.16 (0.44)	82.60 (18.52)	81.80 (24.34)
Base Branches (number)	-0.94 (0.18)	10.70 (11.41)	13.2 (12.62)
Diameter (m)	-0.87 (0.19)	0.72 (0.54)	0.82 (0.58)
Canopy (m)	-0.54 (0.29)	2.74 (0.99)	2.87 (1.13)
Low Branch (m)	1.36 (0.10)	1.14 (1.14)	1.13 (0.65)
Shrub > 2m	1.14 (0.13)	4.37 (3.47)	5.87 (5.88)
Shrub <2m	-0.38 (0.10)	3.76 (5.54)	4.28 (7.14)
Understory Index (cm)	-5.10* (<0.0001)	29.20 (20.67)	52.17 (21.11)
Coverage (percent)	0.19 (0.48)	49.76 (24.16)	48.95 (15.10)

* Significantly different via the paired t-test and pooled variance estimate
** p-value
*** Standard deviation

Table 9. Comparison of Characteristics and Shrike Reproductive Success in Different Species of Nest Trees

Variable	Significance	Salix sp $\bar{X}$	Other Trees $\bar{X}$
Tree Height (m)	-6.18*[1] (<0.0001)	2.77 (0.58)[2]	5.65 (2.29)
Nest Height (m)	-6.57* (<0.001)	1.40 (.58)	3.42 (1.37)
Percentage of Tree Alive	-1.39 (2.66)	80.00 (19.01)	88.46 (16.51)
Base Branches (number)	3.56* (0.0007)	14.35 (12.09)	2.46 (5.25)
Canopy (m)	1.070 (0.248)	2.85 (0.98)	2.50 (1.015)
Lowest Branch (m)	-2.49* (0.0015)	0.91 (1.33)	1.82 (1.24)
Coverage (percentage)	2.02* (0.025)	52.99 (24.91)	42.29 (19.56)
Clutch Size (egg stage.)	1.82 (0.14)	5.50 (2.13)	5.90 (2.27)
Average brood (Nests> 1 young)	0.98 (0.17)	4.77 (2.69)	5.20 (2.21)
Probability Success (Mayfield's)	X^2=0.067 [3] P (df=1)>0.78	0.46 (0.0001)	0.42 (0.0002)
Fledgling Success/ nest	-0.69 (0.25)	1.84 (2.32)	1.90 (2.18)
Fledgling Success/ successful nest	0.72 (1.43)	3.43 (1.20)	3.72 (1.32)

* Significantly different
1= Pooled t- test
2=Standard Deviation.
3=Chi-square test using contingency table. The difference between groups is insignificant.

Table 10. Comparisons of Microhabitat Variables within Pasture, Mixture and Cropland using ANOVA.

Variable	Mixture (N=15) $\bar{X}$	Pasture (N=10) $\bar{X}$	Crop (N=18) $\bar{X}$	F-Ratio	Significance (p values)
Tree Height (m)	3.16 (1.46)[1]	3.10 (1.45)	4.33 (2.23)	2.55	0.091[2]
Nest height (m)	1.98 (1.13)	1.83 (1.30)	2.24 (1.41)	0.65	0.53
Percentage Tree Alive	76.70 (17.6)	75.00 (20.1)	91.60 (14.9)	3.39	0.044*
Number Basal Branches	9.73 (0.32)	18.60 (10.91)	7.28 (11.21)	2.53	0.093
Diameter (m)	0.58 (0.33)	1.11 (0.79)	0.61 (0.55)	4.60	0.016*
Canopy (m)	2.43 (0.923)	3.20 (1.01)	2.75 (0.98)	3.93	0.027*
Low Branch (m)	1.33 (1.38)	1.29 (1.60)	0.99 (0.50)	2.66	0.77
Horizontal (m)	0.78 (0.45)	0.81 (0.45)	1.30 (0.92)	1.08	0.35
Number Shrubs >2 m	5.20 (3.55)	1.90 (1.30)	5.05 (3.72)	2.038	0.031*
Number Shrubs < 2m	5.53 (7.02)	5.50 (5.68)	0.131 (2.70)	2.34	0.041*
Understory (cm)	18.67 (16.81)	32.18 (22.91)	34.89 (17.41)	2.44	0.10
Percent Coverage	48.42 (22.40)	63.16 (30.18)	43.42 (19.91)	1.56	0.22

1= standard deviation
2= ANOVA Test of Significance
*= significant difference among groups

4.4 Relationships Between Habitat and Productivity

4.41 Microhabitat

The major habitat characteristic discriminating between the nest and random sites was the understory index, thus heights of understory were compared against reproductive measures. Nesting locations were divided into four categories of understory. Areas with a lower understory index had significantly higher probabilities of nesting success (Table 11). However, there was no significant difference between the other microhabitat variables of successful and unsuccessful nests however.

Table 11 . Comparisons of Reproductive Success at Various Understory Indices (Height of Vegetation x Cover)

Variable	<10 cm	>10-30 cm	> 30 -50 cm	>50 cm	Significance
Clutch Size	6.00(8) (1.29)	5.63 (11) (6.15)	5.36(11) (2.41)	5.70 (8) (0.71)	0.15[3]
>1 young per nest	5.70 (10)[1] (1.70)[2]	5.60 (10) (1.29)	4.40 (6) (2.83)	4.16 (6) (2.76)	0.33[3]
Nest Survival[4] (Mayfield)	0.87 (0.0008)	0.33 (0.0004)	0.085 (0.0007)	0.47 (0.0004)	X^2=7.94*,[5] P (df=3)< 0.05
Fledgling Success/ Nest	3.70 (10) (1.89)	1.50 (14) (2.23)	0.64 (11) (0.65)	1.87 (8) (2.05)	0.011*[3]
Fledgling Success/ Successful nest	4.11 (9) (1.72)	3.10 (7) (2.10)	3.50(2) (0.78)	3.50(4) (1.74)	0.179

1 = Number of nests
2= Standard Deviation
3= ANOVA test of significance. If p<0.05, reject null hypothesis of similarity among groups.
4= probability of success using Mayfield's Method, (Mayfield, 1968; Johnson, 1979)
5= Chi-Square test of significance among groups (using contingency tables).
*= significantly differerent

4.42 Macrohabitat

In comparing average clutch size, nest success (Mayfield's method), young fledged per nest, young fledged per successful nest, and average brood size, among Mixture, Pasture and Cropland, groupings, pasture was significantly more productive (Table 12). The mayfield nesting success and the number of young fledged per nest was significantly higher in Pasture than in Cropland and Mixture.

Although correlations between the amount of perch lengths and degree of nesting success were insignificant, the probability of nesting success was higher (using the Mayfield's method), for nesting area with >2000m perch length (p=0.51) (SE=0.000057) than areas with <2000 m perch length (p=0.30) (SE=0.00025).

Table 12. Mean Reproductive Rates at Locations Associated with Pasture, Mixture and Cropland

Variable	Mixture	Pasture	Crop	Significance
Number	15	10	18	
Clutch Size	5.64 (11)[1] (1.25)[2]	5.66 (9) (1.32)	5.67 (18) (1.56)	0.86[3]
Nest Success (Mayfield)	0.38 (0.0002)	0.58 (0.0002)	0.33 (0.0002)	$X^2=6.54$ [4] P (df=2) < 0.05
Young Fledged/Nest	1.86 (1.03)	2.50 (1.23)	1.44 (1.00)	0.044*
Young Fledged/ Successful Nest	3.50 (1.25)	3.57 (1.39)	3.71 (1.52)	0.18
Average Brood >1 young	4.92 (2.56)	5.13 (1.36)	4.91 (1.78)	0.16

1=number of nests
2=standard deviation
3=ANOVA test of significance
4=Chi-square test of Mayfield's Method (Mayfield,1960) using contingency table.
*=Reject null hypothesis of similarity among groups

DISCUSSION

CHAPTER 5

5.1 Reproduction and Breeding Biology

Measures of reproductive success were comparable, to a five year study within the same general study area (De Smet 1992). De Smet (1992) found an average clutch size of 6.24, average brood size of 5.29 and average young per nest of 3.54. Nesting success ranged from 46% to 73% during his five year study and was 57% in 1992. Although some measures are slightly lower during the present study, differences could be attributed to a smaller sample size used . As well, reproductive success will vary among years due to contributing factors such as weather conditions and changes in the number of predators. The lower reproductive measures could be attributed to the colder and wet weather patterns in the summer of 1992, as De Smet (1992) also noted lower success during 1992. Kridelbaugh (1982) also reported lowered reproductive rates and a higher incidence of brood reduction during a cold, wet spring.

Egg hatchability (the average number of eggs hatched in nests that produced young) was relatively low in this study compared to other studies. Although Anderson and Duzan (1978) reported hatchability of 83% , most studies report higher values of 89% and 93% respectively (Porter 1975, Luukkonen 1987). Lower rates of hatchability are sometimes associated with birds poisoned with pesticides (Jefferies 1975). However, the lower hatchability in this study is may be attributed to a smaller sample size or colder weather conditions as De Smet (1992) reported higher rates of hatchability for the same general area.

Although overall nesting success seems to be relatively stable in this area in the last five years (De Smet 1992), there is no pre-decline productivity data to compare to this data. Nesting success is comparable to other studies (Porter 1975, Kridelbaugh 1982, Luukkonen 1987) and is high compared to other open-nesting altricial species (Nice 1952, Kridelbaugh 1982). Although nesting success seems to be stable, the numbers of shrikes found in certain regions of areas surveyed has declined with constant search efforts (De Smet 1992). Therefore there appears to be less shrikes returning to some regions to produce offspring. This suggests that post-fledging mortality may be high on the wintering or breeding grounds. As a result, less shrikes may be available to occupy suitable habitat and shrikes are selecting the most optimal nesting territories (Brooks and Temple 1990). Alternatively, apparently suitable habitat in outlying regions may not be optimal breeding habitat, and shrikes may be selecting more optimal habitat in core breeding areas in which to nest.

5.2 Habitat Needs of the Loggerhead Shrike

5.21 Macrohabitat Perspective

Loggerhead Shrikes in southwestern Manitoba nested in a wide variety of habitats. Correspondence analysis separated macrohabitat land use into three significantly different groupings consisting of sites with either a high percentage of pasture, cropland, or a mixture of these land use types with higher proportions of hayland and trees.

Comparison between occupied and random sites indicated that occupied sites possessed a significantly higher percentage of pasture with lower percentages of trees and higher amounts of fenceline and total perching substrata than random sites. As well, reproductive success was higher in nests associated with the highest proportions of pasture. Recent studies provide supporting evidence that Loggerhead Shrikes nest in open areas dominated with active pasture with ample perching sites (Porter et al. 1975, Siegel 1980, Kridelbaugh 1982, Luukkonen 1987, Brooks and Temple 1990). As well, there is evidence that reproductive success is higher in areas dominated by pasture (Kridelbaugh 1982, Luukkonen 1987). Telfer (1992) also noted the importance of pasture for Loggerhead Shrike habitat on a regional level. In examining Alberta and Saskatchewan land use statistics from 1946 to 1986, he noted "Regions which experienced the most severe decline in shrike numbers had a 39% decline in unimproved pasture. This is compared to a 12% decline (of pasture) in regions which retain substantial numbers of nesting shrikes."

Reasons for selection and higher reproductive success in pasture may be related to food supply and greater accessibility to the prey. Loggerhead Shrikes forage by ambushing their prey from perches and taking prey from the ground by detecting their movement (Miller 1931). Intuitively therefore, a preferred nesting site would have an abundance of high perches, unobstructed views and shorter vegetation. Open pasture possesses these characteristics which may be lacking in more modified land use forms.

Telfer (1992) noted that changes in habitat could result in: " reduced quantity or quality of food; changes in habitat structure that increase foraging difficulty or expose nests to greater risk from weather and predators; increased competition with species that have similar food or habitat requirements; and higher mortality rates at all life stages due to predation, exposure, stress, disease or accident." Foraging may prove to be difficult for shrikes in cropland due to: 1) lack of grassy areas /cover for the shrike's prey in the early spring when fields are bare and 2) in the mid-late summer, when crops are higher, hunting view may be obstructed. Gawlik (1988) found that shrikes most often hunted above grassy areas in breeding season. Grassy ditches should therefore be considered relatively important hunting areas where the nest site is surrounded by cultivated fields. Shrikes nesting in cropland may have to fly further distances to ditches to forage for food, expending additional energy and leaving their nests unprotected. Other species of birds exhibit higher foraging success in areas with shorter grass as well . Toland (1987) found kestrels have higher hunting success in short grass cover areas, maintaining that low vegetation in fields afforded better visibility of small mammals. Shrub (1980) reported that Eurasian Kestrels (*Falco tinnunculus*) made 62% of their kills in uncultivated grass fields which represented only 24% of the study area. He suggested that kestrels avoided cereal crops in nesting season due to height, density, and evenness of cereal crops.

There may also be a higher rate of mortality associated with vehicle collision in cropland than in pasture (De Smet and Conrad 1989). Shrikes in pasture areas have more area to forage and therefore would be at less risk of mortality due to pesticides and vehicle collisions .

Greater selection and success in pasture than mixture and cropland could also be related to characteristics other than particular land use forms. In comparing microhabitat characteristics among the three groups, pasture had a greater percentage of willow trees than crop and mixture, and lower percentages of other deciduous trees. As well, a greater proportion of shrubs > 2m were associated with cropland and mixture categories, while a greater proportion of shrubs < 2m were associated with pasture categories. This may be attributed to a greater number of shelterbelts being associated with cropland and mixture, while a greater number of lone standing trees and shrubs were associated with pasture.

Although, this study found no difference in reproductive success between nests in willow bushes and nests in other deciduous trees, reproductive success may be affected by the configuration of trees (such as nests in shelterbelts vs. lone standing trees). Shelterbelts are largely beneficial to wildlife, but they may also present drawbacks (Johnson and Beck 1988). Gates and Gysel (1978) put forth the "ecological trap hypothesis" when they observed unusually high levels of nest predation and brown-headed cowbird (*Molothrus ater*) parasitism along man-made edges. Most windbreaks consist almost entirely of edge habitat, and may attract avian predators.

Anderson and Per Angelstam (1988), provided experimental evidence of elevated predation as an edge effect in habitat islands. Lewis (1969) found that flying insects accumulate in sheltered areas near windbreaks, especially on the leeward side of windbreaks. Barn Swallows (*Hirundo rustica*) and Western Kingbirds (*Tyrannus tyrannus*) are often seen foraging on the leeward side of windbreaks, and may take advantage of high concentrations of insects (Capel 1988). The high concentration of insects would be of beneficial use to the Loggerhead Shrike, which is mainly insectivorous in breeding season. However, the insects may also draw high concentrations of competitors and predators. Several authors have reported negative effects of shelterbelts planted to increase game bird populations (Peterson 1979, Snyder 1985, Ports 1986). However, Shalaway (1985) reported a higher nesting success rate of tree nesting birds in fence rows than in native shrub or woodland. He associated the high success rate with the types of birds and predators involved. He found that larger mammalian predators (order Carnivora) were responsible for most nest losses, whereas rodent and arboreal snake predators of open nesting birds were not present. Nest success was higher for passerine birds (ground and arboreal) than for larger ground nesting birds. Basore et al. (1986) found no difference in nest predation in strip cover compared to agricultural fields. Johnson and Beck (1988) reviewed literature on this subject and concluded that a better understanding is needed of predator-prey relationships in windbreaks.

Other studies provide evidence that in certain years productivity was higher in areas dominated by cropland and shelterbelts, than in scattered willows and pasture (De Smet and Conrad1991). During that 2 year study, nest productivity was found to be higher in grassland dominated areas than shelterbelt/cropland. However from 1990-1991, De Smet (1992) found productivity higher in cropland/ shelterbelt dominated areas than pasture. De Smet (1992) attributed this shift in habitat suitability to change in weather patterns. The summers of 1987-1988 were relatively dry and hot compared to the cold wet summers of 1990-1991. He concluded that the shelterbelts provided greater cover than scattered willow bushes in pasture during the wet years.

There may be numerous reasons why this study differs somewhat in results from De Smet (1992). Firstly, there are differences in the methodology, and in the classification of areas which were compared. "Cropland " in this study is defined as areas with higher proportions of cropland relative to the other nest territories. It was not always associated with shelterbelts. A number of nests in this area were in a willow bush surrounded by crop, which was associated with the cropland category. Similarly the "Mixture" category was sometimes associated with shelterbelts and cropland with a higher proportion of hayland. Degree of reproductive success, may be a product of definite proportions of a certain type of habitat available. Some areas dominated by shelterbelts possess a higher proportion of hay and marginal land than other areas. De Smet (1992) compared shelterbelted areas with crops and hayland against areas with no shelterbelts and dominated by pasture. Perhaps cropland with shelterbelts are more suitable to shrikes than willows and cropland.

Notwithstanding the differences in measurements between the studies, there may be other reasons why there is some disparity. The sample size in this study may have been too small to detect a trend of higher productivity in sites dominated by cropland.

A large proportion of shrikes in this study, however, did nest in sites dominated by cropland and shelterbelts. The importance of these shelterbelts in terms of shrike breeding habitat was also emphasized by De Smet 1992. He hypothesized that this shift in habitat preference was due to the additional cover the shelterbelts gave through a trend of colder wet summers. Another reason, separate from the weather could be a shift in food source. For instance Gawlik and Blinstein (1993) noted a seasonal habitat preference shift , foraging in disturbed grassy habitat in the spring, and areas of cropland in the fall. They attributed this seasonal shift to changes in food availability. Other reasons could include changes in predator pressure in different years. Certain predator and competitor populations may be lower in certain locations in some years than others. It is possible that competing bird populations in the shelterbelt areas may be declining due to weather change or other factors.

Another reason why pasture may vary in importance among years may be due to the spatial scale at which the birds are being studied. Wiens et al. (1987) studied the effects of spatial scale on habitat occupancy patterns of North American shrubsteppe birds. Their results indicated that how one characterizes the habitat occupancy of a species is dependant on the spatial scale used. Densities of several shrubsteppe species varied in relation to features of habitat structure at a biogeographical scale, but these associations disappeared at a regional scale within the shrubsteppe. The Loggerhead Shrike's association with pasture may be more distinct at a regional level than at a biogeographical perspective. The shift towards cropland observed by De Smet (1992) may have been less dramatic at the regional level. The extreme southwest Manitoba region has a higher proportion of mixed grass prairie than most other areas in the province. Shrikes could be attracted to the prairie at a regional level, and then choose breeding areas from a different perspective.

5.22 Microhabitat and Foraging Perspective

This study and other recent research indicates that Loggerhead Shrike nesting habitat selection and reproductive success is also related to factors at a microhabitat perspective (Luukkonen 1987, Gawlik 1988). There is evidence that microhabitat factors related to optimal foraging are conducive to more suitable breeding sites. For instance, Mills (1979) indicated that hunting success, and energy gain of foraging shrikes is related to perch height, ground vegetation height, cover and concealment of prey. Furthermore, Carlson (1985) found that Red-backed Shrikes (*Lanius collurio*) detected prey more easily when prey was close to perches and when ground vegetation was absent. Field research also has shown that in the breeding season, shrikes hunt most often above disturbed grassy areas (Mills 1979, Gawlik and Bildstein 1993).

In this study, the most discriminating factor separating random sites from occupied nest sites at the microhabitat perspective was the lower understory index (cover x vegetation height). Prescott and Collister (1993) also found that shrike habitat selection was related to vegetation height. However, they observed that shrikes actually selected areas with higher grass (> 20 cm). They reasoned that areas with higher vegetation supported more invertebrate prey. Taller grass in southern Alberta, however, is comparatively shorter than vegetation in southern Manitoba (> 30 cm was a tall grass height in the present study). Blumpton (1989) also reported that productivity was highest in vegetation heights (9.1-18 cm), which would be classified as shorter vegetation in this study. Perhaps in areas where land is overgrazed, prey may be limited, and shrikes would choose nesting sites in close proximity to areas where prey was more plentiful (ie., in taller grass). Complete absence of vegetation may be detrimental to foraging as vegetation supports prey. However, ability to see and catch the prey is also a factor in foraging success. In areas where taller grass is plentiful, prey would have ample cover, and the greater limitation would be sighting and catching efficiency.

Prescott and Collister (1993) concluded that availability of tall grass habitat was limiting the Loggerhead Shrike populations southern Alberta. In interpreting their results, they resolved that lack of shrikes in shorter grass areas could either be due to the fact that areas with shorter grass were unsuitable breeding areas, or that factors in the wintering areas were limiting the population, leaving suitable areas on the breeding areas uninhabited. In the later case, the authors assumed that shrikes would occupy the most suitable sites for breeding, and leave less optimal but suitable sites unoccupied. Both cases determine that "higher quality habitats are in short supply". Since a lower understory index was found in occupied surrounding nest sites than in random during this study, higher quality habitat may also be in short supply resulting shrikes selecting shorter grass habitat .

A territory which provides the greatest hunting opportunities is especially important during the breeding season when shrikes are feeding young. It is argued that low vegetation close to the nest site causes the shrike to expend less energy travelling to higher perches and more favorable habitats to hunt (Craig 1978). This study provides some evidence that reproductive success is related to the understory index. Reproductive success was significantly higher in areas associated within the lowest understory category. However, success was relatively high in a higher understory index category, as well. Thus, although the understory index may effect the breeding suitability of a territory, other factors, such as vegetation composition and perch site availability may also contribute to nesting success. Recent studies show the highest nesting success in pasture and hayland areas with shorter grass cover (Kridelbaugh 1982, Luukkonen 1987, Gawlik 1988). Luukkonen (1987) found that 11 nests surrounded by pastures produced twice the number of shrike nestlings as did nests in other habitats. Although the short grass height may be a major contributing factor determining success, other factors such as availability of prey in these pasture and hayland habitats may be equally important.

Loggerhead Shrikes in southwestern Manitoba nested in a wide variety of trees and willow bushes. The most commonly utilized bush or tree were willow shrubs, however, they were not used more than expected based on availability. This suggests that there were ample nest shrubs of this species available for use. Selection of a particular tree may be due more to the characteristics of the trees themselves than species. Porter et al. (1975) reported that nest site selection was based on the degree of cover a plant provided rather than the species. However, certain species may have certain attributes desirable for nesting above others. For instance, aspen trees provide poorer cover and concealment as compared to willow shrubs, which generally have more and denser branches and are rarely used by nesting shrikes.

Both willow shrubs and deciduous trees were commonly used by shrikes as nesting support. Willow bushes on average had significantly lower tree and nest height, a greater number of branches, lower branches and greater coverage than other (deciduous) trees. However, the differences between these two types of nesting supports did not have a noticeable effect on reproductive success. Although willow shrubs possessed greater concealment, the deciduous trees may have other attributes which equally protect the nests from predators. For instance, deciduous trees were taller on average than willow bushes, providing better protection from ground dwelling predators.

5.3 Management Implications

5.31 Maintenance of Loggerhead Shrike Breeding Areas on Private Lands

Most of Loggerhead Shrike nesting habitat in Canada is situated on private lands specifically used for agricultural purposes (Telfer et al. 1992). Therefore much of the conservation of Loggerhead Shrike and wildlife habitat is dependent on the actions of the landowner. The following recommendations will therefore require the cooperation of landowners and other land users. Future areas of study are also indicated.

This study found that Loggerhead Shrike territories can be categorized into three main groups: Pasture, Mixture and Cropland. Each of these groups involve different management implications based upon land use.

5.311 Pasture Territories

The results of this study and other research indicate that pasture is the most important breeding habitat for the Loggerhead Shrike (Luukkonen 1987, Telfer 1992). The amount of pasture has decreased in Canada, to the extent that less than 24% remains today.

Agricultural polices are one of the causes for this decline of habitat. Many promote the cultivation of marginal land and pasture. For instance, the farmer who cultivates more of his pasture will receive higher Federal Grain Quotas (ie. able to sell more grain), receive more insurance coverage and receive a higher amount of subsidies (Thornton et al. 1993 a,b; Girt 1990). Furthermore, municipal and provincial governments tax uncultivated land at the same rate as cultivated acreage. Thus, farmers are encouraged to cultivate more land in order to pay their taxes (Girt 1990).

As pasture and marginal lands are valuable habitat for wildlife, a public good, agricultural policies should be modified and the farmer should be compensated for maintaining this resource (Belcher 1991). Changing the quota system that bases grain deliveries on a volume rather than acreage basis may deter further cultivation of pasture and marginal land (Girt 1991). Insurance and support systems could also be modified to provide coverage for range and pasture (Thornton et al. 1993). Taxation measures might include tax exemptions on marginal land, or paying farmers the opportunity cost for keeping pasture or marginal land, as well as rebating the municipalities lost revenues from removal of taxes on wildlife habitat lands. In Minnesota, unimproved or uncleared land is no longer taxed to encourage farmers to leave these area untouched.

Currently, there are many federal, provincial and private programs which seek to conserve pasture and marginal lands through landowner participation (Wildlife Habitat Canada 1991, Manitoba Environment 1992). These programs promote sustainable farming practices, act to improve the productivity of the land, and help compensate the farmer for any profit losses in maintaining this habitat. Therefore, participation in these programs benefit both the landowner and wildlife.

The conservation of remaining pasture is important. However, proper maintenance of pasture is also crucial for native prairie wildlife such as the shrike, as well as for sustainable agricultural practices. Management implications pertaining to the Loggerhead Shrike include proper grazing practices, removal of encroaching brush, and protection of nesting trees from cattle.

Results of this study suggest selection and higher reproductive success in areas with shorter vegetation. Thus, moderate grazing pressures around the nests do not seem to be detrimental to the Loggerhead Shrike. Other studies also stress the importance of shorter vegetation (Luukkonen 1987, Gawlik 1988). However, Prescott and Collister (1993) suggest that there should also be areas of taller grass available for prey food and cover particularly on predominantly short grass prairie habitat. More study is needed on how certain grazing practices effect shrikes before an appropriate and specific recommendations can be made on how to best use it as a management tool.

Telfer et al. (1992) suggest grazing of fallow pasture be studied to determine utilization by shrikes. Utilizing radio telemetry to determine exactly which areas shrikes forage most will also be important. Many grazing practices may effect breeding site suitability. Stocking rate, continuous verses deferred grazing, density of grazing, pasture size and configuration, water source and type of forage are all factors which must be studied to determine effect and possible grazing schemes. These management practices will have to be within the boundaries of short and long-term goals of the landowner and within the realm of resources (such as land, finances, social and cultural influences).

In order to manage for a high diversity of prairie species, the needs of other grassland birds also need to be considered. Other studies provide evidence that grassland species differ in their tolerance to grazing on their breeding grounds from heavily grazed to lightly grazed pastures(Kantrud and Kologiski 1982, Wershler 1993). Bird species are variably tolerant to grazing patterns relating to the following factors: differences in soil/vegetation height, climatic fluctuations and types of grazing systems (Wershler 1993). Therefore, in order to promote habitat diversity and biodiversity in a particular area, the effects of grazing on various soil and vegetation types must be identified for the region.

Nesting support is also an important habitat component for the Loggerhead Shrike. The nesting support most commonly utilized in pastures in southwestern Manitoba was the willow shrub. As observed in this study area, these shrubs are sometimes partially destroyed by cattle, or removed for forage improvement. Telfer et al. (1992) report incidences of cattle destroying the lower branches of shrubs in which shrikes were nesting. This may cause abandonment or destruction of the nest or alternate suitable nest sites. Research should therefore be undertaken to determine the most efficient way of protecting these shrubs.

Priority for protection should be given to nest sites repeatedly utilized. Landowners should be notified of these nest sites in order to avoid inadvertent damage. Various incentives could be given to the landowner in order to encourage participation including tax incentives or leasing programs (Manitoba Environment 1992, Telfer et al. 1992).

The pasture grouping also had significantly more short shrubs < 2 m surrounding the nest bushes compared to the other groups. Although short shrubs surrounding the nest tree may be important for perching use, and extreme amount of encroachment of brush or aspen may obscure the shrike's view for foraging purposes. In these situations, brush removal practices as described in Appendix 2 are advised.

5.312 Cropland Territories

As evidenced in this study and other studies, Loggerhead Shrikes nest in more modified habitats, and conservation efforts should be applied in these areas as well. Although shrikes were more successful in areas dominated by pasture in this study, they also selected areas in southwestern Manitoba that were dominated by cropland. Possible management issues in this habitat includes increasing foraging areas closer to the nest site, reducing pesticide effects, reducing competition and predation in these areas, and rotating crops.

In this study, shelterbelts were extensively utilized by shrikes within the cropland and mixture groupings. In southwestern Manitoba, these shelterbelts are important nesting habitat for the Loggerhead Shrike. Action should be taken to conserve and protect the remaining shelterbelts. A study within the same general area has shown that two-thirds of the farmers have either partially or fully have removed shelterbelts in the past (Sutton 1983). Reasons for removal include the fact that it is difficult to maneuver machinery around the windbreaks, to taking up too much space. Perhaps, farmers should be paid the opportunity cost, or given tax incentives for keeping these shelterbelts in order to prevent their removal.

The shelterbelts in the study area are mainly comprised of single row windbreaks, consisting of a mixture of deciduous trees and caragana bushes (Koonz 1983). The wind breaks may be especially attractive to the Loggerhead Shrike as the single rows are exposed to open fields, and they require open areas for foraging. However, the high proportion of edge may attract many other edge species such as Eastern Kingbirds (*Tyrannus tyrannus*) and Common Grackles (*Quiscalus quiscula*) which compete for territories and food. As well, potential predators such as blackbirds (*Euphagus cyanocephalus*) and European Starlings (*Sturnus vulgaris*) are also be attracted to the shelterbelts. Management must focus on methods to support this diversity, but reducing populations of competitors or predatory species.

The characteristics of shelterbelts themselves may determine the competitive interactions among birds. For instance, planting trees of different species and form may act to add a greater depth of configuration to the shelterbelts, allowing competitive bird species to harmonize (Yahner 1983).

In this study and De Smet (1992) the majority of Loggerhead Shrike nests in shelterbelts were found in deciduous trees. Caraganas were infrequently used nesting site for the shrike in shelterbelts, although it was commonly observed in these shelterbelts. Shelterbelts of only shrubs (caragana) should be avoided, as they do not provide enough structure for interacting wildlife (Schroder 1986). However, mixing caragana with trees such as ash or maple is advisable, as it is suitable for other species such as Grey Catbirds (*Dumetella carolinensis*), American Robins (*Turdus migratorius*) and brown thrashers (*Toxostoma rufum*) (Johnson 1984), and adds a lower bush layer to reduce competition.

Introducing a different variety of nesting tree may also increase habitat suitability for the shrike. In Manitoba, landowners are only eligible to receive caragana, Manitoba maple and green ash free of charge from the Prairie Farm Rehabilitation Association (PFRA 1993). Thus, the majority of shelterbelts in this area are composed of these species. Additional species such as the hawthorn (*Crataegus sp)*, hedge rose (*Rosa rugosa Thumb.*) and sea-buckthorn (*Hippophae rhamnoides*) have thick branches, and possess thorns, which would act as protection from predators and potential impaling sites. Loggerhead Shrikes tend to nest in thorny bushes (Luukkonen 1987) and their introduction may further provide optimal breeding habitat.

Research has also indicated that windbreak height, age, area, and canopy closure affect bird diversity, competition and presence of individual species (Emmerich 1978,Martin and Vohs 1978, Martin 1978, Yahner 1983). These factors may also affect habitat suitability of the Loggerhead Shrike.

Shrikes most commonly forage above shorter grass habitat during breeding season (Gawlik 1988, pers. observ.). Therefore, marginal areas, ditches, and rights-of-way are important foraging areas for the Loggerhead Shrike, especially in cropland dominated areas where few other grasslands are available. Efforts to properly manage and protect these areas should therefore be undertaken.

All undeveloped road allowances within Manitoba are under the title of the provincial government as Crown land, but trusted in jurisdiction to the rural municipalities. Presently, there are bylaws in 15 municipalities to protect remaining undeveloped road allowances within their jurisdictions. However, these bylaws are unenforced, and these areas remain susceptible to cultivation and burnouts. Wildlife conservation groups and other interested parties should lobby the municipal and provincial government to enforce bylaws which prevent the cultivation of these rights-of-way.

The Municipal governments and the Department of Natural Resources should also plan to properly maintaining these areas. Reconstructing and preserving natural prairie vegetation in ditches and rights- of- way would enhance the shrikes' habitat as well as habitat for other birds indigenous to prairie. Mixed grass prairie is generally comprised of shorter vegetation than introduced vegetation . This would benefit the shrike for foraging purposes as well as support a higher diversity of ground nesting birds (Wilson and Belcher 1989). A feasibility study for habitat restoration along hydro rights-of-way has recently been completed and could be applied in this area (Faminow 1993).

A two to four meter grassy strip surrounding the shelterbelts may give the shrike additional hunting area, closer to its nest. The strip will also be beneficial to the shelterbelts themselves for retaining nutrients and soil moisture and reduce the amount of weeds

(Ferguson et al. 1977). Providing such herbaceous strips adjacent to shelterbelts also benefits pheasants, quail, and other ground nesting birds (Morgan and Gates 1982). Telemetry studies are needed to determine if shrikes would utilize these areas The feasibility of leaving grass strips next to shelterbelts also needs to be considered since farmers may be reluctant to leave these strips because of loss of quotas.

More research is needed on the effects of pesticide use on Loggerhead Shrike reproduction. Although the low percentage hatchability may be due to small sample size or poor weather conditions, pesticides may be a contributing cause. Baril (1993) suggested short-term and long-term methods for reducing pesticide use. Replacement of pesticides with less lethal chemicals, alternative cropping techniques and the use of biological controls should be advocated especially in areas that retain dense numbers of Loggerhead Shrikes. Farmers should be encouraged and compensated for using pesticide alternatives that are less harmful to wildlife. For example, tax incentives could be given to farmers using less harmful pesticides. As well, demonstrations of proven alternative pest control techniques encourage their use (Baril 1993).

Efforts have been made to deter the spraying of Furadan in some core Loggerhead Shrike breeding areas by contacting landowners and municipal officials (De Smet and Conrad 1991). Maps of breeding sites could further be given to municipal officials, biologists, provincial and municipal planners to ensure against pesticide application, and incompatible development at the breeding site.

5.313 Mixture Territories

The mixture grouping in this study had a higher reproductive success rate than the crop grouping. This provides some evidence that even marginally more pasture or hayland within an area dominated by cropland will increase the breeding suitability of an area. Higher proportions of hayland or pasture within cropland dominated areas thus may be more suitable to the shrike than a monoculture of cropland within its territory. In order to promote this land use, agricultural subsidies that encourage the conversion of cropland to tame or natural forage (ie.,the Permanent Cover Program) should be continued (Dale 1993).

The mixture group possessed proportions of pasture and cropland; management implications for these two groupings should be applied in this grouping as well. Hayland, normally cut and baled once or twice during the summer, was also an important component of the groupings. According to this study, nests were relatively successful within shorter grass territories and haying around nest sites is probably beneficial to the Loggerhead Shrike. However, the benefits of lower vegetation may depend on the surrounding land uses. For instance, in areas of predominantly short vegetation, the presence of taller vegetation may be important for attracting prey (Prescott and Collister 1993). Considerations should also be made for other birds which suffer negative effects from haying. Dale (1993) found that haying disturbs endemic passerine birds and removes much of the overhead cover surrounding their nests. She suggested that delayed haying practices and leaving uncut blocks or strips within haylands would increase productivity of these birds. Programs such as the Prairie CARE Program (Conservation of Agriculture, Resources and the Environment) delivered by Ducks Unlimited compensate farmers for such activities. Prairie CARE pays a fee for hay to be cut only once a year no earlier than July 15, and restricts other cover removal such as grazing and burning.

5.32 Management for Maintaining Loggerhead Shrike Breeding Areas on Public Lands

Wildlife Management Areas (WMA's) are areas of land allotted as Crown land, to be utilized for natural resource and wildlife management (Teillet 1993). Public lands have high potential for conserving prairie remnants that are important for declining indigenous wildlife such as the Loggerhead Shrike. The importance of these relatively small areas should not be underestimated Brown (1993).

Since these areas are also designated for wildlife research, WMA's in southwestern Manitoba have the potential to answer some management questions regarding the Loggerhead Shrike. Telfer et al. (1992) suggested habitat management procedures to create and enhance breeding habitat, such as clearing excessive shrubs in pastures, improved grazing practices, or planting shrubs in pastures lacking them. However the management practices most conducive to attracting the shrike and other indigenous species have yet to be determined. Adaptive Resource Management, managing while monitoring and studying the project's effects on a long term basis, would be suitably applicable to WMA's (Wershler 1993). Different methods of managing prairie, such as prescribed burning, mechanical methods, or grazing should be tested in these areas, and monitored over several years in order to determine if native species such as the Loggerhead Shrikes are re-inhabiting the area, and which application would be the most successful. The most successful method could then be applied on a more widespread basis.

Based upon the techniques in Appendix (2) and the habitat requirements of the Loggerhead Shrike as derived from this study and other recent research, a management framework for creating Loggerhead Shrike habitat in WMA's that have become encroached with brush involves the following; Appropriate sitings must first be located. The chosen site for recreating habitat should be a historically used Loggerhead Shrike breeding territory or area, no longer suitable for the Loggerhead Shrike, showing definite change in vegetative characteristics. The area delineated should be at least 30 ha as the average shrike territory is 25 ha. The site should be chosen with regard to alterative land use legislative and municipal constraints, and other wildlife use. A site within 200 m from the recreation site, with similar vegetative qualities should be chosen as a control to be monitored. A biophysical inventory of the physical and biological components or resources of the site and the regional area surrounding the site should be taken. It is necessary to identify and map alternative land uses, topography, water sources, perching substrata, vegetation types, heights and density. Additionally, a species list of the area should be accumulated. Air photos would be useful in characterizing regional qualities, such as tree cover and land use. A historical background of natural history and land use of the site and the area should also be accounted.

Based on gathered information, an operational plan for site establishment should be undertaken. The plan should consider a balance of alternative uses at the site while keeping in focus the main management objective. The plan should also consider the most economically and ecologically feasible method of habitat manipulation, based upon vegetation type and density, soil, topography, and amount of labor required. Habitat manipulation should be based upon the Loggerhead Shrike's habitat requirements as defined above, and the management tools as explained above, within the habitat needs of other species and economic boundaries.

The site should be maintained with secondary treatments such as prescribed burning or grazing. The site and a control site should be monitored for several years for change in species diversity, and attraction of the shrike to the area. It is important to involve land owners and local conservation groups, to increase awareness of the Loggerhead Shrike and its habitat needs, to demonstrate proper maintenance practices so they in turn may be performed on private lands, and to implement a long term monitoring plan for this area.

As WMA's are Crown land, the undertaking of such a study would fall under the jurisdiction of the provincial Department of Natural Resources. Such management would therefore have to be within budget constraints and ongoing management plans as designated by the provincial government. For example, a prescribed burn is being planned for the Broomhill WMA within the vicinity of the study area in 1994 (G. Fortney 1994, pres. comm). Although all aspects of the outlined study would be unfeasible, it could be modified to involve monitoring the flora and fauna present before and after the burn.

Involving landowners and wildlife groups in maintenance and monitoring could reduce the cost of such a study.

Efforts also need to be taken to further protect endangered species habitat within WMA's. The major purpose of these areas is to conserve wildlife habitat. However, many have been designated for several alternative uses that have potential conflict with wildlife habitat. A recent example of such a conflict has been within the Broomhill WMA (within the Albert municipality). This 325 ha WMA was founded in 1967 and has subsequently been designated for water well development, recreational hunting, trapping, gravel extraction, and wildlife research (Teillet 1993). Specific habitat development involves burning and dugouts. This area possesses mixed grass prairie remnants, and supports a variety of endangered birds (Loggerhead Shrike, Burrowing Owl, Baird's sparrows, as well as a host of other declining grassland birds) (De Smet 1992). As this WMA is zoned for gravel extraction, the entire WMA is essentially unprotected from this development. In the summer of 1993, gravel extraction development ensued by the provincial government without assessment or survey of the area. It is unknown what effect this development will have on the species or the ecology of the surrounding area.

In order to increase protection of sites such as this, specific legal designations such as ecological reserves must be developed for use within the WMA system. WMA lands requiring "specific protection for specific uses" should be identified. These areas may be defined by surveying the area for nesting and foraging sites as well as reviewing records of previous use. These changes concerning formal zoning should be incorporated into the Wildlife Act or Endangered Species Act and be implemented immediately.

Additional controls should be placed on non-conforming activities and aggregate extraction on WMA's, including developing proper guidelines, and employing a "differential royalty assessment for aggregate material" removed from WMA areas to encourage use of nearby areas rather than the WMA (Teillet 1993). Such actions are needed if these WMA'is are to properly represent the indigenous species of the area.

CHAPTER 6

SUMMARY OF FINDINGS AND RECOMMENDATIONS

6.1 Summary of Findings

Loggerhead Shrike breeding habitat within southwestern Manitoba was studied from May to August, 1992. Nesting locations differed significantly from randomly chosen locations on both a macrohabitat and microhabitat scale. Nesting locations possessed a higher percentage of pasture, lower percentage of trees and a greater amount of fenceline and total perching substrata than random locations. In comparing occupied and random sites on a microhabitat scale, nesting sites had a significantly lower understory index than random sites.

Although occupied sites possessed a higher percentage of pasture, Loggerhead Shrikes nested an a wide variety of land use types. Correspondence analysis sorted nesting locations into three different groups: nests associated with a high percentage of pasture, a high percentage of crop, and a mixture category containing less pasture or crop, and more hayfields. These three areas also differed with respect to tree species and configuration. Cropland and Mixture possessed a higher percentage of taller trees (> 2m) surrounding the nest tree and pasture possessed a higher percentage of willow bushes, with a greater percentage of low lying bushes (< 2m) surrounding the nest tree.

Reproductive success also differed among the three macrohabitat groups. Nests associated with pasture had the significantly higher reproductive success, followed by mixture and cropland. As well, nests with a shorter understory index had higher reproductive success. Comparisons between two distinct nesting supports, willow bushes and other deciduous trees, found no significant difference in reproductive success.

6.2 Management

Loggerhead Shrike populations are declining across their range and there is evidence that loss of habitat is partially responsible. The following recommendations are made to conserve and enhance the quality of the Loggerhead Shrike in southwestern Manitoba, while maintaining habitat for other species as well. Conservation of the Loggerhead Shrike and its habitat depends on the combined efforts of landowners, government and non-government organizations.

1) According to this study, open pasture with ample perching substrata is selected significantly more than random sites. Areas dominated by pasture were more reproductively successful than mixture and cropland, and mixture was more successful than cropland. These findings indicate that pasture is an important habitat type and even marginally more pasture or hayland within a nest territory was associated with higher success. Many provincial, municipal and federal agricultural policies should be modified to promote the conservation of pasture and compensate the farmer for maintaining this habitat. Farmers should be encouraged to utilize existing agricultural and wildlife habitat conservation programs that will increase their land's productivity as well as to conserve wildlife habitat.

2) In pasture dominated areas, willow shrubs were the most heavily utilized nest substrata by the Loggerhead Shrike. In some situations, damage of these shrubs by cattle, or removal by landowners has been observed. Landowners should be notified by the Department of Natural Resources of well-utilized nest sites in order to prevent inadvertent damage to the site. Farmers could be compensated for maintaining these sites through leasing programs or tax incentives developed by the Department of Natural Resources.

3) Shrikes tended to nest in deciduous trees within shelterbelts in the cropland and mixture groupings. Shelterbelts consisting of only caraganas should be avoided. Shrikes prefer the taller trees as nest sites and shelterbelts consisting of both trees and bush diversifies the habitat and may reduce competition. A two to four meter strip surrounding the shelterbelt may increase foraging area within cropland dominated areas (priority should be given to well- utilized nest sites within the past three to seven years). Landowners should be compensated for maintaining these shelterbelts and the land surrounding them through tax incentives or by being paid the opportunity cost of the land taken out of production.

4) In this study and other recent studies, shrikes foraged most often above short grassy areas as compared to cropland. Thus, in areas dominated by cropland, suitable foraging areas may be reduced. Marginal areas of land, such as rights-of-way and ditches should be seen as important foraging areas for the Loggerhead Shrike. As rights-of-way are under the jurisdiction of the municipal governments, they should pass and enforce bylaws which prohibit the cultivation and misuse of these sites. Municipal and provincial government should also develop a maintenance plan for these areas which considers wildlife needs.

5) The results of this study indicate that nests with shorter vegetation surrounding the nest site is are relatively successful and that moderate haying and grazing practices are probably beneficial to Loggerhead Shrike breeding success.. However, these practices must be undertaken with consideration for other indigenous species and within the constraints of the the landowner.

6) Although pesticides were not proven to be detrimental to Loggerhead Shrikes in this study, there is cause for concern as it is a predatory bird and has a greater chance of accumulating pesticides in its body. Any nest sites known to have been used repeatedly

(ie., three times in last seven years) should be protected from spraying certain chemicals known to be harmful to within 300 m of the nest site. Municipal officials should be given maps of current nest sites and historically well used nest sites to avoid spraying pesticides within the nest's vicinity, and landowners should be notified of nesting sites on their land. The provincial government should consider giving farmers tax incentives for using pesticides less lethal than Furadan, and giving demonstrations which promote alternatives to pesticides.

7) Although the main use of Wildlife Management Areas is to manage for the indigenous wildlife of the area, many areas are designated for potentially conflicting uses as well. Further protection of endangered species is important within WMA's. Nesting and foraging sites should be identified and given the protection of an Ecologically Significant Area. As well, conflicting uses such as oil and gravel extraction should be deterred from WMA's through differential rates. A full environmental assessment, including reviewing recent and historical surveys should be undertaken before any development takes place.

6.3 Future Research Needs

1) Research on how grazing practices (including the type of grazing system, type of forage, grazing density, pasture shape and area) effect Loggerhead Shrike foraging and breeding success is required.

2) Research is needed on how to best protect the nest sites from destruction by cattle.

3) Research is needed on how to reduce competition and predation within shelterbelts. Introducing tree species such as hawthorn, may act to protect shrikes from predators.

4) The Federal government should undertake a feasibility study for compensating farmers for maintaining shelterbelts on their land.

5) Appropriate techniques for maintaining prairie and managing bush encroachment to attract grassland birds should be applied on WMA's and monitored.

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Appendix 1

Glossary of Terms

COSEWIC*: Committee on the Status of Endangered Wildlife in Canada, which is composed of representatives of federal, provincial and territorial governments, World Wildlife Fund Canada, Canadian Nature Federation and Canadian Wildlife Federation.

Endangered*: Any native species that is threatened with immediate extirpation throughout all or a significant portion of its range.

Extinct*: Any native species that no longer exists anywhere.

Indigenous*: Having originated in and being produced, growing, or living naturally in a particular region or environment.

Mixed Prairie Ecoregion:* An ecoregion developed on brown and dark brown chernozoic soils. It supports both mid and short grasses. The taller species (spear grass, porcupine grass and wheat grass) comprise the majority of the vegetative cover over the ecoregion. In dry or heavily grazed situations, the shortgrass species will predominate (low sedge, June grass, and blue gramma).

Native Prairie*: An area of unbroken grassland or parkland dominated by non-introduced species.

Species*: A unit used to classify living things, describing any groups that share general physical characteristics, and which theoretically can mate and produce offspring.

Habitat Suitability: A measure of how well a particular habitat may support a species based on reproductive success or habitat selection.

Threatened Species*: Any indigenous species of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.

Wildlife*: All native species of plants and animals, including all invertebrates and invertebrates.

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* (from Environment Canada 1992)

Appendix 2

Management Techniques for Reducing Brush on Pasture

Assuming that the management objective of a specified area is to maintain or restore open grassland habitat for a variety of open grassland species, including the Loggerhead Shrike, a number of techniques can be utilized. These treatments include mechanical removal, prescribed burning, rotational grazing or a combination of these practices. Many of these techniques have been used for creating habitat for other upland birds such as the sharp-tailed grouse.

Berger et al. (1989) utilized a mechanical technique to re establish leks for sharp-tailed grouse. He used a combination of winter bulldozing to remove aspen and two summer mowings to prevent regrowth. To prevent long-term regrowth, he recommended mowing every three years. These techniques, however are time consuming and expensive (Baydack et al. 1988), and should be used when alternatives are less economical. The alternatives, such as fire and grazing can only top kill aspen and bulldozing may be initially the only feasible way to kill the aspen.

Prescribed Burning, when applied correctly can be a feasible method of controlling brush encroachment. A prescribed burn is defined as " the application of fire to natural fuels on a predetermined area to accomplish planned management objectives" (Miller 1979). There is evidence that burning may in fact be more effective than mechanical methods, in attracting grassland birds. Fitzgerald and Tanner, (1992), in comparing plots which were chopped (with a single pass of Marden M-7 drum choppers), to prescribed burn plots , found that the burned plots supported the highest diversity, and attracted open country birds including the Loggerhead Shrike. They reasoned that the chopped plots would have a lack of vertical diversity and perches which is a habitat requirement for certain birds including the Loggerhead Shrike. In burned plots, defoliated shrubs were still standing, providing perches. However, they indicated that fire alone may not be enough to restore shrub and aspen dominated former grasslands. Fire does not kill the entire tree or bush, as it does not remove the root system. Therefore, for removal of larger trees, such as aspen, bulldozing should be used initially with secondary treatments of prescribed burning. In systems less encroached by bush , however, fire can be used without initial bulldozing treatment (Wright and Baily 1982, Owensby 1984). Depending on the amount of woody growth, areas should be burned about once every 5 to 7 years.

There are many factors to consider before initiating a prescribed burn, including soil type and depth, temperature, vegetation and climate. Wright and Bailey, (1982) recommended prescribed burning guidelines for the Northern Great Plains and Aspen Parkland in Canada . Time of year also affects the reaction of aspen and bush growth to burns. If fire is adhered before active shrub growth, there is an increase in shrub growth. Therefore, spring burns usually increase sprouting and fall burns promote a taller regrowth next year. To control shrub growth, several summer burns are required over a 3-5 year cycle (Wright and Bailey 1982). To control aspen growth, frequent late summer burns combined with other treatments such as mowing from July until August can maintain open grassland areas free of aspen. Costs of a burn vary directly with equipment, amount of labor required and the size of the burn plot. Higgens et al (1989) found that cost and work hours per unit effort were the same for larger burns of 116 to 113 ha but high for burns less than 4 ha. Grazing can also be utilized in combating aspen and brush encroachment as a secondary or maintenance treatment. It has been successfully used in creating sharp-tailed grouse habitat in aspen encroached areas in Alberta. Baily (1986) and Baily and Fitzgerald (1990) found that after burning aspen in short duration, heavy grazing in early June and late August was an economical sharp-tailed grouse improvement tool. The first rotation is six weeks after the spring burn in June and lasts ten days, then the area is rested for forty days followed by another seven days of grazing in early August. Brush will decline after two years of this practice. Many factors must be considered, however, before attempting grazing techniques. Many ground nesting birds need taller grass for nesting from May to early

July. Wildlife managers must weigh the cost of benefiting one species over others. Size of herd per area, water availability, financial cost should all be taken into consideration.

Appendix 3. Raw Data

Legend

Table A and B

T. height= Tree height
N. height= Nest height
%D/A= percentage of Tree Alive
Basal branch =number of basal branches on the nest tree
Diameter of base=diameter of base
canopy width= canopy width of nest tree
horizontal distance=horizontal distance from nest to tree edge
shrub> 2m= number of shrubs > 2m surrounding nest tree
shub< 2m= number of shrubs < 2m surrounding nest tree

Table C and D

% Road (etc.)= percentage of road (landuse type) per territory.

Table E and F

Lth Tree= the lengths surrounding of tree and bush edges.
Lth Fence= the length of fence within a terriory.
Lth HW= the length of hydro wire within a site.
Total length= the total length of the three previus measurements
Dist. fence= the distance of the nest tree to the nearest fence
Dist. Road= the distance of the nest tree to nearest road
Dist H.W.= the distance of the nest tree to the neasrest hydo wire.

Table G.

# eggs= the number of eggs per nest
# young= number of young per nest
# fledglings= number of fledglings per nest
incubation= the number of nest days of incubation per nest (see Mayfield 1968)
Nestling= the number of nest days for nestlings per nest (see Mayfield 1968).

Nest Location	Tree Species	T. height	N. Height	% D/A	# Base Branc	Diam of Bas	Canopy width	Lowest Branc	Horiz. dist.	Shrub>2m	Shrub<2m	Understory I	Coverage
1(18)	willow bush	2.5	1	100	12	0.55	1.55	0.66	0.6	1	1	43.87	30
2(9)	willowbush	3.5	1.3	100	6	1.06	1.1	0.7	0.13	7	5	57.8	30
3(35)	willow bush	3	1	100	8	2	3.1	0.7	2.22	2	5	20.5	20
4(13)	willow bush	3	2.18	50	7	0.8	4	1.34	0.05	12	0	3.6	16.6
5(16)	will./rose	2.5	1.5	100	9	0.1	2.5	0.85	1.18	7	0	30	80
6(21)	willow bush	3	1.5	100	6	0.5	4	0.45	1	1	1	25.08	73.3
7(19)	willow bush	3	1.5	100	10	0.5	2.5	1	1	5	10	66.3	53.3
8(41)	willow bush	3	2	75	14	0.1	2.5	0.7	1.18	3	0	50.32	28.3
9(12)	willow bush	3	1.5	75	10	0.7	2	1	1.15	4	3	31.3	33.3
10(5)	willow bush	2	0.5	75	6	0.7	2.5	1	1.3	6	7	22.5	75
11(18)	willow bush	3	1	75	10	0.7	2.5	1	0.5	0	0	46.6	66.7
12(8)	willow bush	2	0.5	100	50	0.6	3	0.6	1	0	0	31.5	66.7
13(14)	willow bush	2	1.5	75	30	1	2.5	1	1	8	19	15.3	73.3
14(2)	willow bush	3	2.5	75	3	0.2	1.5	1	0.5	9	20	4.5	70
15(6)	Mb. Maple	3.5	3	75	1	0.35	5	1	1.3	0	1.5	19.6	11.7
16(28)	willow tree	6	2	75	3	0.3	3	1.5	4	11	0	74.3	76.6
17(42)	Am. Elm	6.5	3	75	3	0.3	3	2	2	11	0	10.8	28.3
18(24)	Am. Elm	3	1.5	75	1	0.3	2	1	0	9	0	40.9	26.7
19(22)	MB Maple	2.5	2	100	1	0.15	2	6	1	2	3	19.5	26.6
20(30)	Elm	6	4	50	1	0.4	2	1	0.5	6	0	31.62	43.3
21(36)	Elm	10	5	100	5	0.3	3	1	1	8	0	31.35	50
22(25)	Gr. Ash	2.5	1.5	100	1	0.3	2	1	1	4	0	50.25	35
23(23)	G.Ash	5	3.5	100	1	0.3	1	1.5	0.5	3	0	40.3	33.3
24(20)	Willow	4	2.5	75	3	0.8	2	1.5	1.5	5	1	4.9	40
25(32)	Am. Elm	7.5	5	100	1	0.35	2	2	1	7	12	2.55	73.3
26(39)	willow bush	2	1.3	50	20	1.4	3.6	3	1.3	0	3	63.4	40
27(29)	Salix	2.5	1.5	50	20	1	4	0.2	1	3	4	30	35
28(37)	willow bush	3	2	50	32	3.2	3.6	0.2	1	3	3	29.8	95
29(17)	willow bush	2.5	1	50	10	0.87	2.5	0.87	1	0	0	16.5	80
30(3)	willow bush	2.5	1	100	5	1	4	0.6	1.3	1	8	76	95
31(31)	willow bush	2	1.5	75	30	0.75	1	0.15	0.5	3	0	69.66	63.3
32(7)	willow/rose	2.5	0.5	50	30	1	4	0.2	0.3	1	4	10.8	80
33(15)	willow bush	2.5	1	100	30	1	3	0.2	1	0	20	24.2	20
34(27)	willow bush	3.5	2	75	8	0.3	4	1	0.2	4	12	1	25
35(40)	willow bush	3.5	3	75	7	1	4	5	0.5	3	6	2	30
36(33)	willow bush	3	1	100	5	2	4	0.005	1	3	0	21.3	50
37(34)	Rose Bush	2	1	100	2	0.5	1.5	0.2	1	10	5	0	53.3
38(11)	willow	2	1.5	75	30	1	2	0.7	0.03	6	0	22.5	30
39(10)	Maple	6	4	100	1	0.3	1.5	1.5	1	3	0	25	35
40(4)	Maple	8	5	100	1	0.4	3	2	1	3	0	29.6	35
41(38)	willow tree	7	5	100	12	0.4	3	2	1	2	7	8	75
42(26)	salix	4	2	100	8	0.76	3.28	0.98	0.036	10	0	18.3	36.7
43(43)	salix rose	3	1.5	75	10	0.6	4	0.6	0.001	2	1	32.4	100

Table A. Microhabitat Data for Nest Sites (numbers in brackets correspond to reproductive data).

Location	T. Species	T. height	%D/A	# Base Branch	Diam Base	Canopy Width	Lowest Branc	Shrub>2m	shrub<2m	understory l	Coverage
1r	willow bush	3.5	50	13	2	2.2	0.7	0	0	67.3	40
2r	willow bush	3.5	100	15	1.11	2.64	0.6	8	7	51.31	50
3r	willow bush	2	100	30	1.29	4.53	0.2	6	4	28.03	45
4r	willow bush	2.5	100	30	1	3.6	0.5	10	0	58.9	40
5r	aspen	3	100	1	0.1	1	0.8	32	0	56.4	30
6r	willow bush	3	100	15	1	4.2	0.3	4	20	46.61	50
7r	willow bush	3	90	30	1	3.1	0.2	5	15	78	60
8r	willow bush	2	100	30	0.5	3	0.6	0	1	75	100
9r	willow bush	2	60	6	1	2	0.7	5	4	78	50
10r	willow bush	0.5	100	30	0.5	2.5	0.2	0	0	45	45
11r	willow bush	3	90	10	1	3	0.3	3	6	35.4	50
12r	willow bush	3	70	7	1.5	4	0.1	0	0	28.42	60
13r	willow bush	3.5	50	4	1.2	1	0.6	0	10	54	50
14r	willow bush	5.6	50	3	0.5	4	1.5	5	0	63.2	30
15r	willow bush	5	100	1	0.4	4	2	4	0	73.1	40
16r	ash	6.5	100	1	0.15	3	0.3	4	0	90	30
17r	elm	7	100	1	0.35	4	1	9	0	35.7	40
18r	ash	4.5	65	1	0.35	2	1	4	1	90	50
19r	ash	10	65	3	0.35	2	3	4	0	18.8	50
20r	ash	7.5	100	1	0.3	2	0.5	5	0	50	70
21r	maple	2	100	0.5	0.3	3	1.5	3	1	25	30
22r	ash	4.5	100	1	0.2	4	2	4	0	50	50
23r	willow bush	4.5	45	3	0.5	4	1	3	1	30	30
24r	elm	4.5	100	1	1.5	1.5	1	5	0	0.5	40
25r	aspen	6.5	100	2	0.15	2	2	2	0	25	35
26r	Maple	3.5	100	1	0.2	4	2	3	0	70	40
27r	willow bush	2	100	30	2	4	0.2	5	10	56.5	50
28r	willow bush	2.5	30	30	0.9	3	0.5	7	30	80	30
29r	willow bush	1.5	60	1	0.5	4.5	0.5	27	3	54	60
30r	willow bush	3.5	100	30	1	2	0.3	6	30	70	60
31r	willow bush	3	100	30	1	2	0.3	4	2	53.7	70
32r	willow bush	3.5	90	25	1	2	0.3	3	2	57.8	60
33r	willow bush	2.1	50	20	1	1	0.3	7	6	56.6	40
34r	willow bush	2	50	30	1	1	0.3	7	6	54.3	30
35r	willow bush	4	100	30	1	4	0.6	4	0	25	35
36r	poplar	5.5	100	30	1	3.5	0.3	6	5	45	35
37r	willow bush	2	75	30	1.5	4	0.2	3	6	53.25	60
38r	maple	2	75	25	1.5	3	0.3	6	2	59.4	70
39r	willow bush	3	75	6	2	3	0.3	4	2	50	70
40r	maple	3	4	4	0.3	4	0.3	4	2	2	70
41r	willow bush	2.5	100	3	0.9	4	0.5	9	2	62.4	40
42r	poplar	3	100	1	0.1	1	0.4	5	3	72.1	60
43r	poplar	2.5	75	3	0.2	1	0.4	4	3	67.5	60

Table B. Microhabitat Data for Random Sites.

N. Location	%Trees	%Road	%Lowland	%Hayland	%Ditch	%Cropland(W)	%Pasture(A)	%Miscellan	%sSummer Fa	Canola	% sunflower
(1) 1	3.98	2.37	5.75	9.1025	5.68	65.81	7.31	0	0	0	0
(9) 2	3.74	3.62	0.871	0	7.65	60	0	1.02	23.1	0	0
(35) 3	5.92	3.36	1.06	0	7.03	0	58.9	0.21	23.5	0	0
(13) 4	4.28	2.67	33	0	5.27	26.7	0	0	0	0	28.6
(16) 5	2.2	1.95	8.71	0	6.6	61	19.5	0	0	0	0
(21) 6	5.09	3.05	4.44	10.17	10.26	0	45.7	0	0	0	21.2
(19) 7	0.175	0.17	3.87	0	10.56	63.63	21.67	0	0	0	0
(41) 8	3.71	1.65	0	45.6	3.98	0	45.1	0	0	0	0
(12) 9	13.82	1.72	8.35	0	2.5	73.6	0	0	0	0	0
(5) 10	1.06	3.33	0	0	9.56	0	86	0	0	0	0
(18) 11	11.58	2.48	10.8	0	0	39.1	0	0	36	0	0
(8) 12	10.3	6.08	12.7	0	0	50.3	20.6	0	0	0	0
(14) 13	4.82	0	7.3	0	6.7	22	0	0	59.1	0	0
(2) 14	7.46	2.94	9.64	0	6.9	73	0	0	0	0	0
(6) 15	0.071	0	0.181	0	1.21	97.16	0	0	0	1.17	0
(28) 16	1.23	4.94	3.1	0	0	0	90.7	0	0	0	0
(42) 17	0.72	1.47	10.4	0	7.47	41.3	39.1	0	0	0	0
(24) 18	8.19	8.48	0	0	10	44.9	28.46	0	0	0	0
(22) 19	1.81	1.98	3.3	0	0	29	0	0	15.35	48.5	0
(30) 20	4.34	3.47	0	0	2.28	26.3	0	0	0	63.6	0
(36) 21	2.83	1.36	7.27	0	3.48	0	85.1	0	0	0	0
(25) 22	2.9	10.1	0	0	0	86.6	0	0	0	0	0
(23) 23	3.29	2.63	7.3	0	7.12	32.5	47.9	0	0	0	0
(20) 24	1.49	1.13	23.04	0	0	74.3	0	0	0	0	0
(32) 25	1.39	0	0	0	0	14.7	83.91	0	0	0	0
(39) 26	4.63	2.7	0	43.3	7.67	41.7	0	0	0	0	0
(29) 27	1.8	2.28	0	0	5.16	91.2	0	0	0	0	0
(37) 28	2.46	4.74	3.35	0	11.1	78.4	0	0	0	0	0
(17) 29	1.47	3.39	0	0	9.15	46.15	8.46	0	0	31.38	0
(3) 30	4.71	18.4	0	50.34	0	26.6	0	0	0	0	0
(31) 31	1.08	1.19	0	0	2.08	9.41	0	0	0	86.2	0
(7) 32	5.87	0	0	7.26	0	21.9	0	0	0	64.9	0
(15) 33	5.08	5.36	4.5	0	3.04	81.5	0	0.514	0	0	0
(27) 34	2.14	0	11.76	0	0	0	86.1	0	0	0	0
(40) 35	1.35	0.733	6.36	9.28	6.19	40.3	36	0	0	0	0
(33) 36	2.18	3.79	3.1	0	8.75	38.6	43.63	0	0	0	0
(34) 37	4.97	9	0	0	12.3	40.48	32.6	0	0	0	0
(11) 38	5.4	0.77	3.3	0	4.19	0	86.3	0	0	0	0
(10) 39	2.9	3.05	0	0	9.86	0	84.6	0	0	0	0
(4) 40	3.79	3.43	6.9	0	4.41	0	81.4	0	0	0	0
(38) 41	4.53	0	0	5.8	6.8	0	82.87	0	0	0	0
(26) 42	2.79	2.3	6.71	7.28	2.08	42.8	36.04	0	0	0	0
(43) 43	5.4	5.36	4.5	0	0	30	55	0	0	0	0

Table C. Data for Macrohabtat Nest Sites (numbers in brackets correspond to reproductive data).

Random Sites	%Trees	%Road	%Lowland	%Hayland	%Ditch	%Cropland(W)	%Pasture(A)	%Miscellan	%sSummer Fa	Canola	SUnflower
1	9.58	3.52	4.2	18.4	4.14	21.7	0	0	38.5	0	0
2	3.48	4.86	16.07	0	3.71	37.7	0	0	34.1	0	0
3	26.7	3.65	0	0	5.82	0	63.8	0	0	0	0
4	15.6	1.74	6.58	0	8.11	68.9	0	0	0	0	0
5	1.49	3	8.2	0	9	46.44	0	0	0	32.8	0
6	0	3.41	6.29	0	10.3	0	79.6	0	0	0	0
7	3.93	2.32	0	45.9	3.21	17.93	0	0	26.7	0	0
8	1.71	2.17	0	0	7.47	88.8	0	0	0	0	0
9	0.001	3.24	0	0	3.24	93.5	0	0	0	0	0
10	0.783	3.35	0	47	3.2	0	43.6	2.03	0	0	0
11	0.886	4.36	15.1	0	8.3	24.3	0	0	47.1	0	0
12	4.17	2.07	10.2	0	9.08	74.5	0	0	0	0	0
13	5.51	2.72	0	0	6.37	85.4	0	0	0	0	0
14	2.57	4.8	13.4	0	11.9	0	0	0	67.4	0	0
15	3.12	3.38	3.74	0	3.68	24.9	61.2	0	0	0	0
16	7.43	0	0	0	5.51	87.1	0	0	0	0	0
17	0.136	8.99	0	0	0	59.2	31.6	0	0	0	0
18	3.99	0	0	9.79	0	86.3	0	0	0	0	0
19	4.76	0	6.08	0	0	22.4	66.8	0	0	0	0
20	30.6	5.8	0	0	0	63.5	0	0	0	0	0
21	9.19	2.15	0	0	0	88.7	0	0	0	0	0
22	12.85	2.15	2.49	0	0	82.5	0	0	0	0	0
23	1.89	2.49	0	0	8.32	72.8	0	0	0	0	14.6
24	5.09	1.84	7.62	6.23	3.43	75.8	0	0.315	0	0	0
25	9.67	0	0	0	15.1	67.9	0	1.4	5.88	0	0
26	12.8	4.34	0	0	8.69	40.8	0	0	34	0	0
27	0.62	0	0	33.9	8.29	0	57	0	0	0	0
28	6.76	2.09	6.08	20.3	5.89	0	48.3	0	10.64	0	0
29	8.12	2.57	3.76	5.89	0	79.66	0	0	0	0	0
30	10.3	1.84	15.1	7.01	8.32	56.7	0	0	0	0	0

Table D. Data for Macrohabitat Random Sites.

Nest#	Lth Tree(m)	Lth Fence (m)	Lth HW (m)	Total Lth	Dist fence	Dist. road	dist. HW
1	1860.94	1244.5	509.45	3614.89	5	10	5
2	1197.26	1234.5	506.99	2938.75	5	10	5
3	1365.87	886.45	926.93	3179.25	64.9	70.3	66
4	856.43	517.17	0	1373.6	55	48.65	0
5	690.4	1978.32	180.98	2849.7	59.5	64.9	75.7
6	936.4	1007.16	1435.46	3379.02	5	10	5
7	114.37	924.13	0	1038.5	135.1	108.1	0
8	643.53	502.19	338.6	1484.32	1	216	300
9	3289.45	169.16	0	3458.61	1	5	0
10	282.56	827.68	0	1110.24	172.3	174	0
11	1932.8	1981.04	982.84	4896.68	5	10	5
12	3110.9	899.73	0	4010.63	0	81	0
13	1418.3	1007.3	987.84	3413.44	87	108	0
14	1485.9	474.14	0	1960.04	64.86	70.3	0
15	243.27	981.04	981.04	2205.35	86.5	64.9	65
16	424.73	3133.23	0	3557.96	43.2	48.6	0
17	349.5	979.29	0	1328.79	0	75.6	0
18	1891.57	612.28	1224.57	3728.42	37.2	54.1	36
19	805.17	629.54	0	1434.71	27	37.8	0
20	1232.6	0	987.06	2219.66	0	81.1	108.1
21	809.82	0	597.81	1407.63	0	200	189.2
22	801.19	0	0	801.19	0	54.1	0
23	1247.79	504.9	0	1752.69	43.2	48.6	0
24	646.31	0	0	646.31	0	184	0
25	1328.43	0	0	1328.43	0	185	0
26	1337.02	994.56	994.56	3326.14	10	10.8	10
27	718.52	855.43	855.43	2429.38	118.9	135.1	162.1
28	717.19	961.85	961.85	2640.89	50	54.1	49
29	711.37	964.24	964.24	2639.85	109	81.8	108.1
30	1788.38	500	1107.02	3395.4	162	189.2	160
31	451.4	0	543.15	994.55	0	81	81.1
32	1729.75	0	472.95	2202.7	150	70	210
33	1444.91	0	0	1444.91	0	108.1	0
34	693.36	0	0	693.36	0	219	0
35	994.39	0	0	994.39	20	30	0
36	796.59	1191.28	0	1987.87	205	200	0
37	891.42	975.99	975.99	2843.4	145	150	145
38	2016.59	328.66	0	2345.25	15	20	0
39	1120.92	1283	105.71	2509.63	115	119	115
40	892.42	974.55	0	1866.97	5	100	0
41	1445.8	756.9	0	2202.7	15	10	0
42	789.6	875.4	924.3	2589.3	20	25	35
43	892.5	975.55	952.34	2820.39	25	35	30

Table E. Data for Nest Site Perching Substrata.

Lth Tree(m)	Lth Fence (m)	Lth HW (m)	Total Length	Dist Fence	Dist. Road	Dist. HW
(1) 2136.57	1005.4	0	3141.97	70	108	0
(2) 911.51	465.5	0	1377.01	102.7	81.1	0
(3) 566.54	506.73	949.34	2022.61	162	178.4	162
(4) 2645.2	1061.3	1061.3	4767.8	86.4	81.1	86.4
(5) 642.4	994.6	479.45	2116.45	90	100.1	120
(6) 0	1033	1033	2066	135	124.3	140
(7) 1021.68	0	0	1021.68	0	91.1	0
(8) 643.39	977.46	977.46	2598.31	124	162.1	162.1
(9) 51.59	0	498.96	550.55	0	70.3	70.2
(10) 473.28	0	0	473.28	0	108.1	0
(11) 286.09	0	489.12	775.21	0	10	10
(12) 688.06	0	0	688.06	0	105	0
(13) 786.61	509.25	0	1295.86	162.2	172.9	0
(14) 435.51	0	0	435.51	0	90	0
(15) 504.45	675.3	0	1179.75	195	145.9	0
(16) 2308.03	0	604.34	2912.37	0	54.1	97.3
(17) 97.54	0	0	97.54	0	81.8	0
(18) 902.93	0	474.34	1377.27	0	54	70
(19) 1094.17	0	1030.55	2124.72	0	80	75
(20) 3010.86	0	882.52	3893.38	0	55	45
(21) 1935.73	0	0	1935.73	0	120	0
(22) 3135.46	525.15	0	3660.61	73	80	0
(23) 0	0	492.24	492.24	0	20	195
(24) 1853.99	0	363.85	2217.84	0	20	200
(25) 1787.32	0	948.68	2736	0	20	116
(26) 1902.49	0	1030.55	2933.04	0	162	150
(27) 392.6	0	549.5	942.1	0	155	123.5
(28) 567.8	0	0	567.8	0	108	0
(29) 436.2	0	0	436.2	0	102	0
(30) 1904.05	0	0	1904.05	0	55	0

Table F. Data for Random Site Perching Substrata.

Nest	# eggs	#young	#fledglings	Incubation	Nestling
1	8	4	4	16	17
2	6	0	0	10	0
3	7	5	5	16	17
4	5	2	0	16	3
5	6	0	0	5	0
6	6	6	2	16	17
7	4	3	0	7	10
8	6	6	3	16	16
9	7	6	6	15	15
10	6	6	6	14	12
11	5	0	0	14	0
12	6	6	0	15	13
13	5	0	0	14	0
14	6	5	3	15	12
15	2	0	0	2	0
16	5	2	0	13	10
17	6	0	0	10	0
18	6	2	0	16	10
19	7	7	3	15	14
20	5	4	2	3	13
21	5	5	4	16	18
22	6	5	0	2	2
23	7	5	0	1	4
24	6	2	0	7	8
25	6	0	0	15	0
-26	—	6	3	0	17
27	6	6	2	15	17
28	6	4	4	6	17
29	6	6	3	8	18
30	6	0	0	10	0
31	7	0	0	2	0
32	7	7	5	4	11
33	6	6	2	4	17
34	2	0	0	3	0
35	—	6	2	0	17
36	—	6	2	0	17
37	6	6	0	4	13
38	3	0	0	6	0
39	5	5	5	12	17
40	—	6	6	0	4
41	6	4	4	16	17
42	—	5	3	0	2
43	5	5	0	5	0

Table G. Data for Reproductive Success.