Habitat use by Loggerhead Shrikes in Ontario and Quebec

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Abstract: Once common throughout northeastern North America, the migrant race of Loggerhead Shrike (*Lanius ludovicianus migrans*) has undergone a drastic decline since the middle of the last century. The subspecies was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1991. To gain a better understanding of the factors affecting the decline of this species in eastern Canada, habitat selection by Loggerhead Shrikes breeding in Ontario (Smith's Falls, Napanee, and Carden limestone plains) and southern Quebec was studied in 1991 and 1992. Nest trees used by breeding shrikes were compared with similar arbitrarily identified trees in suitable unoccupied habitat to determine if there was a nest-tree preference. Territories where successful nesting attempts were made (i.e., young fledged from at least one of the eggs laid) were located over a 2-year period; data were not collected for unsuccessful nests or nests used for double-brooding. Thirty-seven nests (50%) were located in hawthorn shrubs (*Crataegus* spp.) and 29 nests (40%) in red-cedar trees (*Juniperus virginianus*). White cedar (*Thuja occidentalis*), buckthorn (*Rhamnus catharticus*), and ash (*Fraxinus* spp.) were used infrequently (10%). Sixty-two nests (86%) were located in isolated trees or in a copse. Ten nests (14%) were located in hedgerows. Fifty-one (64%) nest sites were located in an actively grazed pasture. The other nest sites were located in idle pasture, hayfields, or old fields. Nest trees and arbitrarily chosen trees in suitable unoccupied habitat did not differ significantly in average height, width, or canopy concealment. Few differences were detected in the average height of the vegetation or the composition of ground cover within a 10-m radius of nest trees and arbitrarily chosen trees. The average numbers of shrubs per hectare did not differ between breeding sites and suitable unoccupied habitat. Nest trees in the Smith's Falls core breeding area were located significantly closer to roads than arbitrarily chosen trees in suitable unoccupied habitat. Habitat suitability was also assessed according to the density of perches (trees and shrubs), which directly affects the amount of actual utilizable habitat in a territory. Significant differences were found in the amounts of actual habitat and potential habitat. The amount of habitat around active nest sites, historic nest sites, and suitable unoccupied sites was significantly greater around active nest sites. Since few statistically significant differences were found between habitat occupied by shrikes and that which was not used, it is not possible to build a predictive model of suitable breeding habitat for shrikes in this study area.

Résumé : Autrefois répandue dans tout le nord-est de l'Amérique du Nord, la race migratrice de la Pie-grièche migratrice (*Lanius ludovicianus migrans*) a subi un déclin sérieux depuis le milieu du siècle. Cette sous-espèce a été mise sur la liste des taxons menacés par le Comité sur le statut des espèces en péril au Canada (COSEPAC) en 1991. Afin de mieux comprendre les facteurs qui peuvent expliquer le déclin de cette espèce dans l'est du Canada, nous avons étudié le choix de l'habitat chez les pies-grièches en période de reproduction en Ontario (Smith's Falls, Napanee et les plaines calcaires de Carden) et dans le sud du Québec en 1991 et 1992. Les arbres occupés par des nids ont été comparés à d'autres arbres semblables identifiés de façon arbitraire dans des habitats adéquats inoccupés pour déterminer si les oiseaux nichent dans des espèces particulières d'arbres. Les territoires où la nidification a été réussie (i.e., où au moins un oeuf a donné un oisillon prêt à l'envol) ont été repérés sur une période de 2 ans; ces résultats ne tiennent pas compte des nids où la nidification a été ratée ou qui ont servi à deux couvées. Trente-sept nids (50 %) ont été repérés dans des buissons d'aubépine (*Crataegus* spp.) et 29 nids (40 %) dans des genévriers de Virginie (*Juniperus virginianus*). Le Thuya occidental (*Thuja occidentalis*), le Nerprun cathartique (*Rhamnus catharticus*) et des frênes (*Fraxinus* spp.) ont aussi été utilisés, quoique rarement (10 %). Soixante-deux nids (86 %) étaient localisés dans des arbres isolés ou dans un bosquet. Dix nids (14 %) ont été repérés dans des haies. Cinquante et un nids (64 %) se trouvaient dans des champs broutés. Les autre nids ont été repérés dans des pâturage inutilisés, près de champs de foin ou dans des champs à l'abandon. La hauteur moyenne, la largeur et le feuillage protecteur ne différaient pas significativement entre les arbres occupés par des nids et des arbres choisis arbitrairement dans des habitats convenables mais inhabités. La hauteur moyenne de la végétation et la composition de la couverture du sol différaient peu entre les arbres situés dans un rayon de 10 m d'arbres occupés par des nids et les arbres désignés au hasard. Le nombre moyen de

Received July 19, 2000. Accepted February 14, 2001. Published on the NRC Research Press Web site on May 8, 2001.

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 DOI: 10.1139/cjz-79-5-916

buissons par hectare ne différait pas entre les sites de reproduction et les sites d'un habitat approprié mais inoccupé. Les arbres occupés par des nids dans la partie centrale de l'aire de reproduction à Smith's Falls étaient situés plus près des routes que des arbres choisis aléatoirement dans un habitat approprié inoccupé. La convenance de l'habitat a également été évaluée d'après la densité des perchoirs (les arbres et les buissons) qui affecte directement la proportion d'habitat utilisable dans un territoire. Des différences significatives ont été trouvées entre l'importance potentielle et l'importance réelle de l'habitat. L'importance d'habitats adéquats était significativement plus grande au voisinage des nids occupés que dans des sites de nidification antérieurs et dans des sites adéquats inoccupés. Comme il existe peu de différences significatives entre les habitats occupés par les pies-grièche et les sites inoccupés, il est impossible d'élaborer un modèle prédictif de l'habitat de reproduction convenable pour les pies-grièches dans la région de l'étude.

[Traduit par la Rédaction]

Introduction

The Loggerhead Shrike (*Lanius ludovicianus*) is widespread throughout North America. The species uses a variety of similar habitats and usually nests in open pasture or grassland regions with hedgerows or scattered trees and shrubs. The Loggerhead Shrike has undergone a marked decline over much of its range since the mid-1950s (Peterson 1965; Erdman 1970; Geissler and Noon 1981; Morrison 1981; Cadman 1985[3]). Habitat loss has been suggested as the principal cause of decline in many areas (Graber et al. 1973; Bull 1974; Campbell 1975[4]; Kridelbaugh 1982; Smith and Kruse 1992; Prescott and Collister 1993). However, Cadman (1985)[3] reported that the population of shrikes breeding in eastern Canada had declined more rapidly than anticipated, based on the availability of apparently suitable habitat.

While the characteristics of Loggerhead Shrike breeding habitat have been described by many authors (Porter et al. 1975; Seigel 1980; Kridelbaugh 1983; Luukkonen 1987; Gawlick 1988; Brooks and Temple 1990; Prescott and Collister 1993; Woods and Cade 1996), populations of the migrant race of Loggerhead Shrike (*L. l. migrans*) in Ontario and Quebec have remained largely unstudied, and the nesting habits of these shrikes are relatively unknown. Information on habitat selection can be used to determine if habitat loss is a factor in the continued decline of the Loggerhead Shrike in eastern Canada and will help to guide future management efforts by elucidating limiting factors such as perch density (Yosef 1993).

Research into habitat selection by Loggerhead Shrikes in Quebec and Ontario was conducted during the breeding seasons of 1991 and 1992; the characteristics of habitat used by shrikes versus habitat that was apparently suitable but unoccupied and historic breeding territories were studied to determine the basis for nest-site selection. Few differences were found in the habitat characteristics measured. However, the amount of habitat was significantly greater around active nest sites.

Methods

Study site

Habitat use by Loggerhead Shrikes was studied in all active breeding territories located in 1991 and 1992 in each of the three core breeding areas in Ontario. The easternmost area is associated with the Smith's Falls limestone plain to the south and west of Ottawa, Ontario. The second area is situated on the Napanee plain to the west of Kingston, Ontario. The third and most westerly area is associated with the Carden plain to the north of Lindsay, Ontario. All three regions are located in south-central Ontario between the Precambrian Shield and Lake Ontario.

The Carden plain is an area of approximately 583 km^2 of limestone plain with very little overburden (Chapman and Putnam 1984). The plain is named for Carden Township, which occupies the central part of the area, and its physical conditions are similar to those of the Napanee and Smith's Falls plains farther east. According to the 1981 agricultural census for Carden Township, rough pasture accounted for more than 70% of the land (Chapman and Putnam 1984). The habitat in this area is characterized by unimproved pasture interspersed with scattered hawthorn (*Crataegus* spp.) trees.

The Napanee plain is a flat to undulating limestone plain from which the last glaciation stripped most of the overburden (Chapman and Putnam 1984). Centring on the town of Napanee, it covers approximately 1813 km^2. In 1981, cultivated and rough pasture occupied 26% of the farmland, and cattle grazing was extensive. Pasture with scattered red-cedar trees (*Juniperus virginianus*) characterizes the habitat in this area.

The Smith's Falls plain is the largest and most continuous tract of shallow soil over limestone in southern Ontario and covers nearly 3626 km^2 in the United Counties of Leeds and Grenville, the Regional Municipality of Ottawa-Carleton, and Lanark County. In 1981, approximately 80% of the land was occupied by farms of which approximately 50% was unimproved pastureland in accordance with the extensive dairy farming occurring in this area (Chapman and Putnam 1984). Like the Carden plain, the habitat in this area is characterized by unimproved pasture interspersed with scattered hawthorn trees. In some areas the habitat consists of mature hawthorns, which occur in hedgerows at the edge of pastures or cropland.

Habitat use

Habitat use was examined at both the microhabitat and the macrohabitat level (Table 1). The microhabitat measurements are those taken at the nest tree or shrub and within the habitat in a 10-m radius from the canopy edge. Nest shrub or tree species was recorded. Shrub or tree height was measured with an optical range finder and width was measured with a tape measure at the widest point of the canopy. Both height and width were measured to the nearest 0.1 m. Percent cover provided by the nest tree or shrub was measured using a spherical densiometer (Lemmon 1956) held flat in the palm. Four measurements were taken at equal distances around the canopy and averaged. The location of the nest tree or shrub was recorded as isolated, in a hedgerow, or in a copse.

[3] M.D. Cadman. 1985. Status report on the Loggerhead Shrike (*Lanius ludovicianus*) in Canada. Unpublished report for the Committee on the Status of Endangered Wildlife in Canada.

[4] C. Campbell. 1975. Distribution and breeding success of the Loggerhead Shrike in southern Ontario. Unpublished report No. 6055, Canadian Wildlife Service.

Table 1. Habitat-use measurements at nest sites and suitable Loggerhead Shrike habitat.

	Nest sites			
Microhabitat measurement	Nest tree?	Nearest neighbouring tree?	Unoccupied sites?	Historic sites?
Nest-tree species	Yes		Yes	
Spatial location of nest tree	Yes		Yes	
Land-use classification	Yes		Yes	
Nest-tree height	Yes	Yes	Yes	
Nest-tree width	Yes	Yes	Yes	
Concealment of canopy	Yes	Yes	Yes	
Vegetation height	Yes		Yes	
Ground-cover composition	Yes		Yes	
Shrub density				
<1 m in height	Yes		Yes	
>1 m in height	Yes		Yes	
Distance to source of disturbance	Yes		Yes	
Traffic volume	Yes		Yes	
Amount of potential habitat within 400 m	Yes		Yes	
Amount of actual habitat within 400 m	Yes		Yes	
Macrohabitat measurements				
Habitat within 1-km radius	Yes		Yes	Yes
Habitat within 5-km radius	Yes		Yes	Yes

Table 2. Numbers of hawthorn, red-cedar, and other species used as nest sites by Loggerhead Shrikes in the three core breeding areas in Ontario in 1991 and 1992.

Core breeding area	Hawthorn nest shrubs	Red-cedar nest trees	Other nest-tree species
Carden plain	11	0	2
Napanee plain	10	29	1
Smith's Falls plain	16	0	4

Four 10-m transects were used to quantify the herbaceous ground cover around the nest tree. The first was positioned in a randomly chosen direction, starting at the edge of the shrub or tree canopy. The other transects were positioned at 90°, 180°, or 270° relative to the first transect. Measurements of vegetation composition were taken at two circular plots, each with a radius of 56.4 cm, centred on two points, one located at 1 m and one located at 10 m from the edge of the canopy. A total of 8 plots were measured around each nest tree. The composition of each of the following classes of ground cover was measured using the Braun–Blanquet scale: bare ground, wildflowers, grasses or forbs, trees or shrubs, and mosses or lichens. Vegetation height was measured to the nearest centimetre at 1, 5, and 10 m from the edge of the canopy to obtain a more accurate assessment and the three measurements were averaged.

Shrub density was calculated using 0.1-acre (0.04 ha) circles (James and Shugart 1970), shrubs being assigned to one of two categories: less than 1 m high and more than 1 m high. Shrub density was sampled by recording the number of trees intercepted in a 1.8 m wide strip (approximately the width of a person's outstretched arms) while walking along a compass line for 11.1 m (the radius of the 0.1-acre circle). The total number of shrubs counted on two transects in each of five 0.1-acre circles multiplied by 10 is an estimate of the number of shrubs per acre.

The habitat was classified as actively grazed pasture, idle pasture, old field, hayfield, or cultivated land with a row crop. Active pastures were grazed intensively and were characterized by short grass. Idle pastures received little or no grazing pressure. Hayfields were maintained by mowing. Old fields, identified from the presence of perennial weeds and invading woody plants, were neither grazed or mowed.

To determine if nest trees were selected randomly, all microhabitat measurements were repeated at the tree nearest to the nest tree that appeared to be suitable for nesting. Additionally, 20 apparently suitable but unoccupied sites were chosen for comparison in each of the three major types of shrike habitat in Ontario: fields with scattered isolated red-cedar trees, fields with scattered isolated hawthorn shrubs, and fields with hawthorn shrubs in hedgerows. In each suitable unoccupied site, one tree that appeared to be suitable for nesting was arbitrarily selected (i.e., selection was not based on randomized selection techniques nor was the tree selected on the basis of other factors). The arbitrarily chosen tree and habitat in this site were characterized in the same manner as nest trees in breeding territories.

Additional habitat measurements were taken from aerial photographs at a scale of 1 : 10 000 or 1 : 15 840, depending upon the availability of aerial-photograph coverage. The amount of habitat within a 1-km radius of nest trees in active territories and around arbitrarily chosen trees in suitable but unoccupied patches of habitat was measured. Additionally, the amount of habitat within a 5-km radius of nest trees in active territories, arbitrarily chosen trees in suitable but unoccupied habitat, and around the central point of historically occupied habitat was measured. When determining the amount of habitat within a 5-km radius of sites, only habitat patches 10 ha in area or larger were mapped, as this is the minimum patch size believed to be enough to support a pair of breeding shrikes (Dyer and Cadman 1991[5]). All measurements were centred on the nest tree or on the arbitrarily selected tree in suitable unoccupied sites. When there were multiple nest trees at a single breeding site because of breeding at the same site in both years, the

[5] M. Dyer and M.D. Cadman. 1991. Loggerhead Shrike habitat survey, Napanee District, June 1991. Unpublished report, Ontario Ministry of Natural Resources, Napanee.

Table 3. Spatial relationship of nest trees chosen by Loggerhead Shrikes in the three core breeding areas in Ontario in 1991 and 1992.

	Hawthorn shrubs			Other species	
Core breeding area	Isolated	Hedgerow	Isolated red-cedar trees	Isolated	Hedgerow
Carden plain	13	0	0	2	0
Napanee plain	9	0	28	1	0
Smith's Falls plain	8	9	0	2	1
Total	29	9	28	5	1

Table 4. Land-use classification of active Loggerhead Shrike breeding territories in each of the three core breeding areas in Ontario in 1991 and 1992.

Core breeding area	Active pasture	Idle pasture	Hayfield	Old field	Row crop
Carden plain	9	3	0	0	0
Napanee plain	30	9	1	2	0
Smith's Falls plain	12	6	6	2	0

arithmetic centre between the nest trees was used as the centre point for measurements.

The distance from the nest tree or arbitrarily chosen tree to roads, houses, and other sources of disturbance, including gravel pits, quarries, and railroad tracks, was measured on aerial photographs. The number of cars passing on the road nearest the nest tree in breeding territories every hour was noted during field observations and averaged for all measurements taken, regardless of the time of day and day of the week when the observations were made.

A circle of 400 m radius (50 ha) is believed to encompass most or all of a shrike's breeding territory (Collister 1994) and has been used for management purposes in Ontario. The amount of potential habitat versus actual habitat around each nest site was calculated from aerial photographs. Shrikes are perch-and-wait hunters, so the amount of actual habitat was determined by perch availability as follows. Perches were defined as being all trees and shrubs visible on the aerial photograph. Based upon the distance of shrike hunting attempts observed in the field, a 20-m zone on either side of hedgerows, isolated trees, and forest patches was delineated as utilizable habitat. Also included as suitable habitat was a 10-m zone into the edge of forested areas bordering suitable habitat and all forest patches narrower than 30 m. A dot grid was used to measure the amount of potential habitat (i.e., all habitat within a patch of habitat) and actual shrike habitat (i.e., the amount of utilizable habitat only).

All habitat measurements at nest trees were undertaken after the young had fledged and left the territory. Habitat measurements were completed over period of 1 month. Micro- and macro-habitat measurements were compared using Student's *t* test for normally distributed data and the Mann–Whitney rank sum test for data that were not normally distributed, using the SigmaStat software package (SigmaStat 1992).

Results

Thirty-seven nests were found in a hawthorn shrub and 29 nests were constructed in red-cedar trees in 1991 and 1992. Other nests were constructed in white cedar trees (5), a buckthorn shrub (1), and an ash tree (1). On the Carden and Smith's Falls plains, the majority of nests were constructed in hawthorn shrubs; on the Napanee plain, nests were most often built in red-cedar trees (Table 2). Nest trees were most commonly isolated trees (88%); a few nest trees (8%) were located in hedgerows (Table 3). Most breeding territories were located in actively grazed fields with scattered trees and shrubs (Table 4). Some shrikes established territories in idle pastures (18) or old fields (4); no territories were located in or adjacent to row crops.

Hawthorn nest shrubs in hedgerows provided significantly less canopy concealment (Mann–Whitney *U* test, $p < 0.05$) than arbitrarily chosen hawthorn shrubs in hedgerows (Table 5). Red-cedar nest trees were significantly taller than the nest tree's nearest neighbouring tree (Mann–Whitney *U* test, $p < 0.05$). Comparisons of the other characteristics of nest trees, i.e., height, width, and canopy concealment, with those of nearest neighbouring trees and arbitrarily chosen trees at suitable unoccupied sites revealed no statistically significant differences (Mann–Whitney *U* test, all $p > 0.05$).

The average height of the vegetation around nest trees ranged from 30.33 ± 5.6 to 36.7 ± 3.2 (mean ± SD) cm at active nest sites and from 24.6 ± 3.4 to 34.9 ± 3.3 cm at suitable unoccupied sites (Table 6). No statistically significant differences in vegetation height were found between nest sites and suitable unoccupied sites (Mann–Whitney *U* test, all $p > 0.05$).

Very few statistically significant differences were found in ground-cover composition at active and suitable unoccupied sites (Table 7). Grass cover was significantly greater at nest sites characterized by isolated hawthorn shrubs than at similar suitable unoccupied sites (Mann–Whitney *U* test, $p < 0.05$). The amount of bare ground at nest sites in hedgerow habitat was significantly greater than at similar suitable unoccupied sites (Mann–Whitney *U* test, $p < 0.05$). The tree or shrub cover around nest trees in red-cedar habitat was significantly greater than at similar suitable unoccupied sites (Mann–Whitney *U* test, $p < 0.05$). The moss or lichen cover at nest sites characterized by both isolated hawthorn shrubs and red-cedar trees was significantly greater than at nest sites in hedgerow habitat (Mann–Whitney *U* test, $p < 0.05$).

The mean number of shrubs per acre that were less than 1 m in height ranged from 86.1 ± 16.4 to 147.3 ± 22.9 at nest sites and from 117.4 ± 18.7 to 120.5 ± 20.9 at suitable unoccupied sites (Table 8). The mean number of shrubs per acre that were taller than 1 m ranged from 79.6 ± 12.3 to 121.0 ± 35.7 at nest sites and from 92.0 ± 11.4 to 93.7 ± 18.0 at suitable unoccupied sites. No statistically significant differences in shrub density in either category were detected at active and suitable unoccupied sites (Mann–Whitney *U* tests, all $p > 0.05$).

The average distance from a nest tree to the nearest road, house, or source of disturbance (i.e., railroad tracks, gravel pits, or quarries) ranged from 96.0 ± 31.1 to 137.8 ± 29.4, 245.9 ± 35.0 to 344.9 ± 46.6, and 310.0 ± 92.9 to 608.6 ±

Table 5. Height (m), width (m), and concealment (percent cover of canopy) of Loggerhead Shrike nest trees, the nest tree's nearest neighbouring tree, and arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Nest trees	Height (m)	Width (m)	Concealment (% cover)
Isolated hawthorn shrubs			
Nest shrub	3.6 ± 0.2	3.7 ± 0.2	77.7 ± 2.8
Nearest neighbour	3.2 ± 0.2	3.2 ± 0.2	78.7 ± 2.6
Arbitrarily chosen	3.9 ± 0.2	4.0 ± 0.3	80.8 ± 2.7
Hedgerow hawthorn shrubs			
Nest shrub	3.7 ± 0.3	4.2 ± 0.8	84.9 ± 1.2*a*
Nearest neighbour			
Arbitrarily chosen	3.9 ± 0.2	3.7 ± 0.2	93.0 ± 0.5*b*
Isolated red-cedar trees			
Nest tree	5.0 ± 0.3*c*	2.9 ± 0.2	88.8 ± 1.8
Nearest neighbour	4.1 ± 0.3*d*	2.6 ± 0.1	88.6 ± 1.2
Arbitrarily chosen	4.9 ± 0.3	3.0 ± 0.2	87.2 ± 1.5
Other nest trees			
White cedar	5.7 ± 0.3	2.9 ± 0.5	80.5 ± 7.1
Buckthorn	3.3 ± 0.0	3.8 ± 0.0	96.0 ± 0.0
Ash	11.0 ± 0.0	5.5 ± 0.0	91.8 ± 0.0

Note: Values are given as the mean ± SD. Values followed by *ab* and *cd* are statistically significantly different (Mann–Whitney *U* test, $p < 0.05$).

Table 6. Height of vegetation (cm) within a 10-m radius of Loggerhead Shrike nest trees and arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Habitat	Height at 1 m (cm)	Height at 10 m (cm)	Avg. height (cm)
Isolated hawthorn shrubs			
Nest sites	29.4 ± 3.0	31.23 ± 3.4	31.5 ± 3.3
Suitable unoccupied sites	23.5 ± 3.5	20.2 ± 2.8	24.6 ± 3.4
Hedgerow hawthorn shrubs			
Nest sites	44.7 ± 11.3	30.1 ± 6.1	30.3 ± 5.6
Suitable unoccupied sites	34.4 ± 4.3	34.7 ± 3.4	34.9 ± 3.3
Isolated red-cedar trees			
Nest sites	38.9 ± 4.1	38.3 ± 6.0	36.7 ± 3.2
Suitable unoccupied sites	30.2 ± 5.2	28.1 ± 3.4	30.4 ± 5.0
Other nest trees			
Nest sites	40.4 ± 7.6	36.4 ± 5.9	32.2 ± 5.3

Note: Values are given as the mean ± SD. There were no statistically significant differences (Mann–Whitney *U* test, $p < 0.05$).

88.7 m, respectively (Table 9). At suitable unoccupied sites the average distance from the arbitrarily chosen tree to roads, houses, or other sources of disturbance ranged from 108.5 ± 19.2 to 232.1 ± 34.3, 316.0 ± 35.0 to 366.8 ± 46.2, and 280.0 ± 180.0 m to >1 km, respectively. Isolated hawthorn nest shrubs were significantly closer to roads than the arbitrarily chosen hawthorn shrubs in suitable unoccupied sites (Mann–Whitney *U* test, $p < 0.05$). No other significant differences were detected (Mann–Whitney *U* tests, all $p > 0.05$).

Data were regrouped by core area and distance from nest trees to roads, etc., and the traffic volumes were compared among core areas and between nest trees and arbitrarily chosen trees in the same area (Table 10). The traffic volume per hour at breeding sites in the Napanee plain area was significantly greater than that in the Smith's Falls area (Mann–Whitney *U* test, $p < 0.05$). Nest trees in the Smith's Falls plain area were located significantly closer to roads than arbitrarily chosen trees in the same area (Mann–Whitney *U* test, $p < 0.05$). No other significant differences were detected (Mann–Whitney *U* tests, all $p > 0.05$).

The amount of potential habitat within a 400-m radius around isolated red-cedar nest trees, isolated hawthorn nest shrubs, and hawthorn nest shrubs in hedgerow habitat was significantly greater than the amount of actual habitat, based on perch density (Mann–Whitney *U* test, all $p > 0.05$) (Table 11). The amount of potential habitat around isolated hawthorn nest shrubs was significantly greater than that around red-cedar nest trees (Mann–Whitney *U* test, $p < 0.05$). The amount of potential habitat was significantly greater at nest sites characterized by isolated hawthorn shrubs and red-cedar trees than at nest sites characterized by hawthorn shrubs in hedgerows (Mann–Whitney *U* test, $p < 0.05$). The amount of potential habitat within 400 m of isolated red-cedar nest trees was significantly greater than that around arbitrarily

Table 7. Composition of ground cover measured according to the Braun–Blanquet scale (1 = 0–12%; 2 = 12–25%; 3 = 25–50%; 4 = 50–75%; 5 = >75%) within a 10-m radius of Loggerhead Shrike nest trees and arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Habitat	Bare ground	Grasses/forbs	Wildflowers	Trees/shrubs	Mosses/lichens
Isolated hawthorn shrubs					
Nest sites	1.8 ± 0.2	3.3 ± 0.2*a*	2.4 ± 0.1	0.4 ± 0.1	0.7 ± 0.1*g*
Suitable unoccupied sites	1.5 ± 0.1	2.0 ± 0.3*b*	2.4 ± 0.2	0.3 ± 0.1	0.6 ± 0.1
Hedgerow hawthorn shrubs					
Nest sites	2.4 ± 0.4*c*	2.5 ± 0.6	2.09 ± 0.2	0.1 ± 0.1	0.0 ± 0.0*h*
Suitable unoccupied sites	1.3 ± 0.9*d*	3.6 ± 0.2	2.5 ± 0.2	0.0 ± 0.0	0.0 ± 0.0
Isolated red-cedar trees					
Nest sites	1.7 ± 0.2	3.2 ± 0.2	2.6 ± 0.2	0.4 ± 0.1*e*	0.8 ± 0.1*i*
Suitable unoccupied sites	1.5 ± 0.2	3.3 ± 0.2	2.6 ± 0.2	0.1 ± 0.0*f*	0.7 ± 0.2
Other nest trees					
Nest sites	1.7 ± 0.3	2.5 ± 0.4	2.5 ± 0.2	0.2 ± 0.2	1.0 ± 0.2

Note: Values are given as the mean ± SD. Values followed by *ab*, *cd*, *ef*, *gh*, and *hi* are statistically significant different (Mann–Whitney *U* test, $p < 0.05$).

Table 8. Shrub and tree density per acre within a 200-m radius of Loggerhead Shrike nest trees and arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Habitat	<1 m in height	>1 m in height
Isolated hawthorn shrubs		
Nest sites	147.3 ± 22.9	121.0 ± 35.7
Suitable unoccupied sites	117.4 ± 18.7	92.0 ± 11.4
Hedgerow hawthorn shrubs		
Nest sites	0.0 ± 0.0	0.0 ± 0.0
Suitable unoccupied sites	0.0 ± 0.0	0.0 ± 0.0
Isolated red-cedar trees		
Nest sites	86.1 ± 16.4	79.6 ± 12.3
Suitable unoccupied sites	120.5 ± 20.9	93.7 ± 18.0
Other nest trees		
Nest sites	105.0 ± 35.2	97.5 ± 24.6

Note: Values are given as the mean ± SD. There were no statistically significant differences (Mann–Whitney *U* test, $p < 0.05$).

chosen trees in suitable unoccupied sites (Mann–Whitney *U* test, $p < 0.05$).

The data were regrouped according to core area and the amount of habitat within a 400-m and a 1-km radius around nest trees and arbitrarily chosen trees was compared. The amount of habitat within a 5-km radius of nest trees, arbitrarily chosen trees, and a tree in historic nest sites was also compared. The amount of potential habitat within a 400-m radius of the nest tree or arbitrarily chosen tree was significantly greater than the amount of actual habitat in all three core areas (Mann–Whitney *U* tests, all $p > 0.05$) (Table 12). The amount of habitat within 400 m was significantly greater at nest sites than around arbitrarily chosen trees in suitable unoccupied sites in the Napanee and Smith's Falls plains areas (Mann–Whitney *U* tests, all $p > 0.05$). Similarly, the amount of habitat within 1 km of the nest tree was significantly greater than around arbitrarily chosen trees in suitable unoccupied sites in the Smith's Falls and Carden plains areas (Mann–Whitney *U* test, $p < 0.05$) (Table 13). The amount of habitat within a 5-km radius was significantly greater at nest sites than at either suitable unoccupied sites or historic breeding sites (Mann–Whitney *U* test, $p < 0.05$). The amount of habitat within 5 km of nest trees in the Carden plain core area was significantly greater than around nest trees in the Smith's Falls and Napanee plain core areas and around nest trees in the province of Quebec (Mann–Whitney *U* test, $p < 0.05$) (Table 14).

Discussion

Loggerhead Shrikes nested most commonly in hawthorn and red-cedar in Ontario. Hawthorn was the commonest nest shrub in the Carden and Smith's Falls plains core areas; the Napanee plain core area was characterized by fields with scattered red-cedar trees. Several authors have commented on the shrike's preference for red-cedar and hawthorn and on the importance of dense, thorny trees such as these for nesting (Kridelbaugh 1983; Peck and James 1987; Brooks and Temple 1990; Gawlick and Bildstein 1990; Tyler 1992). Gawlick and Bildstein (1990) believed that the hawthorn's thorns and the red-cedar's sharp needles discourage predators. Luukkonen (1987) further suggested that nests in both red-cedar trees and hawthorn shrubs are better concealed from potential predators. Overall, our results indicate that with the exception of species preferences for nest trees, habitat selection occurred at random within a breeding site.

Although 6 of 7 Loggerhead Shrike nests located during a 5-year period in Quebec were found in hedgerows (Chabot 1993[6]), only 13% of nests in Ontario were located in hedgerows. Few areas in Ontario have hedgerow habitat, while in Quebec suitable habitat is most often recognized as being located in hedgerows. Eighty-three percent of the shrike nests in Ontario were located in isolated trees. Our results are comparable only to those of Brooks and Temple (1990), who found that only 32% of the shrikes in their study nested in either a hedgerow or a windbreak, while 61% of nests were located in isolated trees. The number of nests in isolated trees in Ontario is higher than that reported elsewhere. Kridelbaugh (1983) reported that 62% of the nests in his study were located along fencerows or hedgerows. Seigel

[6] A.A. Chabot. 1993. Loggerhead Shrike habitat availability and suitability in Quebec. Unpublished report for the Canadian Wildlife Service.

Table 9. Distances to roads, houses, and other sources of disturbance from Loggerhead Shrike nests in isolated hawthorn shrubs, hedgerow hawthorn shrubs, isolated red-cedar trees, and other species of nest trees and arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Habitat	Distance to road	Distance to house	Distance to other sources of disturbance
Isolated hawthorn shrubs			
Nest sites	135.6 ± 27.7*a*	344.9 ± 46.6	481.8 ± 161.1
Suitable unoccupied sites	232.1 ± 34.3*b*	366.8 ± 46.2	<1 km
Hedgerow hawthorn shrubs			
Nest sites	108.5 ± 19.2	245.8 ± 35.0	608.6 ± 88.7
Suitable unoccupied sites	108.5 ± 19.2	316.0 ± 35.0	280.0 ± 180.0
Isolated red-cedar trees			
Nest sites	137.8 ± 29.4	294.1 ± 32.7	<1 km
Suitable unoccupied sites	162.2 ± 24.0	348.2 ± 59.9	<1 km
Other nest trees			
Nest sites	96.0 ± 31.1	333.1 ± 102.4	310.0 ± 92.9

Note: Values are given as the mean ± SD. Values followed by *ab* are statistically significant different (Mann–Whitney *U* test, $p < 0.05$).

Table 10. Distances to roads, houses, and other sources of disturbance and traffic rate per hour at Loggerhead Shrike nests in the three core breeding areas and arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Core breeding area	Distance to road (m)	Traffic volume (vehicles/h)	Distance to house (m)	Distance to other sources of disturbance (m)
Carden plain				
Nest sites	145.4 ± 27.4	7.8 ± 1.8	413.9 ± 101.1	220.8 ± 66.7
Suitable unoccupied sites	201.8 ± 23.9		369.6 ± 60.5	<1 km
Napanee plain				
Nest sites	137.8 ± 29.4	12.8 ± 4.3*a*	294.1 ± 32.7	<1 km
Suitable unoccupied sites	162.2 ± 24.0		348.2 ± 59.9	<1 km
Smith's Falls plain				
Nest sites	126.8 ± 47.9*c*	3.7 ± 0.9*b*	300.9 ± 40.5	570.0 ± 216.4
Suitable unoccupied sites	232.1 ± 34.3*d*		366.8 ± 46.2	<1 km

Note: Values are given as the mean ± SD. Values followed by *ab* and *cd* are statistically significantly different (Mann–Whitney *U* test, $p < 0.05$).

(1980) reported that 65% of all shrike nests were located in hedgerows associated with pastures. Gawlick and Bildstein (1990) also reported that shrikes commonly nested in fencerows or hedgerows.

Active and idle pasture accounted for 86% of the territories in this study, indicating the importance of grazers in maintaining shrike habitat in eastern Canada. Indeed, in most studies the majority of breeding territories have been located in pasture, with the remainder located in hayfields, residential lawns, fallow fields, or urban areas (Kridelbaugh 1983; Gawlick and Bildstein 1990). Shrikes have long been described as birds of farming country (Miller 1931; Bent 1950). More recently, researchers have reported the apparent importance of pastures, grassland, and hayfields as habitat for Loggerhead Shrikes (Porter et al. 1975; Seigel 1980; Kridelbaugh 1982; Luukkonen 1987; Gawlick 1988; Smith and Kruse 1992; Telfer 1992; Bjorge and Prescott 1996).

Although most researchers agree that pastures are optimal habitat for shrikes, the optimal height of ground cover and the importance of grazers within shrike territories vary among studies. Prescott and Collister (1993) were of the opinion that the population of Loggerhead Shrikes in Alberta was limited by the availability of high-quality habitats for breeding. They felt that management practices which increased the prevalence of tall grass and reduced grazing pressure could render areas more suitable for occupation by shrikes. Conversely, Gawlick and Bildstein (1990) felt that shorter vegetation would increase a shrike's hunting efficiency and that this "would be important during the breeding season when adults are providing approximately 165 food items per day to their nests." Yosef and Grubb (1992) reported that shrikes were typically found in habitats marked by short vegetation. While they considered taller vegetation to render a site "suboptimal," their results did not support the hypothesis that the rate of prey capture is severely limited in habitats with tall grasses or shrubs. Shrikes were able to adjust to modifications of their habitat by altering their hunting behaviour. However, the increased time spent in aerial pursuits by shrikes occupying tall-grass habitats did affect "personal-maintenance activities" (preening and resting), and

Table 11. Areas (ha) of potential and actual Loggerhead Shrike habitat within a 400-m radius of isolated hawthorn nest shrubs, isolated red-cedar nest trees, hedgerow hawthorn nest shrubs, and other species of nest tree and similar, arbitrarily chosen trees in suitable unoccupied habitat in Ontario in 1991 and 1992.

Habitat	Potential habitat area (ha)	Actual habitat area (ha)
Isolated hawthorn shrubs		
Nest sites	45.1 ± 4.8*a*	20.1 ± 1.8*b*
Suitable unoccupied sites	36.3 ± 5.2*c*	18.7 ± 2.1*d*
Hedgerow hawthorn shrubs		
Nest sites	32.0 ± 1.8*e*	8.7 ± 1.5*e*
Suitable unoccupied sites	28.0 ± 2.3*g*	9.8 ± 2.2*h*
Isolated red-cedar trees		
Nest sites	33.6 ± 4.9*i*	15.4 ± 1.4*j*
Suitable unoccupied sites	22.5 ± 2.0*k*	16.4 ± 1.3*l*
Other nest trees		
Nest sites	38.1 ± 6.3*m*	18.3 ± 4.7*n*

Note: Values are given as the mean ± SD. Values followed by *ab*, *cd*, *ef*, *gh*, *ij*, *kl*, *mn*, *ae*, *ai*, *ei*, and *ik* are statistically significantly different (Mann–Whitney *U* test, $p < 0.05$).

Table 13. Areas (ha) of potential Loggerhead Shrike habitat within a 1-km radius of nest trees/shrubs and arbitrarily chosen trees in suitable unoccupied habitat in the three core breeding areas in Ontario in 1991 and 1992.

Core breeding area	Potential habitat (ha)
Carden plain	
Nest sites	203.1 ± 14.8*a*
Suitable unoccupied sites	175.4 ± 22.6*b*
Napanee Plain	
Nest sites	103.2 ± 7.4
Suitable unoccupied sites	119.3 ± 12.2
Smith's Falls plain	
Nest sites	149.3 ± 14.1*c*
Suitable unoccupied sites	57.8 ± 10.0*d*

Note: Values are given as the mean ± SD. Values followed by *ab* and *cd* are statistically significantly different (Mann–Whitney *U* test, $p < 0.05$).

the authors believed that their results "substantiated the conclusions of others that short grassland habitats permit energetically efficient hunting in shrikes."

In fact, optimal habitat in eastern Canada may comprise a variety of vegetation heights rather than homogeneous tall- or short-grass habitats. For Ontario this hypothesis is supported by the apparent importance of grazers in shrike habitats, which creates a heterogeneous mosaic of tall and short grasses: grass is tall around grazers' droppings and short where it has been grazed. Many insects use cattle droppings as habitat (Mohr 1943) and these insects are an important source of food for shrikes (Judd 1898; Chapman and Casto 1972; Graber et al. 1973; Craig 1974, 1978; Morrison 1980; Scott and Morrison 1990). Without the presence of these "ecological units," the amount of insect prey and a shrike's hunting success may decrease, subsequently reducing habitat suitability.

The availability of food resources may also be a factor in

Table 12. Areas (ha) of potential Loggerhead Shrike habitat within a 400-m radius of nest trees/shrubs and arbitrarily chosen trees in suitable unoccupied habitat in the three core breeding areas in Ontario in 1991 and 1992.

Core breeding area	Potential habitat (ha)	Actual habitat (ha)
Carden plain		
Nest sites	50.3 ± 1.7*a*	19.0 ± 2.5*b*
Suitable unoccupied sites	48.1 ± 6.9*c*	20.6 ± 2.7*d*
Napanee plain		
Nest sites	33.1 ± 4.1*e*	15.3 ± 1.2*f*
Suitable unoccupied sites	22.5 ± 2.0*g*	16.4 ± 1.3*h*
Smith's Falls plain		
Nest sites	36.6 ± 2.4*i*	26.4 ± 1.8*j*
Suitable unoccupied sites	20.1 ± 2.9*k*	16.2 ± 3.4*l*

Note: Values are given as the mean ± SD. Values followed by *ab*, *cd*, *ef*, *gh*, *ij*, *kl*, *eg*, and *ik* are statistically significantly different (Mann–Whitney *U* test, $p < 0.05$).

Table 14. Areas (ha) of potential Loggerhead Shrike habitat within a 5-km radius of nest trees/shrubs, arbitrarily chosen trees in suitable unoccupied habitat, and historic nest sites in the three core breeding areas in Ontario in 1991 and 1992.

Core breeding area	Potential habitat (ha)
Grey and Bruce counties	
Historic sites	177.9 ± 48.7
Carden plain	
Nest area	2187.5 ± 141.3*a*
Suitable unoccupied sites	1184.1 ± 291.3*b*
Historic sites	2020.2 ± 128.4*c*
Napanee plain	
Nest area	1440.9 ± 112.9
Suitable unoccupied sites	942.8 ± 126.2*e*
Historic area	701.0 ± 173.7*f*
Smith's Falls plain	
Nest area	1672.6 ± 158.3*g*
Suitable unoccupied sites	1019.4 ± 207.3*h*
Historic area	378.6 ± 76.8
Province of Quebec	
Nest area	1439.0 ± 127.0*j*
Historic area	629.0 ± 208.4*k*

Note: Values are given as the mean ± SD. Values followed by *ab*, *ac*, *de*, *df*, *gh*, *gi*, *jk*, *ad*, *ag*, and *aj* are statistically significantly different (Mann–Whitney *U* test, $p < 0.05$).

shrikes' selection of open, grassland habitats over row-crop fields and hayfields. While the extent of pesticide use and prey availability were not investigated in this study, one would expect reduced insect populations in row crops, owing to weed- and insect-control activities. Grazed areas may not be subject to applications of pesticides. This factor, coupled with short or heterogeneous vegetation height, may increase the suitability of grazed pastures as nest sites for shrikes.

In Ontario, several shrikes have been killed by collisions with cars and many more near misses have been observed.

However, little evidence was found that shrikes tended to nest close to roads. Shrikes nesting in the Smiths Falls core area nested closest to roads but, on average, the distance was still approximately 127 m. Nevertheless, in this and many other studies, shrikes have routinely been observed using roadside ditches and road surfaces for foraging, which may tend to increase their susceptibility to collisions (Robertson 1930; Miller 1931; Bent 1950; Zimmerman 1955; Smith 1973; Bull 1974; Campbell 1975[4]; Craig 1978). In Virginia, Luukkonen (1987) reported that 17.6% of the known mortality in his study involved juvenile birds which had been killed by vehicles. Gawlick and Bildstein (1990) reported two cases in which shrike mortality was due to collisions with vehicles.

Yosef (1993) found that the number of available hunting perches was a limiting resource for male Great Grey Shrikes (*Lanius excubitor*). He proposed that the addition of hunting perches would decrease the size of a male's territory by increasing the amount of suitable habitat within the territory. This premise was used to assess habitat suitability in occupied and unoccupied, but apparently suitable, habitats in Ontario. Based upon perch availability, habitat characterized by scattered hawthorn shrubs appeared to be more suitable than that characterized by isolated red-cedar trees. Hedgerow habitat appears less suitable than habitat with scattered trees and shrubs. In the Napanee and Smith's Falls areas, unoccupied sites were found to be surrounded by significantly less suitable habitat than sites chosen by shrikes. Overall, these results indicate that site selection may occur at a level not readily apparent upon visual inspection.

The suitability of breeding sites was further investigated by comparing the amounts of habitat around the nest sites on a larger scale. Habitat occupied by shrikes in the Smith's Falls and Carden areas had a significantly greater amount of habitat within a 1-km radius of the nest tree than did suitable unoccupied habitat. On the Napanee plain, the core area with the greatest proportion of the Ontario population, the amount of habitat within a 1-km radius of the nest tree did not differ from the amount of habitat around suitable unoccupied sites or historic nest sites. However, all breeding sites had a significantly greater amount of habitat within a 5-km radius then did either suitable unoccupied sites or historic nest sites.

It has been suggested that habitat loss is one of the most important possible causes of the decline in Loggerhead Shrike numbers. Based upon the results of our study, it would appear that habitat suitability is affected by the amount of habitat around a nest site and the amount of utilizable habitat within a site. Although the rate of decline in Loggerhead Shrike populations in northeastern North American appears to exceed the rate of habitat loss, suggesting that other factors may be affecting this species, the first step in conserving the Loggerhead Shrike in eastern Canada should be the protection of habitat on a large scale. Unfortunately, all breeding pairs found since 1991 were on private land, so this task will not be easily accomplished. Communication with landowners of shrike habitat and incentive programs that encourage landowners to maintain grazers and the "unimproved" nature of their land may help in efforts to conserve this subspecies. Efforts to improve habitat in unoccupied and historic sites through the addition of perches or clearing of overgrown areas may also help slow the subspecies' decline.

Acknowledgements

We are grateful to Marie-Christine Paquin, Isabelle Bisson, Glenn Barrett, Andre Chabot, and Peter Judge for their invaluable assistance with fieldwork. We especially thank Don Cuddy, Karen Bellamy, Ron Pittaway, Tim Haxton, Chris Grooms, and the many other employees of the Ontario Ministry of Natural Resources and Pierre Laporte of the Canadian Wildlife Service in Quebec for their support of this work. We are grateful to the farmers who granted access to their land during this study. In addition, we sincerely thank Mike Runtz, Ron Curtis, Nora Mansfield, Annette Mess, Bob Bowles, Jim Ferguson, Bruce DiLabio, Ed Czerwinski, and the many other volunteers who spent countless hours contributing to the successful completion of this project. Funding for this research was provided by Challenge 1991, the Fondation de la Faune du Quebec, the Fondation pour la Sauvegarde des Espèces Menacées, McGill University, the Natural Sciences and Engineering Research Council of Canada, the Province of Quebec Society for the Protection of Birds, the Ontario Ministry of Natural Resources, and World Wildlife Fund Canada.

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