I. Productivity, nest sites, and habitat of Red-shouldered and Red-tailed Hawks in Iowa. II. Status, habitat utilization, and management of Red-shouldered Hawks in Iowa

James Cary Bednarz
Iowa State University

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I. Productivity, nest sites, and habitat of Red-shouldered and Red-tailed Hawks in Iowa

II. Status, habitat utilization, and management of Red-shouldered Hawks in Iowa

by

James Cary Bednarz

A Thesis Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of

MASTER OF SCIENCE

Department: Animal Ecology
Major: Wildlife Biology

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa
1979
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This study compares the productivity, nest sites, and nest habitats of Red-shouldered and Red-tailed hawks in northeastern and central Iowa. Fledging rates of Red-shoulders and Red-tails (3.3 and 1.9 per successful nest, respectively) were significantly different. Red-shoulder and Red-tail nest sites differed significantly in nest tree height, tree-nest height difference, nest tree dbh, canopy cover at nest height, mean support branch diameter, mean nest diameter, mean distance between support branches, slope of ground supporting nest site structure, woodlot size, distance to nearest water, distance to nearest road, and distance to nearest building. The Red-tail nest was characterized by accessibility, being placed high in a tree, on small support branches, in areas of little canopy cover, typically on a hillside, and having large distances between support branches. Red-shoulder nests provide secure support and protection by being placed lower in trees, on large support branches, in areas of greater canopy cover, on level topography, and having smaller distances between support branches. Red-shoulders built nests in woodlots with more canopy trees and a greater tree density ($\bar{x} = 643$/ha) than
Red-tails ($\bar{x} = 473/\text{ha}$). The area of floodplain forest, marsh, upland nonforested hunting area, cropland, open water, number of hunting areas, mean size of hunting areas, and total edge surrounding the nest differed significantly between species. Red-shoulders required large amounts of floodplain forest, edge, and numerous small hunting areas. Red-tails typically were found in areas with nearly equal proportions of woodland, pasture, and cropland. Logging in floodplain forests may open these areas to encroachment by Red-tails and competition between the two species.
Part II

This study examines the status and habitat utilization and presents initial management recommendations for Red-shouldered Hawks breeding in Iowa. Computer analysis of land use data identified 1030 km$^2$ of potential Red-shoulder nesting habitat occurring in Iowa. In 1978, 376 km$^2$ (36.5%) of the potential habitat was searched; 7 pairs were found. The estimated statewide population is 19 pairs. Red-shoulders were seen in floodplain forest (64%), forested hillside (20%), and marsh or wetland habitats (16%). The primary prey items (Microtus pennsylvanicus, amphibians, and crayfish) were generally restricted to marsh habitats. Microtus pennsylvanicus was the primary prey in a dry year, 1977, while frogs and crayfish were the primary prey in a wet year, 1978. Principal component analysis indicated that total forest cover was important to nesting Red-shoulders, with limited floodplain forest being compensated for by adjacent upland forest. Management of nesting Red-shoulders should emphasize maintaining large mature forest tracts, primarily on floodplains with approximately 15% of the area in small interspersed marshes and clearings. Where nesting ranges can be identified, they should be protected from adverse habitat alterations and human disturbances during the breeding season.
INTRODUCTION

General Introduction

Formerly, Red-shouldered Hawks were considered common summer residents in eastern Iowa (Anderson 1907, Bailey 1918, DuMont 1933). In recent years, Red-shouldered Hawk numbers have declined drastically in the Midwest (Trautman 1940, Brown 1964, Brown 1971, Kent and Kent 1975, Koenig 1975). In the north central United States, Illinois, Iowa, Michigan, Missouri and Wisconsin all have included this species on their rare and endangered species lists (Roosa 1977, Merz 1978).

Proposed causes for the Red-shouldered Hawk population decline include nest desertion due to human disturbance (Portnoy 1974), pesticide contamination (Henny 1972, Wiley 1975), interspecific competition with the Red-tailed Hawk (Brown 1964, Bock and Lepthien 1976), and habitat alteration (Todd 1940, Cohen 1970, Henny et al. 1973, Oberholser 1974, Portnoy 1974, Campbell 1975, Bock and Lepthien 1976). However, data are not available to relate any of these factors to the Red-shouldered Hawk population decline in the Midwest.

The major objective of this research is to provide information that will assist natural resource managers in preserving the Red-shouldered Hawk as a component of
Midwestern ecosystems. The emphasis of this study was to examine the status of the Iowa Red-shouldered Hawk and the factors causing the population decline. Special effort was made to determine Red-shoulder habitat needs and to relate these to current land use trends. The probability of habitat competition with Red-tailed Hawks was realized early in the study, and the project was expanded to include that species. The thesis concludes with initial management recommendations that will enable resource managers to begin to fulfill the responsibility of preserving the Red-shouldered Hawk in its ecosystem for the benefit of all mankind.

Explanation of Thesis Format

This thesis is divided into two major parts, each in the format of a separate, complete paper designed for immediate submission to appropriate scholarly journals. The first part is a comparative analysis of some aspects of the nesting biology of Red-shouldered and Red-tailed hawks in Iowa. Productivity, nest sites, and habitat of these two species are examined for differences, and the potential for interspecific competition is discussed. Part two examines status, habitat utilization, and management of the Red-shouldered Hawk in Iowa and is an extension of the results in part one. The results of both papers are integrated to develop initial management recommendations for the Iowa Red-shouldered Hawk.
The Red-shouldered Hawk was suggested as a research problem by Dean M. Roosa and James J. Dinsmore. Paul F. Anderson supplied technical support in developing the land use map of potential Red-shouldered Hawk nesting habitat. I am responsible for the research design, implementation of the field work, and analysis of the results. However, James J. Dinsmore, my major advisor, continuously offered constructive advice and was active in all phases of this study.
PART I. PRODUCTIVITY, NEST SITES, AND HABITAT OF RED-SHOULDERED AND RED-TAILED HAWKS IN IOWA

\(^1\)This paper to be submitted to The Auk.
INTRODUCTION

Numerous studies have addressed the breeding biology of the Red-tailed Hawk (*Buteo jamaicensis*) (e.g., Hardy 1939, Fitch et al. 1946, Orians and Kuhlman 1956, Luttich et al. 1971, Seidensticker and Reynolds 1971, Gates 1972, McInvaille and Keith 1974, Johnson 1975), and the Red-shouldered Hawk (*Buteo lineatus*) (Stewart 1949, Henny et al. 1973, Portnoy 1974, Wiley 1975). Although Campbell (1975) and Howell et al. (1978) have provided quantified descriptions of the nesting habitats of Red-shoulders and Red-tails respectively, no study has attempted to quantitatively describe and differentiate the nest sites or habitat of these sympatric species.

This paper compares quantitative data collected from Red-shouldered and Red-tailed hawk nesting areas in Iowa. The primary objectives of this study were to determine productivity and examine its relationship to habitat variables; describe nest sites and examine differences between species; and examine habitat partitioning by nesting Red-shouldered and Red-tailed hawks in Iowa.
STUDY AREA AND METHODS

Most nests studied were in northeastern Iowa, but data also were collected from four Red-tail nest sites in central Iowa (Fig. 1). Intensive agriculture (corn, soybeans, cattle feedlots) is the dominant land use in both areas. Most hawk nests were along rivers and streams where cropland interdigitated with woodland and pasture. The land along these drainage systems has steep topography or intermittently flooded bottomlands and is unsuitable for row crops. All Red-shoulder nests found were in floodplain forest communities dominated by silver maple (Acer saccharinum), American elm (Ulmus americana), and cottonwood (Populus deltoides). Red-tailed Hawk nests were found both in floodplains and upland oak-hickory communities.

Field work was done during spring and summer of 1977 and 1978. Nest searching techniques generally followed Craighead and Craighead (1956), but because of high water in 1978, floodplains were searched from canoe. Searches for Red-shouldered Hawk nests were concentrated in densely forested bottomlands. Most Red-tail nests were found while driving between potential Red-shoulder habitats or while searching floodplains. Nests were visited a minimum of three times with one visit on the estimated date of fledging.

Nest tree height and nest height were determined with a rangefinder. Slope of ground supporting nest tree was
Fig. 1. Iowa counties (shaded) where nesting data on
Red-shouldered and Red-tailed hawks were collected
determined with the oblique distance pendulum on the range-finder. Diameter of branches supporting nests and nest diameter were recorded only for 22 nests climbed in 1978 and two 1977 Red-shouldered Hawk nests.

The quadrat and point-centered quarter methods were used to measure vegetation at 38 nest sites (Mueller-Dombois and Ellenberg 1974). Species and diameter at breast height (dbh) were recorded, and tree density was calculated for all trees greater than 5 cm dbh. These measures are referred to as quadrat dbh, quadrat density, point dbh, and point density. The quadrat consisted of a 730 m$^2$ circle (radius=15.24 m) centered on the nest tree. Four 64 m point-quarter transects following the cardinal directions were run from each nest tree. A total of 29 points were sampled at each nest site; one at the nest tree and seven points (spaced 9.14 m) on each transect. If the transect entered a non-forested clearing, point-quarter transects were continued only to the last point where trees could be measured.

Other variables examined in the nest site analysis are as follows: tree-nest difference—nest tree height minus nest height in m; slope aspect—direction exposure of slope (N, NE, E, SE, S, SW, W, NW); nest location—main crotch, main branch crotch, braced against trunk, leaning branch, or overhanging branch (crotch—a vertically oriented three or more branch junction on the main trunk or principal
branch capable of supporting a buteo nest); nest-trunk difference--actual distance between nest and main trunk estimated in m; branch class--number of branches supporting nest with diameter <5 cm (A), >5 cm but <10 cm (B), or >10 cm (C) (estimated from ground); canopy cover--canopy cover at nest height in percent (estimated: 0, 5, 10, 20, 30, 40, or 50%); mean nest diameter--longest + shortest diameter/2 in m; mean support branch diameter--mean diameter of branches supporting nests in cm; woodlot--size of nesting woodlot in ha (determined from cover map with planimeter).

Nest access distance is the mean arc distance between nest support branches, calculated as follows:

\[
\text{Nest access distance} = \frac{\text{nest circumference} - \text{sum of diameters of support branches}}{\text{no. of support branches}}
\]

Tree density at nest height was estimated as follows: Regression analysis was used to determine the relationship between nest tree dbh and nest tree height (dbh = 19.78 + 1.39 nest height). Because in most tree species diameter growth of the lower trunk starts later and continues longer than does height (Kramer and Kozlowski 1960), the lower confidence interval \((P = 0.05)\) was used (dbh = 2.58 + 1.39 nest height). The number of trees having a dbh greater than or equal to that of a tree estimated to reach nest height (with the above regression equation) was recorded within each 730 m² nest quadrat (reported as number/ha).
Life form of the nest trees, height of the four trees adjacent to nest tree, and the number of dead branches supporting the nest also were measured, but deleted from the final analysis because they showed no relationship with either raptor species.

Data were collected at four inactive and eight active Red-shoulder nest sites. Nest site sample size is not consistent for all variables because several nest trees could not be climbed and one inactive nest blew down before a complete set of data was collected. Variables used in nest site discrimination analysis were: nest tree height, tree-nest difference, nest tree dbh, slope, nest location, nest-trunk difference, number of nest support branches, branch class A (percent), branch class B (percent), mean nest diameter, mean supporting branch diameter, nest access distance, tree density at nest height, quadrat density, quadrat dbh, and woodlot size.

Cover maps were drawn from 1969-1971 ASCS aerial photos at 38 nest sites. Maps were updated in the field for any land use changes that occurred after the photographs were taken. A compensating polar planimeter was used to determine the areas of cover types within a 314 ha circle (radius = 1 km) centered at each nest. Distance of woodland edge along potential nonforested hunting habitat (pastures, marshes, prairie, etc.) was measured with a map measuring
wheel. Cropland was not considered potential hunting habitat. The mean maximum diameter of 34 Red-shoulder and 16 Red-tail ranges were 1.4 km and 2.8 km, respectively (calculated from Craighead and Craighead 1956:258-263). Therefore, the 2 km plot diameter should include most of the range used at each nest.

Variables included in the habitat discriminant analysis were: upland forest area, marsh area, upland hunting area, number of hunting areas, mean size of hunting areas, human use area, cropland area, and edge. Floodplain forest area was negatively correlated with upland forest and cropland and was discarded from the analysis by the BMDP computer subroutine.

Univariate data were statistically tested with student's t tests, chi-square tests, and analysis of variance (Snedecor and Cochran 1967); multivariate analysis included multiple regression, discriminant function, and profile analysis (Morrison 1976). Plus or minus values presented after means are standard deviations. Computer analysis was accomplished with SAS (Statistical Analysis System, Barr et al. 1976) and BMDP (Biomedical Data Package-1977; Health Sciences Computing Facility, University of California-Los Angeles).
RESULTS AND DISCUSSION

Productivity

Seven of eight active Red-shouldered Hawk nests located in northeastern Iowa along the Mississippi River successfully hatched young. No mortality occurred during the nestling period and $3.3 \pm 0.76$ young fledged per successful nest.

Of the 27 Red-tailed Hawk nests monitored, 22 (81.5%) were successful. The mean number of young fledged at 21 successful nests was $1.9 \pm 0.62$. The other successful nest fledged one or two young. Fledging rates per successful nest were significantly different ($P < 0.0001$) between species.

Three Red-tail nests were deserted during indubation, and one nest contained a single addled egg. Two other Red-tail nests were predated late in the nestling period. After two young Red-tails fledged from a nest, the third and youngest sibling was killed when the tree fell. A raccoon (*Procyon lotor*) killed the adult and destroyed the eggs of the one unsuccessful Red-shouldered Hawk nest.

The results of this study are compared with previous studies that reported nest success and fledging rate in Tables 1 and 2. Because young hawks often are lost in the nestling period (Seidensticker and Reynolds 1971, Luttich et al. 1971, Gates 1972, Johnson 1975, Wiley 1975, Bohm 1978, Adamcik et al. 1979, this study), the 2.3 young per
Table 1. Production per nest attempt and nest success of Red-shouldered Hawks reported from various studies

<table>
<thead>
<tr>
<th>State</th>
<th>No. of nests</th>
<th>Percent</th>
<th>No. of nest young</th>
<th>No. of young per nest young</th>
<th>No. of successful nests</th>
<th>Successful per nest attempt</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>8</td>
<td>87.5</td>
<td>3.3</td>
<td>2.9</td>
<td></td>
<td>This study</td>
<td></td>
</tr>
<tr>
<td>Missouri</td>
<td>6</td>
<td>83.3</td>
<td>2.0</td>
<td>1.7</td>
<td></td>
<td>Dahlke 1978(^a)</td>
<td></td>
</tr>
<tr>
<td>Michigan</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Craighead and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Craighead 1956</td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.7</td>
<td>Campbell 1975</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>11</td>
<td>36.4</td>
<td>2.5</td>
<td>0.9</td>
<td></td>
<td>Portnoy 1974</td>
<td></td>
</tr>
<tr>
<td>Maryland</td>
<td>74</td>
<td>68</td>
<td>2.3(^b)</td>
<td>1.6</td>
<td></td>
<td>Henny et al. 1973</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>29</td>
<td>65.5</td>
<td>2.1</td>
<td>1.3</td>
<td></td>
<td>Wiley 1975</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Unpublished manuscript, Missouri Department of Conservation, Jefferson City.

\(^b\)Based on number of young banded late in nestling period.
Table 2. Production per nest attempted and nest success of Red-tailed Hawks reported from various studies

<table>
<thead>
<tr>
<th>State</th>
<th>No. of nests</th>
<th>Percent</th>
<th>No. of nest young per success</th>
<th>No. of young successful per nest attempt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>27</td>
<td>81.5</td>
<td>1.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Iowa</td>
<td>15</td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>87</td>
<td>73.5</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>31</td>
<td>64.5</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Minnesota</td>
<td>72</td>
<td>61</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Alberta</td>
<td>191</td>
<td></td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Montana</td>
<td>54</td>
<td>50</td>
<td>1.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Montana</td>
<td>121</td>
<td>60.3</td>
<td>2.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Based on 15 nests.
<sup>b</sup>Estimated.
<sup>c</sup>Based on 57 nests.

References:
- This study
- Roosa 1964
- Orians and Kuhlman 1956
- Gates 1972
- Bohm 1978
- Adamcik et al. 1979
- Seidensticker and Reynolds 1971
- Johnson 1975
Table 2. (Continued)

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<thead>
<tr>
<th>State</th>
<th>No. of nests</th>
<th>Percent</th>
<th>No. of young per nest success</th>
<th>No. of successful per nest attempt</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utah</td>
<td>19</td>
<td>58.9</td>
<td>1.7</td>
<td></td>
<td>Smith and Murphy 1973</td>
</tr>
<tr>
<td>Arizona</td>
<td>42</td>
<td>81.0</td>
<td>1.9</td>
<td>1.6</td>
<td>Mader 1978</td>
</tr>
<tr>
<td>California</td>
<td>53</td>
<td>73.6</td>
<td>2.2</td>
<td>1.6</td>
<td>Wiley 1975</td>
</tr>
<tr>
<td>California</td>
<td>18</td>
<td></td>
<td>0.9</td>
<td></td>
<td>Fitch et al. 1946</td>
</tr>
</tbody>
</table>

successful nest of Henny et al. (1973) is probably an overestimate of the actual production rate. Interference by the investigator may have caused the low fledging rate in Massachusetts (Portnoy 1974; Table 1).

Sample size is small but this is the only field study to report productivity greater than the 2.12 per nest attempt that Henny (1972) calculated was needed to maintain a stable population and larger than the mean number of young banded
per nest (2.7) in the Great Lakes region prior to 1946 (Henny 1972). All nests found in Iowa were in relatively remote wooded floodplains where human disturbance is almost nonexistent. The apparent low density of Red-shouldered Hawks in Iowa may also be a factor contributing to the high fledging rate (Henny et al. 1973).

Iowa Red-tailed Hawk productivity is similar to that reported in other areas (Table 2).

Brood size (dependent variable), counted at the time of banding, was compared to 20 habitat and nest site variables (independent variables) using multiple regression techniques. Brood size of Red-shouldered Hawks was negatively related to the area of bottom woodlands \( r = -0.78, P = 0.04 \) and positively correlated to the mean dbh determined with the point-quarter technique \( r = 0.73, P = 0.04 \). However, I am unable to interpret these relationships and believe they are spurious correlations due to the small sample size.

Regression analysis of 23 Red-tailed Hawk broods shows no significant relationships with habitat or nest size variables. Lack (1947) hypothesized that clutch size was related to the amount of food that could be fed to the young. Ingram (1959) suggested sibling cannibalism in raptors adjusts brood size to the amount of food available. Thus, it might be expected that the amount of prey habitat (primarily pasture) available to Red-tails is related to
their brood size as found by Howell et al. (1978). My analysis did not show such a relationship ($r = 0.4590$). Perhaps, food availability is more closely related to the quality than quantity of hunting areas. Pastures in my study varied in quality from heavily overgrazed to lightly grazed. Other variables, such as age, hunting skill, and experience of adults may distort any relationships of habitat and brood size.

Howell et al. (1978) found low productive Red-tailed Hawk sites had a greater density of small trees (dbh < 15.24 cm) than two highly productive sites. I found no such correlation ($r = -0.05$, $P = 0.81$).

Nest Sites and Nests

In this study, nesting Red-shouldered Hawks used 6 cottonwoods, 4 silver maples, 1 American elm, and 1 white oak (Quercus alba). Nesting Red-tailed Hawks used 11 red oaks (Q. rubra), 4 American elms, 2 shagbark hickories (Carya ovata), and 1 each of green ash (Fraxinus pennsylvanica), black walnut (Juglans nigra), black ash (F. nigra), basswood (Tilia americana), silver maple, boxelder (Acer negundo), and prairie crabapple (Malus ioensis).

Buteos are thought to select nest trees in relation to the availability of large tree species (Dixon 1928, Bent
(1937). Howell et al. (1978) reported that species of nest trees used by Red-tails were correlated with tree importance values. Perusal of 44 papers on nesting Red-shoulders revealed that 40 tree species have been used as nest trees. This suggests that the tree species is relatively unimportant in nest site selection.

Means of 12 nest site variables for Red-shouldered and Red-tailed hawks are compared in Table 3. Significant differences between species in nest tree height and dbh suggest that Red-shoulders consistently selected large trees, while Red-tails used large or small trees. Red-tailed Hawks built nests with greater access distance, closer to the tops of trees, in areas of less canopy cover, and often in a tree on a slope (Table 3). All these factors are related to the accessibility of the nest.

This study supports the hypothesis that Red-tails require sites with unobstructed access to the nest (Orians and Kuhlman 1956, Mader 1978). In Minnesota the typical Red-tail nest was located at 81% of the tree height (Bohm 1978), similar to the 77% found in this study. On many steep slopes, the canopy of trees downslope of the nest tree does not reach nest height. Therefore, access to that side of the nest is free of obstructions. Thus, building nests high in trees on slopes increases access to the nest. In addition, nest access distance of only three Red-tail
Table 3. Comparison of Red-shouldered and Red-tailed hawk nest site characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Red-shouldered Hawk</th>
<th>Red-tailed Hawk</th>
<th>Probability of a larger t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nest height (m)</td>
<td>11 19.1 ± 4.8</td>
<td>26 17.1 ± 4.2</td>
<td>0.2035</td>
</tr>
<tr>
<td>Nest tree height (m)</td>
<td>12 28.6 ± 4.6</td>
<td>26 22.1 ± 5.1</td>
<td>0.0006**</td>
</tr>
<tr>
<td>Tree-nest difference (m)</td>
<td>11 9.2 ± 1.9</td>
<td>26 5.0 ± 3.0</td>
<td>&lt;0.0001**</td>
</tr>
<tr>
<td>Nest tree dbh (cm)</td>
<td>12 63.0 ± 12.7</td>
<td>26 48.9 ± 12.9</td>
<td>0.0031*</td>
</tr>
<tr>
<td>No. of support branches</td>
<td>11 3.6 ± 0.5</td>
<td>27 3.7 ± 1.3</td>
<td>0.6891</td>
</tr>
<tr>
<td>Nest-trunk difference (m)</td>
<td>11 0.3 ± 0.8</td>
<td>26 0.7 ± 1.2</td>
<td>0.2381</td>
</tr>
<tr>
<td>Canopy cover (%)</td>
<td>12 27.5 ± 12.9</td>
<td>26 12.2 ± 11.8</td>
<td>0.0009**</td>
</tr>
<tr>
<td>Mean supporting branch diameter (cm)</td>
<td>7 17.2 ± 6.6</td>
<td>18 8.9 ± 3.0</td>
<td>0.0126*</td>
</tr>
<tr>
<td>Mean nest diameter (cm)</td>
<td>7 57.1 ± 8.4</td>
<td>17 68.2 ± 10.0</td>
<td>0.0169*</td>
</tr>
</tbody>
</table>

*Significant (P < 0.05).

**Very highly significant (P < 0.001).
nests overlapped the range of Red-shoulders. Two of these nests were unsuccessful; one of these had been deserted for several days prior to measurement and that nest had weathered. The nest access distance of the third nest was only 0.02 cm smaller than the largest Red-shoulder nest.

In contrast, Red-shouldered Hawks used sites with less access and more obstructions. Typically, Red-shoulder nests were deep in the tree canopy, having tree-nest differences much greater than those of Red-tails (Table 3). The tree-nest difference, calculated for 12 nests from Portnoy (1974),

Table 3. (Continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Red-shouldered Hawk</th>
<th>Red-tailed Hawk</th>
<th>Probability of a larger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nest access distance (cm)</td>
<td>7 33.8 ± 9.0</td>
<td>17 55.6 ± 14.7</td>
<td>0.0015*</td>
</tr>
<tr>
<td>Slope (degrees)</td>
<td>12 0.1 ± 0.3</td>
<td>26 17.2 ± 12.3</td>
<td>&lt;0.0001**</td>
</tr>
<tr>
<td>Tree density at nest height (#/ha)</td>
<td>11 161.9 ± 68.1</td>
<td>26 118.7 ± 71.1</td>
<td>0.0961</td>
</tr>
</tbody>
</table>
averaged 13.1 m compared to 9.2 m found in this study. Additionally, Red-shoulders tended to build nests with small access distances, in areas with greater canopy cover, and on level topography (Table 3). All of these factors decrease accessibility to the nest.

Red-tails built larger nests than Red-shoulders, but placed them on smaller support branches (Table 3). Fig. 2 shows percentages of the branches supporting nests in various diameter size classes. Species differences are highly significant ($\chi^2 = 38.3$, $P < 0.0001$). Apparently, the Red-shoulder is more agile (Johnson and Peeters 1963) and can construct its nest lower in the tree canopy where larger support branches are available.

Red-shoulders placed their nests either in a main trunk crotch (86%) or a main branch crotch (14%) while Red-tails built nests in all locations (see Methods) with no definite preference. Most often in this study Red-tail nests were braced by small branches against the main trunk (38%). The tendency for Red-shoulders to place nests on a main trunk crotch more often than Red-tails was significant ($\chi^2 = 8.6$, $P < 0.01$). Previous workers also noted that Red-shoulders primarily built nests in secure tree crotches (Flanagan 1899, Hart 1927, Bent 1937, Stewart 1949).

Red-tails tended to avoid placing nests on southwest facing slopes (Fig. 3), but the sample size was too small
Fig. 2. Percentage of nest support branches occurring in three diameter size classes determined from 11 Red-shouldered and 27 Red-tailed hawk nests
RED-SHOULDERED HAWK
NO. BRANCHES = 39

RED-TAILED HAWK
NO. BRANCHES = 99

SUPPORT BRANCH SIZE in cm (D=Diameter)
Fig. 3. Direction aspect of 22 Iowa Red-tailed Hawk nests located on hillsides
to statistically test for differences between the eight classes. Furthermore, the single nests located on west and south facing slopes were unsuccessful. The prevailing winds in the area blew from the northwest in spring and the southeast in summer. Perhaps, hawk nests on southwest facing slopes are exposed to higher temperatures and greater insolation causing heat stress in the young. Mosher and White (1976) thought that Golden Eagles (*Aquila chrysaeotos*) select cliff nests oriented to reduce direct insolation and thermal stress.

The two species differed significantly in four general habitat features (Table 4). Red-shouldered Hawks required a large woodlot and built their nest close to water, but seemed to avoid buildings and roads. I believe that woodlot size is the only important variable. Many workers have reported that Red-shoulders nest primarily in larger forest areas (Kennard 1894, Dixon 1928, Bent 1937, Stewart 1949, Henny et al. 1973, Campbell 1975). Conversely, Red-tails generally inhabit more open habitats and will nest in fence rows or single trees (Hagar 1957, Bock and Lepthien 1976).

Red-shoulders are often associated with open water (Hahn 1927, Dixon 1928, Wiley 1975). This species is probably not dependent on water but rather is adapted to the forested floodplain consisting of level woodlands
Table 4. Comparison of Red-shouldered and Red-tailed hawk nest locations in relation to woodlot size and distance to nearest water, buildings and roads

<table>
<thead>
<tr>
<th>Variable</th>
<th>Woodlot size (ha)</th>
<th>Distance to water (m)</th>
<th>Distance to road (m)</th>
<th>Distance to building (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>mean ± SD</td>
<td>n</td>
<td>mean ± SD</td>
<td>mean ± SD</td>
</tr>
<tr>
<td>Red-shouldered Hawk</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Red-tailed Hawk</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Probability of a larger n</td>
<td>mean ± SD</td>
<td>t value</td>
<td>*Significant (P &lt; 0.05)</td>
<td></td>
</tr>
<tr>
<td>98 ± 65</td>
<td>47 ± 44</td>
<td>0.0076*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>142 ± 120</td>
<td>522 ± 571</td>
<td>0.0030*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>820 ± 509</td>
<td>309 ± 233</td>
<td>0.0054*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1001 ± 510</td>
<td>495 ± 218</td>
<td>0.0058*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant (P < 0.05).

interspersed with small marshes and backwater channels created by flowing water.

Red-tails nested closer to buildings and roads than Red-shoulders (Table 4). This appears to be a consequence of the habitat in Iowa. Pasture land, which is associated with roads and farm buildings, provided most of the Red-tail hunting habitat, while Red-shoulders were found in wildlife refuges and parks with few roads and buildings. Campbell
(1975) found Red-shoulders nesting in woodlots near busy highways and ongoing land development projects.

The discriminant analysis (Morrison 1976) of 13 variables that appeared to exhibit differences or to represent important characteristics of the nest site (see Methods) correctly classified all 37 nest sites to the proper species (11 Red-shoulder and 26 Red-tail nests, Fig. 4). The two Red-shoulder outliers (Fig. 4) have the highest values for quadrat density and tree-nest difference. The Red-tail outlier (Fig. 4) was located in a group of four trees while all other nests were located in woodlots.

Mean nest diameter, mean supporting branch diameter, and nest access distance were recorded at only 23 of the 37 nest sites and could not be included in the analysis of the total sample. These three variables were included in a second discriminant analysis with a smaller sample. Branch class A and B were deleted from the second analysis because they duplicated the variable mean supporting branch diameter. Again, all nest sites were properly classified (Fig. 5). The single Red-shoulder outlier had the largest nest access distance and the greatest mean supporting branch diameter (Fig. 5).

For each analysis, the six variables with the best discrimination power ranked according to the discriminant coefficients are shown in Table 5. Most of these variables are directly related to nest accessibility.
Fig. 4. Discriminant analysis of 11 Red-shouldered and 26 Red-tailed hawk nest sites graphically represented by Mahalanobis distances from the respective means.
RED-SHOULDERED HAWK

---

RED-TAILED HAWK

DISTANCE FROM RED-SHOULDERED HAWK MEAN

DISTANCE FROM RED-TAILED HAWK MEAN
Fig. 5. Discriminant analysis of 7 Red-shouldered and 16 Red-tailed hawk nest sites graphically represented by Mahalanobis distances from the respective means.
Table 5. The six most important variables in the classification of Red-shouldered and Red-tailed hawk nest sites ranked according to discriminant coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage of variation&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Discriminant analysis of 37 nest sites</th>
<th>Discriminant analysis of 23 nest sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree density at nest height</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nest location</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree-nest difference</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadrat density</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nest tree height</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadrat density</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nest access distance</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of support branches</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadrat dbh</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree-nest difference</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Percentage of variation accounted for by each variable in the discrimination.

Natural selection of a species' nest site preference is related to many factors such as providing safety from predators and environment, adequate access to nest, proper support, and adequate area for adults and young. This study
shows that Red-tail nests are characterized by high accessibility. Red-tailed nests are large, built high in trees, and on small support branches (Table 3). This accessibility increases exposure to direct sunlight and temperature extremes which can be stressful to young raptors (Mosher and White 1976). Large nests constructed on small branches also are probably vulnerable to storm damage. Several authors report destruction of active Red-tail nests due to wind or storms (Fitch et al. 1946, Seidensticker and Reynolds 1971, Gates 1972, Johnson 1975, Mader 1978, Bohm 1978, Adamcik et al. 1979), whereas I can find only two accounts of Red-shouldered Hawk nests being destroyed by wind (Carter 1960, Wiley 1975).

Possibly, the large nest is necessary to provide room for the young. The nest area available per gram of young for the maximum observed brood size (Red-tail = 3 and Red-shoulder = 4), using the mean female weights reported by Brown and Amadon (1968) and the mean nest diameters of this study, reveals that Red-tail nests provided more room for young (1.0 cm²/gm) than Red-shoulder nests (0.9 cm²/gm). Red-shoulder nests with four large young were extremely crowded, with young sometimes being pushed off the nest (pers. observ.). However, Red-tail young seemed to have room to spare. Thus, the large nest of the Red-tail is vulnerable to storms and provides more than enough space
for young. Perhaps, one function of the large nest size is to increase nest access distance.

Seemingly, Red-tailed Hawks also increase nest accessibility by placing nests in isolated trees or edge situations (Orians and Kuhlman 1956, Bohm 1978). Mader (1978) reported that nests in saguaro cacti have access routes for flight, possibly reducing chances of injury. Considering all of the above, I hypothesize that, given suitable habitat, the overriding factor in Red-tailed Hawk nest site selection is accessibility to the nest.

Red-shouldered Hawks have wing and tail proportions that are suggestive of accipiters (Johnson and Peeters 1963), theoretically improving steering ability and maneuverability. Therefore, nest access probably is a less important selective force, and the Red-shoulder is able to use nests lower in the canopy and with larger support branches, thereby protecting it from insolation and adverse weather. Nest size is probably limited by the area required for the young.

In summary, the nest sites of these two species are almost completely separated by several variables; the Red-tailed Hawk selecting and constructing a nest that provides great accessibility, while the Red-shouldered Hawk selects nest sites that provide secure support and protection from adverse environmental conditions.
Floodplain tree species such as American elm, silver maple, and green ash had the highest frequencies at Red-shouldered nest sites, while xeric species such as red oak, eastern hop hornbeam (Ostrya virginiana), sugar maple (Acer saccharum), and basswood exhibited high frequencies at Red-tail sites (Table 6). No differences were found in tree dbh ($P > 0.1$) or density ($P > 0.1$) with distance from the nest tree for either species. Nesting Red-shouldered Hawks inhabited denser woodlots than Red-tailed Hawks (Table 7). This agrees with the hypothesis that Red-tails only used nest sites with high accessibility. Selective cutting in dense woodlots possibly could open habitats currently used only by Red-shoulders to competition with Red-tails.

Trees at nest sites were nearly identical in size for both species (Table 7). However, Red-shouldered Hawks tended to nest in woodlots with more large canopy trees and fewer subcanopy ones than Red-tailed Hawk nesting woodlots (Fig. 6). The difference was significant for quadrat data ($\chi^2 = 11.7, P = 0.0086$), but not for the point-quarter data ($\chi^2 = 7.5, P = 0.0573$), although the trend was the same. Perhaps Red-shoulders, which commonly fly below the canopy (Dixon 1928, Bent 1937, Stewart 1943, Johnson and Peeters 1963, pers. observ.), selected woodlands with a larger
Table 6. Tree species occurring with the greatest frequencies at Iowa Red-shouldered and Red-tailed Hawk nest sites

<table>
<thead>
<tr>
<th>Tree species</th>
<th>No. of nest sites where species was present with greatest frequency</th>
<th>No. of nest sites where species was present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red-shoulder</td>
<td>Red-tail</td>
</tr>
<tr>
<td>American elm</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Silver maple</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Green ash</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Shagbark hickory</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Prairie crabapple</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Eastern redcedar</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(<strong>Juniperus virginiana</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bur oak</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Black maple</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(<strong>Acer nigrum</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basswood</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Sugar maple</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Eastern hophornbeam</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Red oak</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total nest sites</td>
<td>12</td>
<td>26</td>
</tr>
</tbody>
</table>
Table 7. Comparison of mean tree density and dbh determined by the quadrat and point-quarter sampling techniques at 12 Red-shouldered and 26 Red-tailed hawk nest sites in Iowa

<table>
<thead>
<tr>
<th>Variable</th>
<th>Red-shouldered Hawk mean ± SD</th>
<th>Red-tailed Hawk mean ± SD</th>
<th>Probability of a larger t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadrat density (number of trees/ha)</td>
<td>643.0 ± 236.0</td>
<td>473.0 ± 216.0</td>
<td>0.0347*</td>
</tr>
<tr>
<td>Point density (number of trees/ha)</td>
<td>591.1 ± 193.0</td>
<td>393.0 ± 197.0</td>
<td>0.0065*</td>
</tr>
<tr>
<td>Quadrat dbh (cm)</td>
<td>21.5 ± 4.8</td>
<td>20.9 ± 6.4</td>
<td>0.7822</td>
</tr>
<tr>
<td>Point dbh (cm)</td>
<td>22.6 ± 4.3</td>
<td>22.7 ± 6.3</td>
<td>0.9641</td>
</tr>
</tbody>
</table>

*Significant (P < 0.05).
Fig. 6. Percentage of trees in four different dbh classes occurring within a 730 m$^2$ circular quadrat centered on 12 Red-shouldered and 26 Red-tailed hawk nests.
proportion of canopy trees and thereby have fewer obstructions from small and middle-sized trees.

Mean tree density and dbh did not differ significantly \( (P > 0.1) \) between the two vegetation sampling techniques (Table 7). Densities determined by the point quarter method generally were lower than those determined by the quadrat method (Table 7). The point quarter method tends to underestimate density when sampling aggregated populations (Risser and Zedler 1968). Therefore, results from the quadrat method were used for the discriminant function analysis of nest sites.

Nesting Habitat

For both species, hunting area was considered to be nonforested marsh, pasture, or other open area. Red-tails usually hunt in nonforested areas, often from perches (Fitch et al. 1946, Craighead and Craighead 1956, Smith and Murphy 1973). Red-shoulders also do much of their hunting in nonforested areas, primarily marshes and wet meadows (Craighead and Craighead 1956, Portnoy 1974), although they may also hunt within woodlands.

Red-shoulder nesting habitat is characterized by a large area of floodplain forest, numerous small hunting areas, usually marshes, and little cropland (Table 8). The large edge distance is an important indicator of this habitat.
Table 8. Comparison of 11 habitat parameters determined from a 314 hectare circular plot (radius = 1 km) centered on Red-shouldered and Red-tailed hawk nests in Iowa

<table>
<thead>
<tr>
<th>Variable</th>
<th>Red-shouldered Hawk mean ± SD (n = 12)</th>
<th>Red-tailed Hawk mean ± SD (n = 26)</th>
<th>Probability of a larger t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodplain forest (ha)</td>
<td>123.2 ± 75.6</td>
<td>11.3 ± 26.0</td>
<td>0.0003**</td>
</tr>
<tr>
<td>Upland forest (ha)</td>
<td>70.0 ± 51.7</td>
<td>92.5 ± 52.2</td>
<td>0.2244</td>
</tr>
<tr>
<td>Marsh (ha)</td>
<td>39.3 ± 22.9</td>
<td>5.0 ± 14.2</td>
<td>0.0002**</td>
</tr>
<tr>
<td>Upland nonforested hunting area (ha)</td>
<td>19.1 ± 17.4</td>
<td>70.5 ± 20.0</td>
<td>&lt;0.0001**</td>
</tr>
<tr>
<td>Total nonforested hunting area (ha)</td>
<td>58.4 ± 26.8</td>
<td>75.4 ± 24.1</td>
<td>0.0578</td>
</tr>
<tr>
<td>Number of hunting areas</td>
<td>24.6 ± 12.1</td>
<td>14.0 ± 5.2</td>
<td>0.0124*</td>
</tr>
<tr>
<td>Mean size of hunting areas (ha)</td>
<td>2.8 ± 1.5</td>
<td>6.4 ± 4.0</td>
<td>0.0003**</td>
</tr>
</tbody>
</table>

*aTotal hunting area includes marsh and upland hunting area.

*Significant (P < 0.05).

**Very highly significant (P < 0.001).
Table 8. (Continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Red-shouldered Hawk mean ± SD (n = 12)</th>
<th>Red-tailed Hawk mean ± SD (n = 26)</th>
<th>Probability of a larger t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge (m)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15115.0 ± 6497.0</td>
<td>9718.0 ± 3990.0</td>
<td>0.0180*</td>
</tr>
<tr>
<td>Human use area (ha)</td>
<td>2.6 ± 4.2</td>
<td>4.5 ± 4.4</td>
<td>0.2099</td>
</tr>
<tr>
<td>Cropland (ha)</td>
<td>17.3 ± 17.1</td>
<td>113.2 ± 53.8</td>
<td>&lt;0.0001**</td>
</tr>
<tr>
<td>Open water (ha)</td>
<td>40.6 ± 20.5</td>
<td>11.3 ± 20.5</td>
<td>0.0002**</td>
</tr>
</tbody>
</table>

<sup>b</sup> Edge is distance of forest bordering marsh or upland hunting areas.

Red-tailed Hawk habitat is characterized by the presence of some upland forest, fewer but larger hunting areas, and a large area of cropland (Table 8).

Discriminant analysis (variables used are listed in Methods) correctly classified all Red-shoulder nests and 24 of 26 Red-tail nests (Fig. 7). The most important variables in this discrimination, ranked according to their discriminant coefficient, are: cropland area (1.03), upland forest area...
Fig. 7. Discriminant analysis of the habitat surrounding 12 Red-shouldered and 26 Red-tailed hawk nests represented by Mahalanobis distances from the respective means.
(0.88), number of feeding areas (0.63), upland hunting area (0.52), and edge distance (0.49).

Cropland area is by far the most important discriminating variable. As long as adequate hunting area is available, the Red-tail is able to utilize intensive agriculture lands. Large areas of cropland on level floodplains usually mean marshes and forest habitats, vital to Red-shoulders, have been altered. Upland forest area probably is an important discriminator because it supplies perches and, usually, the nesting area for Red-tails. Upland forest is not necessary for the Red-shouldered Hawk if adequate floodplain forest is available. Both Red-tailed and Red-shouldered hawks will use and probably compete for floodplain forests of limited size. However, it is disadvantageous for a Red-tail to nest in an area far removed from its preferred nonforested hunting habitat. Thus, Red-tails may avoid using floodplain forest that is surrounded by upland forest, leaving such areas vacant for nesting Red-shoulders.

Upland hunting area was important in discrimination because it was found primarily in Red-tail habitats, while marsh was the primary hunting area for Red-shoulders (Table 8). However, these species probably are not limited to these respective types of hunting areas.
Edge and number of feeding areas are important to Red-shoulders which use numerous small marshes interspersed with forest. Red-tails seem to prefer larger hunting areas with less interspersion and hence less edge (Table 8).

Nest habitat falls into three apparent groups (Fig. 7). Outliers are normally the result of a single high or low value of one variable and in most cases have little significance. The Red-shoulder group encircled by a solid line includes three nests in a large floodplain forest (comprising 80% or more of the area) with no upland, agricultural land or human development. Conversely, the Red-tail group of 20 nesting habitats consisted of a variety of cover types averaging 33% upland forest, 25% pasture or some type of hunting area, 35% cropland, and 7% other land uses. The third group, within the dashed line, includes Red-shoulder nests plus two Red-tail nests in floodplains. These habitats average 66% forest area (both bottomland and upland), but also include some area in cover types commonly identified with Red-tailed hawks (cropland, upland, and human use areas). This habitat could be considered a transition zone between typical Red-shoulder and Red-tail habitats. These transitional sites generally provide enough habitat for Red-shouldered Hawks that hunt within the floodplain forest and associated marsh and backwater areas. The two Red-tailed Hawk pairs using this habitat were never seen hunting within
the floodplain, but normally were seen soaring to and from adjacent large open hunting areas.

Scattered data and remarks in the literature indicate nesting Red-shoulders generally are associated with extensive forest interspersed with small clearings or wet meadows (Bent 1937, Stewart 1949, Henny et al. 1973, Portnoy 1974), while nesting Red-tails are found in open areas and are much less dependent on large woodlands (Fitch et al. 1946, Hagar 1957, Smith and Murphy 1973, Bock and Leptien 1976, Howell et al. 1978). Red-tailed Hawk habitat in Alberta averaged 34% forest, 41% agriculture (including pastures), 11% brush, 10% bog-meadow, and 4% aquatic (McInvaille and Keith 1974). This is similar to what I found (33% forest, 25% hunting area, and 35% cropland).

Dixon (1928), Bent (1937), Kilham (1964), Portnoy (1974), Campbell (1975) and I have witnessed aggressive encounters between Red-shoulders and Red-tails. Austing (1964) reported that Red-shouldered and Red-tailed hawks alternately replaced each other in "fringe" areas. The Craigheads (1956) suggested that Red-tails nested first, and the number of Red-shoulders that were able to nest was dependent on the number of Red-tails already established. In 6 years, they noted a loss of three Red-shoulder pairs and a gain of four Red-tail pairs occurring simultaneously with draining of swamps, cutting of woodlots, and more
intensive farming. These observations strongly suggest that these two species compete for habitat. I believe this competition is probably restricted to transitional habitat. The degree of competition for transitional habitat probably varies with region. In Iowa almost all upland areas are intensively farmed, and few trees or pastures exist except along drainage systems too steep to cultivate. Most Red-tails in Iowa nest extremely close to running water. Roosa (1964) reported all 15 nests he located in central Iowa were within 107 m of a stream. In Iowa, displacement from intensively cultivated upland areas may have forced Red-tails to compete for transitional areas. Presently, Red-shoulders in Iowa are restricted to large wooded areas. Woodlands averaging 123 ha of floodplain forest and 70 ha of upland forest within 1 km of the nest (Table 8) could be considered a minimum size for the Red-shoulder in Iowa.

Habitat profiles of six variables important to these species are shown in Fig. 8. A test for parallelism using profile analysis (Morrison 1976) revealed highly significant differences between species (F = 13.01, P < 0.0001). Iowa Red-shoulders used a large area of floodplain forest, numerous small hunting areas, and much edge, while Red-tailed Hawks primarily used areas with upland forest along streams, relatively few large hunting areas, and a large area of cropland.
Fig. 8. Nesting habitat profiles of Red-shouldered and Red-tailed hawks in Iowa. Values were standardized by subtracting the mean and dividing by the standard deviation so values between variables could be compared.
The Red-tail has been referred to as an edge species (Bock and Leptien 1976). However, my analysis demonstrates that the Red-shoulder occupies habitats with more edge than the Red-tail (Table 8 and Fig. 8). The Red-tailed Hawk is probably more accurately called an openland species that requires perches.

The Red-shouldered Hawk in Iowa is obviously adapted to woodlands. The nest site, vegetation analysis, and habitat all show that Red-shoulders typically utilized dense woodlands and situations with numerous obstructions (Tables 3, 7, and 8). As harvest of midwestern forests continues, the Red-shouldered Hawk undoubtedly will lose more of its optimum habitat, allowing competition and displacement by the larger Red-tailed Hawk.
PART II. STATUS, HABITAT UTILIZATION, AND MANAGEMENT OF RED-SHOULDERED HAWKS IN IOWA

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1Paper to be submitted to The Journal of Wildlife Management.
INTRODUCTION

The Red-shouldered Hawk (Buteo lineatus) has experienced a population decline both nationwide (Trautman 1940, Cohen 1970, Brown 1971, Hackman and Henny 1971) and in Iowa (Brown 1964, Kent and Kent 1975, Koenig 1975). In the Midwest it is on the state list of rare or endangered species of Illinois, Iowa, Michigan, Missouri, and Wisconsin (Roosa 1977, Merz 1978). Most attempts to assess the statewide status of breeding raptors are done subjectively, and the value of comparisons and estimates is limited. This paper discusses a systematic survey of potential Red-shoulder habitat using a land use data base. This technique may be applicable in other states and for other species. The Red-shoulder decline probably is due directly or indirectly to habitat alteration (Todd 1940, Cohen 1970, Henny et al. 1973 Oberholser 1974, Portnoy 1974, Campbell 1975, Bock and Leptien 1976). I have presented data supporting this hypothesis and have examined habitat competition with Red-tailed Hawks (Buteo jamaicensis) (Bednarz, Part I, M.S. Thesis). The primary purpose of this paper is to provide basic information on habitat utilization by and to develop initial management recommendations for the Midwestern Red-shouldered Hawk population.
METHODS

In 1977 several professional and amateur ornithologists were interviewed concerning possible locations of breeding Red-shoulders in Iowa. Also, requests for information were circulated to state conservation personnel and were published in local newspapers and journals. Although no active nest locations of Red-shouldered Hawks in Iowa were known, several areas they habitually used were identified.

Field work was done during the spring and summer of 1977 and 1978. Nest searching techniques generally followed Craighead and Craighead (1956), but because of high water in 1978, floodplains were searched by canoe.

Habitat factors important for breeding Iowa Red-shouldered Hawks were identified in 1977. Data collected and stored by the Land Use Analysis Laboratory at Iowa State University was associated with MSDAMP (Multi-scale Data Analysis and Mapping Program, Beavers 1977) to develop a statewide map of potential Red-shouldered Hawk habitat. Data were printed out as map cells, each representing approximately 0.634 km² (156.7 acres). Shuck and White (1978) describe the land use data base available to MSDAMP. Land cover types were interpreted from ERTS (LANDSAT) satellite imagery (imaged in 1972 and 1973), supplemented by aerial photographs and maps, by the Iowa Geological Survey Remote Sensing Laboratory. In 1978, as much as possible of the potential breeding habitat
was searched (36.5%), especially in areas where Red-shoulders were observed or reported.

All map cells containing primarily forest cover and/or with level or gently sloping prairie derived soil developed from alluvium (floodplain soils) and/or containing a second order or larger stream were printed. Order of stream is based on the number of drainage tributaries. Cells were classified as potential Red-shouldered Hawk nesting habitat only if they were in a block of forested habitat of approximately 2.5 km² or larger (i.e., at least four cells in a square shape), and if they were either on level floodplain soils or contained a stream or river. Forested cells not grouped in a square configuration represented a relatively narrow forest belt which is not acceptable for breeding Iowa Red-shoulders (Bednarz, Part I, M.S. Thesis).

The location and habitat type were recorded each time a resident Red-shouldered Hawk was observed, exclusive of movements of hawks to and from nests. Just prior to fledging, four young hawks were equipped with radio transmitters (approximately 16 g) attached with a Teflon harness (Dunstan 1972). A handheld single yagi antenna was used to detect radio signals. Because radio signals were deflected by trees and bluffs, radioed hawks were difficult to locate. Thus, locations were recorded only if auditory or visual confirmation was made. All transmitters ceased functioning 26 days
after the young fledged, although all four were known to be alive and healthy.

Food habits were determined by watching from blinds and analyzing prey remains and pellets. The relative proportions of different prey remains occurring in 41 pellets and 105 pellet fragments were determined with the method of Chamrad and Box (1964). Twenty-five random samples were taken from each of the pellets. Mammal hair was identified with a reference collection and Moore et al. (1974).

Traplines consisting of 30 snap traps set on 7 consecutive days approximately 1 month after the young had fledged were used to assess the small mammals present at the edge of a marsh and in the floodplain forest.

The linear distance of woodland edge and the area of cover types were determined within a 314 ha circle (radius = 1 km) centered on the nest (Bednarz, Part I, M.S. Thesis). To increase sample size for habitat analysis, data also were collected at four inactive Red-shouldered Hawk nest sites. Habitat data were examined with principal component analysis (Morrison 1976). Statistical analysis was accomplished with SAS (Statistical Analysis System, Barr et al., 1976).
RESULTS AND DISCUSSION

Status and Distribution in Iowa

Red-shouldered Hawk nest locations reported in Iowa before 1973 (Fig. 9; taken from Iowa Bird Life, Bailey 1918, Kent and Kent 1975, and personal communications; see Appendix A) were almost exclusively from the eastern half of the state. However, ornithologists and birders were more abundant in eastern Iowa.

During this study, eight active nests (3 in 1977 and 5 in 1978) were located. In 1978, two additional pairs were found in separate woodlots of approximately 8 km². Considering the size of these woodlands, the hawk's nests may have been missed or perhaps they did not nest. Based on land use data, present potential Red-shouldered Hawk habitat represents approximately 1030 km² (0.71%) of the state (Fig. 10). A total of 376 km² (36.5%) of the potential Red-shoulder habitat was searched. Most of the field search effort was concentrated in the eastern half of the state which contained 73 percent of the potential habitat (Table 9). Additionally, an estimated 200 km² not designated as potential habitat was searched. All of the nests and pairs found were located in the potential habitat area. All areas searched are listed in Appendix B.
Figure 9. Distribution of Red-shouldered Hawk nests reported before 1973 in Iowa
Fig. 10. Distribution of Red-shouldered Hawk pairs in 1977 and 1978 and potential nesting habitat in Iowa. Pair locations are designated by the year(s) they were found. Each circle represents between 0.6 and 2.5 km$^2$ of potential Red-shoulder habitat.
Table 9. Distribution of potential Red-shouldered Hawk nesting habitat in Iowa as determined from a land use data base (see Methods and Fig. 10)

<table>
<thead>
<tr>
<th>Section of State</th>
<th>Searched</th>
<th>Not searched</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km²  Percent</td>
<td>km²  Percent</td>
<td>km²  Percent</td>
</tr>
<tr>
<td>Northeast</td>
<td>215 54</td>
<td>185 46</td>
<td>400 39a</td>
</tr>
<tr>
<td>Southeast</td>
<td>94 27</td>
<td>259 73</td>
<td>353 34a</td>
</tr>
<tr>
<td>Southwest</td>
<td>17 11</td>
<td>135 89</td>
<td>152 15a</td>
</tr>
<tr>
<td>Northwest</td>
<td>50 40</td>
<td>75 60</td>
<td>125 12a</td>
</tr>
</tbody>
</table>

*Percentage of potential habitat found in that quarter of the state is in parentheses.*
In 1978 five nests and one pair were found in the northeastern quarter (2.8 pairs/100 km² searched), and one pair was found in the southeastern quarter (1.1 pairs/100 km² searched) of the state. In northeastern Iowa, 11 percent of the map cells containing streams or rivers had the proper forest cover to be classified as potential habitat. In the southeastern, southwestern, and northwestern sections, potential habitat occurred in 7.5, 4.4, and 3.2 percent of the river cells, respectively. During this study only 2 Red-shoulders were reported in western Iowa. One observed in northwestern Iowa was obviously a migrant, while one from the southwestern section was seen in a potential habitat area along the Raccoon River drainage in the summer. I believe that Red-shoulders no longer breed in northwestern Iowa. If any pairs occur in southwestern Iowa, they probably are nesting along the North and/or Raccoon river drainages, the only areas where potential habitat occurred in greater than 7.0 percent of the river cells in that section of the state. Perhaps, Red-shoulder habitat must be clumped or be available at some minimum density per unit area in order to sustain a breeding population.

Assuming that the density of pairs in the area searched is similar for the entire potential Red-shouldered Hawk habitat, the statewide breeding population is estimated at 19 pairs. This estimate is liberal because search efforts
were concentrated in areas where Red-shoulders were reported, and where potential habitat was clumped. Much of the potential nesting habitat for Red-shouldered Hawks proved to be inadequate when examined (forests were harvested or being harvested). This mapping technique reduced the area that needed to be field searched to less than 1 percent of the state. The method also enabled me to systematically estimate the statewide breeding population of Red-shouldered Hawks.

Habitat Utilization

**Habitat use observations**

Red-shouldered Hawks in Iowa are extremely wary and difficult to observe. All 55 observations of breeding pairs or their fledglings were made in forested or wetland habitat (Table 10). Because few observations were made at each nest site, this data could not be statistically related to habitat availability. However, Red-shoulders primarily used forest types, especially floodplains (Table 10). All hawks observed in hillside forests were immediately adjacent to the floodplain. Wetland habitats where Red-shoulders were observed were generally small, the largest being 10 ha. The mean size of nonforested hunting areas within 1 km of 12 Red-shoulder nest sites was 2.8 ha (Bednarz, Part I. M.S. Thesis). The tendency of Red-shoulders to avoid researchers may have biased downward the number seen in wetland habitats (Table 10). A
Table 10. Comparison of breeding Red-shouldered Hawk habitat utilization observations and the habitat types within 1 km of 12 Iowa nest sites. Observations were visual, auditory, or telemetric.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Hawk observations</th>
<th>Mean percentage composition of habitat type at 12 nest areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forested floodplain</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>Forested hillside</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>Marsh or wetland edge</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Other&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>a</sup>Includes crops, pasture, and human use areas.
hawk perched on the edge of a marsh probably can detect a ground intruder and leave the area before the observer is able to see the hawk. I never saw Red-shoulders using cropland, upland pasture, human use areas (residential, farm yards, etc.), or large open-water sloughs or lakes.

Feeding ecology

The proportion of mammal and nonmammal prey were significantly different between years both for items brought to the nest ($\chi^2 = 67.8, P < 0.001$, Table 11) and in pellets ($\chi^2 = 130.6, P < 0.001$, Table 12). However in 1978, mammals were the dominant prey in pellets (Table 12), but made up only 10 percent of the items brought to the nest. Snyder and Wiley (1976) also reported discrepancies between pellet analysis and blind observations, the most serious bias being the lack of amphibian, reptile, and crayfish remains in pellets. The pellet analysis (Table 12) probably shows the relative difference between the number of meadow voles (Microtus pennsylvanicus) and Peromyscus eaten. Sixteen M. pennsylvanicus and only four Peromyscus spp. were identified from blind observations, supporting the importance of meadow voles in the Red-shoulder diet. Nonpellet prey remains found near nests included chelipeds from 30 crayfish (Cambaridae), exoskeleton fragments from 27 Coleopterans, skeletal remains from two young muskrats (Ondatra zibethicus), pelvic bones of a bullhead (Ictalurus sp.), and feathers of a
Table 11. Percentage of identified food items brought to Red-shouldered Hawk nests in 1977 and 1978

<table>
<thead>
<tr>
<th>Item</th>
<th>Year 1977</th>
<th>Year 1978</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammals</td>
<td>92</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>Amphibians b</td>
<td>6</td>
<td>46</td>
<td>33</td>
</tr>
<tr>
<td>Arthropods c</td>
<td>0</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>Reptiles d</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Birds</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No. of items</td>
<td>36</td>
<td>78</td>
<td>114</td>
</tr>
</tbody>
</table>

a A total of 44 unidentified items were brought to nests in 1977 and 1978.

b Rana pipiens and Rana catesbiana were identified.

cCrayfish (Cambaridae) and caterpillars.

dThamnophis sirtalis and Natrix sipedon were identified.
Table 12. Percentage of the different prey types occurring in Red-shouldered Hawk pellets in 1977 and 1978

<table>
<thead>
<tr>
<th>Item</th>
<th>1977(^a)</th>
<th>1978(^b)</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microtus pennsylvanicus</td>
<td>70.1</td>
<td>38.4</td>
<td>47.8</td>
</tr>
<tr>
<td>Peromyscus spp.</td>
<td>16.5</td>
<td>13.6</td>
<td>14.4</td>
</tr>
<tr>
<td>Other mammals(^c)</td>
<td>3.7</td>
<td>5.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Total mammals</td>
<td>90.3</td>
<td>57.1</td>
<td>66.9</td>
</tr>
<tr>
<td>Bird feathers</td>
<td>9.4</td>
<td>22.7</td>
<td>18.7</td>
</tr>
<tr>
<td>Crayfish</td>
<td>0</td>
<td>9.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Insects</td>
<td>0.3</td>
<td>9.8</td>
<td>7.0</td>
</tr>
<tr>
<td>Other(^d)</td>
<td>0</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

\(^a\)Based on 375 samples.
\(^b\)Based on 900 samples.
\(^c\)Shrews (Soricidae), Ondatra zibethicus (muskrat), Reithrodontomys megalotis (western harvest mouse), Tamias striatus (eastern chipmunk).
\(^d\)Snake (Serpentes), frogs (Ranidae).
nestling crow (*Corvus brachyrhynchos*). The majority of the feathers found in the pellets, especially large down feathers, were probably accidentally swallowed during preening.

The drastic shift in food habits between years (Table 11) was directly related to water levels in the Mississippi River backwaters and marshes. Tailwater elevations at Lock and Dam No. 9, located between nests where food data were collected, were a mean of 1.06 m higher in March-June 1978 than 1977 (unpublished data, Corps of Engineers, Lock and Dam No. 9, Lynxville, Wisconsin). A severe drought occurred in 1977 while water levels were higher than normal in 1978. Meadow voles, which made up the bulk of the 1977 diet (Table 11), were trapped only on the edge of marshes, while *Peromyscus* spp. were found both in marshes and the floodplain forest. All of the primary prey animals (meadow voles, amphibians, and crayfish; Tables 11 and 12) generally are restricted to marsh and wetland areas revealing the importance of these habitats as hunting areas for nesting Red-shouldered Hawks.

Productivity was excellent both years for the small sample of nests that was monitored (9 young from 3 nests in 1977, 14 young from 4 successful nests in 1978; Bednarz, Part I, M.S. Thesis). Campbell (1975) suggested that a decrease in reptiles and amphibians and an increase in
mammals may contribute to the replacement of Red-shoulders by Red-tailed Hawks and Great Horned Owls (*Bubo virginianus*). My results showed that with changes in water levels, Red-shoulders adapted to the available prey and were capable of successfully raising young with either mammal or nonmammal prey. The Red-shoulder does not seem to depend on any particular prey type (Fisher 1893, McAtee 1935, Trautman 1940, Mendall 1944, Ernst 1945, Stewart 1949, Craighead and Craighead 1956, Portnoy 1974, Pettingill 1976), but rather is adapted to the forested floodplain habitat.

Nesting habitat

The habitat in a 314 ha plot surrounding 12 Red-shouldered Hawk nests was examined with principal component analysis (Morrison 1976). For this analysis, hunting area was considered to be any nonforested area where prey may be available. Two categories were recognized: upland hunting area (pasture, fallow fields, and prairie) and marsh (including wet meadows). Edge is defined as the distance of woodland edge along nonforested hunting area.

Three principal components explained 93 percent of the variation in the habitat variables. The first principal component explains 53 percent of the variation and can be interpreted as the variation in habitat structure tolerable by Iowa Red-shouldered Hawks (Table 13). This component deals primarily with the variation in forest and hunting
Table 13. Habitat surrounding 12 Iowa Red-shouldered Hawk nests ordered according to their first principal component value. Correlations between the component and variables indicate the importance of the variables in the first principal component

<table>
<thead>
<tr>
<th>Principal component value</th>
<th>Nest No.</th>
<th>Floodplain forest area (ha)</th>
<th>Upland forest area (ha)</th>
<th>Crop area (ha)</th>
<th>No. of hunting areas</th>
<th>Mean size of hunting area (m)</th>
<th>Edge hunting area (ha)</th>
<th>Upland hunting area (ha)</th>
<th>Marsh area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.84</td>
<td>4</td>
<td>75.9</td>
<td>128.2</td>
<td>33.4</td>
<td>9</td>
<td>3.7</td>
<td>7984</td>
<td>11.5</td>
<td>22.2</td>
</tr>
<tr>
<td>-2.18</td>
<td>2</td>
<td>79.0</td>
<td>123.2</td>
<td>31.4</td>
<td>11</td>
<td>3.2</td>
<td>8594</td>
<td>11.6</td>
<td>24.2</td>
</tr>
<tr>
<td>-2.16</td>
<td>11</td>
<td>77.5</td>
<td>134.9</td>
<td>11.3</td>
<td>11</td>
<td>4.2</td>
<td>11414</td>
<td>24.8</td>
<td>22.0</td>
</tr>
<tr>
<td>-2.03</td>
<td>6</td>
<td>42.0</td>
<td>71.8</td>
<td>15.8</td>
<td>19</td>
<td>5.9</td>
<td>7509</td>
<td>10.0</td>
<td>102.8</td>
</tr>
<tr>
<td>-0.79</td>
<td>8</td>
<td>53.4</td>
<td>141.4</td>
<td>0.0</td>
<td>15</td>
<td>1.9</td>
<td>7184</td>
<td>1.6</td>
<td>27.9</td>
</tr>
<tr>
<td>0.35</td>
<td>1</td>
<td>94.8</td>
<td>47.2</td>
<td>41.3</td>
<td>21</td>
<td>4.3</td>
<td>24714</td>
<td>53.9</td>
<td>35.6</td>
</tr>
<tr>
<td>0.39</td>
<td>9</td>
<td>88.3</td>
<td>71.0</td>
<td>43.9</td>
<td>24</td>
<td>2.7</td>
<td>19509</td>
<td>36.6</td>
<td>28.4</td>
</tr>
<tr>
<td>2.42</td>
<td>12</td>
<td>113.4</td>
<td>53.8</td>
<td>14.1</td>
<td>32</td>
<td>2.6</td>
<td>15589</td>
<td>37.1</td>
<td>45.6</td>
</tr>
</tbody>
</table>
Table 13. (Continued)

| Principal Nest Floodplain Upland Crop No. of Mean Edge Upland Marsh component No. forest forest area area (ha) area (ha) (ha) No. of hunting size of (m) hunting area area (ha) area (ha) area (ha) |
|----------------|-----------------|-----------------|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2.84           | 10              | 126.6           | 52.8            | 9.9            | 32              | 2.3             | 14337           | 31.4            | 41.7            |
| 7.58           | 5               | 251.7           | 15.6            | 2.1            | 38              | 1.0             | 21244           | 10.7            | 26.7            |
| 7.80           | 7               | 223.8           | 0.0             | 0.0            | 40              | 1.5             | 22464           | 0.0             | 59.7            |
| 8.53           | 3               | 251.4           | 0.0             | 0.0            | 43              | 0.8             | 20832           | 0.0             | 34.2            |

Correlation

| Correlation | 0.96 | -0.89 | -0.57 | 0.96 | -0.80 | 0.73 | -0.27 | 0.03 |

between the component and variable
habitat structure. Total forest cover available appears to be an important requirement of Iowa Red-shouldered Hawks. As the area of floodplain forest was reduced, the area of upland forest compensated for this loss (Table 13). This upland forest may be important in restricting Red-tails from competing for floodplain habitat (Bednarz, Part I, M.S. Thesis).

The hunting habitat of the Red-shoulder varied from numerous extremely small marshes to fewer large hunting areas. The numerous small hunting areas were associated with large floodplain forest habitats, while few larger hunting areas were found near nests with more upland forest. This variation of Red-shoulder hunting habitat generally did not overlap with that of Red-tailed Hawks which had significantly larger and fewer hunting areas (Bednarz, Part I, M.S. Thesis). Whether hunting areas were upland or marsh areas was of little importance in the first principal component. Habitat at nest 6 (Table 13), had been altered recently and probably does not represent typical Iowa Red-shoulder habitat.

Principal components 2 and 3, accounted for 23 and 17 percent of the variance, respectively (Table 14). The second principal component is primarily related to increasing upland hunting and cropland areas (Table 14). This component is interpreted as representing the habitat variation of the
Table 14. The habitat variables surrounding 12 Iowa Red-shouldered Hawk nests that showed high correlations with the second and third principal components. Nest areas are ordered according to their principal component value.

<table>
<thead>
<tr>
<th>Principal component</th>
<th>Nest No.</th>
<th>Upland area (ha)</th>
<th>Crop area (ha)</th>
<th>Edge (m)</th>
<th>Principal component No.</th>
<th>Marsh area (ha)</th>
<th>Mean size of hunting areas (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.16</td>
<td>8</td>
<td>1.6</td>
<td>0.0</td>
<td>7184</td>
<td>1.07</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>1.61</td>
<td>6</td>
<td>10.0</td>
<td>15.8</td>
<td>7509</td>
<td>1.21</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2.18</td>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
<td>20832</td>
<td>1.22</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2.23</td>
<td>7</td>
<td>0.0</td>
<td>0.0</td>
<td>22464</td>
<td>1.46</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2.32</td>
<td>2</td>
<td>11.6</td>
<td>31.4</td>
<td>8594</td>
<td>1.51</td>
<td>11</td>
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<tr>
<td></td>
<td>2.35</td>
<td>4</td>
<td>11.5</td>
<td>33.4</td>
<td>7984</td>
<td>1.66</td>
<td>9</td>
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<tr>
<td></td>
<td>2.52</td>
<td>11</td>
<td>24.8</td>
<td>11.3</td>
<td>11414</td>
<td>1.90</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2.80</td>
<td>5</td>
<td>10.7</td>
<td>2.1</td>
<td>21244</td>
<td>2.46</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>3.33</td>
<td>10</td>
<td>31.4</td>
<td>9.9</td>
<td>14337</td>
<td>2.66</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3.92</td>
<td>12</td>
<td>37.1</td>
<td>14.1</td>
<td>15589</td>
<td>2.72</td>
<td>12</td>
</tr>
<tr>
<td>Principal Nest Upland Crop Edge Principal Nest Marsh Mean size component No. hunting area area area component (m) (ha) No. area of hunting (ha)</td>
<td></td>
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<tr>
<td>5.65</td>
<td>9</td>
<td>36.6</td>
<td>47.9</td>
<td>19509</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.02</td>
<td>1</td>
<td>53.9</td>
<td>41.3</td>
<td>24714</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation between the component and variable</td>
<td>0.89</td>
<td>0.70</td>
<td>0.63</td>
<td>0.52</td>
<td></td>
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</tr>
</tbody>
</table>
upland habitat of the land surrounding Red-shouldered Hawk nests. This upland portion was rarely used by Red-shoulders and makes up a very small proportion of the habitat except at nests 1 and 9 (Table 14). These nests were probably built by the same pair (in 1977 and 1978) in an area that has been logged heavily in the last few years.

The third principal component indicates the importance of marshes in the Red-shouldered Hawk habitat as shown by its high correlation with marsh area ($r = 0.98$; Table 14). Apparently, 22 to 60 ha of marsh habitat met most prey needs of nesting Red-shouldered Hawks. Nest 6 probably should be considered an outlier as discussed previously.

In summary, nesting Iowa Red-shoulders have two important habitat requirements; a large area of forest cover including some level floodplain forest, and several interspersed small nonforested areas, usually marshes (Tables 10 and 13). At the 12 nest areas examined, forest covered 70 percent (47-88) including a mean of 44 percent (17-88) floodplain forest, and marshland covered 15 percent (8-42) of the total land area.

Habitat Alteration and the Red-shoulder Population Decline

Forest cover obviously is important to nesting Red-shouldered Hawks (Bent 1937, Stewart 1949, Portnoy 1974,
Oberholser 1974, Campbell 1975, Bock and Leptien 1976, this study) and timber harvesting (selective or clear-cutting) has a major detrimental impact. The woodland area of Iowa has been reduced 67 percent since settlement (Hertel 1976). Timber was being harvested within 2 km of all nests examined during this study except one. This study suggests that as Red-shouldered Hawk habitat is reduced, the number of nesting pairs will decline at a much greater rate. Isolated blocks of adequate habitat appear unable to maintain a breeding pair for long time periods. In transitional habitats with limited forest cover, Red-tails may compete with and displace Red-shoulders (Bednarz, Part I, M.S. Thesis).

In Iowa, Red-shouldered Hawks utilize level floodplain forest habitat interspersed with small marshes and wet meadows, a habitat created and maintained by meandering flowing water. Dam construction and channelization generally destroy these habitats, also contributing to the Red-shoulder decline. Oberholser (1974) reported that dam construction destroyed over 240,000 ha of Red-shoulder habitat in Texas. The lock and dam system on the Mississippi River has inundated thousands of ha of forested floodplain (Claflin 1973, Ekblad 1973, Cawley 1973), creating vast marshes that do not meet the forest cover requirements of nesting Red-shouldered Hawks. Barstow (1971) and Choate (1972) have documented the loss of floodplain wetlands and forest resulting from channelization.
Management Recommendations

Red-shouldered Hawk nesting areas can be located by the presence of hawks during the breeding season (in Iowa 15 March to 1 September). Wildlife field personnel should note the location of any Red-shoulder during their regular duties and plot these on maps. Red-shoulders occupy the same areas for several years (Kennard 1894, Bent 1937, Craighead and Craighead 1956) and a nesting range could be delineated over time. As few as three or four observations could be used to arbitrarily designate a center of activity. An artificial circular nesting range located around this center point would include most if not all of the true Red-shoulder range (radius of 1 km is recommended). This technique would require little extra effort once field personnel learn the visual and vocal characteristics of Red-shoulders.

Once nesting ranges are identified, all disturbances (spring hunting, public use, any type of construction activities, etc.) should be minimized in these areas from the beginning of the nesting season until young are approximately 2 weeks old (in Iowa, 15 March to 15 May).

Red-shouldered Hawks nesting in Iowa require large tracts of forest cover including some level floodplain with small clearings or marshes. These habitats can be maintained by not disrupting natural riverine systems (damming,
channelizing, or clearing large areas of forest). In river systems that have been stabilized (e.g., Mississippi River), habitats should be maintained in the most natural state possible. The maximum current permissible should be allowed to flow into backwater areas, thereby creating and maintaining small marshes. Dredge spoil should not be placed in designated Red-shouldered Hawk nesting ranges. Unnatural sediment loads in backwater areas should be reduced as much as possible. When managing for nesting Red-shouldered Hawks, large agricultural fields on wildlife refuge floodplains should be reduced in size where possible. In many cases, large portions of these fields are harvested and probably are of limited value to wildlife.

Where damming and channelizing have destroyed dispersed clearings in floodplains, conventional management practices such as logging areas smaller than 4 ha may be possible. The openings should be dispersed throughout the floodplain forest and occupy approximately 15 percent of the land area (within the range of 8 to 23 percent is probably acceptable). Forests should be maintained in a mature state at densities between 370 and 1000 trees/ha with few understory trees (e.g., in Iowa a mature maple-elm floodplain community; Bednarz, Part I, M.S. Thesis). These management recommendations are consistent with the habitat requirements of nesting Wood Ducks (Aix sponsa) (McGilvrey 1968) and probably would be beneficial for Wood Duck production.
Land acquisition could be used as a tool to preserve natural Red-shouldered Hawk habitat. Acquisition of habitat would be most effective near large protected forested flood-plains in wildlife refuges and where Red-shoulders presently occur. Preservation of isolated areas of suitable habitat would be of little value in maintaining a stable breeding population.

These recommendations are meant to be a starting point, and modification and improvement should be an objective as management for nesting Red-shoulders is implemented (management recommendations for specific federal and state lands in Iowa are given in Appendix C).
GENERAL CONCLUSIONS

Red-shouldered and Red-tailed hawks fledged 2.9 and 1.5 young per nest attempt, respectively. Though Red-shouldered Hawk production appears high, the Iowa population is probably still declining. Perhaps, some of the young are moving out of the state in search of better habitat.

Nest sites of Red-shouldered and Red-tailed hawks differed significantly with both univariate and multivariate analysis. Red-tailed Hawk nests were characterized by accessibility, being placed high on trees, on small support branches, in areas of little canopy cover, typically on a hillside, and constructed with large access distances between branches. Red-shouldered Hawk nests were characterized by secure support and protection from the environment, being placed lower in the canopy, on large support branches, in areas with much canopy cover, typically on level ground, and built with smaller access distances between support branches. Red-shouldered Hawks preferred mature forests with more canopy trees than forests used by Red-tailed Hawks. Generally, Red-shouldered Hawks used nest sites and habitats that had many obstructions and required steering ability and maneuverability. Red-tailed Hawks occurred in open habitats using nest sites with few obstructions.

Red-tailed Hawk habitat in Iowa was usually associated with pastures, farm buildings, and roads. When Red-tailed
Hawks used forested areas, most hunting was probably done in large adjacent nonforested habitat.

Red-shouldered Hawks utilized forest habitat, primarily on level floodplains. The major prey items (Microtus, amphibians, and crayfish were primarily restricted to small marshes and wet meadows within the floodplain forest. Red-shouldered Hawks adapted to prey types available in the small marshes, utilizing M. pennsylvanicus when the marshes were dry and amphibians when the marshes were wet.

Habitat competition between these species apparently occurs only in transitional habitats where forest cover is limited but adequate for Red-shoulders, and where large open hunting areas for Red-tails are adjacent to the woodland.

Deforestation and intensive agriculture on upland areas have destroyed Red-tailed Hawk nesting and hunting habitat in Iowa. Timber harvests and the development of large pastures along bottomlands have converted excellent Red-shouldered Hawk habitat into transitional habitat, probably allowing the Red-tail to replace the Red-shoulder in much of Iowa.

Channelization and dam construction also have destroyed Red-shouldered Hawk habitat by inundation and by controlling natural river processes that create and maintain backwater marshes and openings.

Presently, nesting Red-shouldered Hawks are limited primarily to northeastern Iowa. Isolated habitat in other
portions of the state cannot maintain breeding Red-shoulders. In 1978, less than 19 Red-shouldered Hawk pairs were estimated to exist in the state.

Identification of breeding ranges will allow managers to protect nesting hawks from human disturbances and proposed adverse habitat alterations (deforestation, dam construction, and channelization). Red-shouldered Hawk habitat can be managed by protecting forest cover and maintaining small interspersed marshes and openings to provide hunting areas.

The Red-shouldered Hawk situation in Iowa is critical and management measures and land acquisition to protect habitat should be initiated immediately. The Midwestern Red-shouldered Hawk population should be considered for listing as a threatened species on the federal endangered species list. This would better enable resource agencies to finance and develop the management programs needed for this species.
LITERATURE CITED


ACKNOWLEDGEMENTS

I am very grateful to the numerous cooperators who have contributed to the results presented in this thesis. Foremost, James J. Dinsmore suggested the research problem, provided encouragement, and continuous advice and assistance throughout this project. Additionally, Dean M. Roosa suggested the research problem, and provided constant encouragement and assistance necessary for the completion of this study. Darwin Koenig contributed his invaluable skills as a field biologist which aided in locating several nests. Paul F. Anderson suggested using the land use data and provided the technical assistance needed to develop the map of potential Red-shouldered Hawk breeding habitat. The assistance of V. Pat McCrow in several phases of this project is responsible for the completion of this thesis. Rich Ervin and Jim Wagner assisted in the field for several months in 1978. Joe Schaufenbuel assisted in the field and sent more reports of Red-shouldered Hawks than any observer in the state. Other individuals who eagerly assisted in the field despite sometimes intolerable conditions include: Paul Bartelt, Scott Fegile, Monte Garrett, Fred Heinz, Ellen Johnson, Andy Jones, Peter T. Knight, Margie Plouffe, Rochelle Renken, Larry Stone, and John Stravers. My wife, George Anne, typed an earlier draft of Part I and was supportive throughout this study. Robert B. Dahlgren
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APPENDIX A

Locations of Red-shouldered Hawk nests found in Iowa before 1973, either reported in the literature or by personal communication. Nests are listed alphabetically by county. The original description of the specific location is given. A question mark appears if no specific location was reported.

<table>
<thead>
<tr>
<th>County</th>
<th>Location</th>
<th>Date</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allamakee</td>
<td>mouth of Wexford Creek</td>
<td>22 April 1972</td>
<td>F. Lesher pers. comm.</td>
</tr>
<tr>
<td>Black Hawk</td>
<td>2 mi. NW of Cedar Falls</td>
<td>1943</td>
<td>M. L. Grant IBL 13:6-8.</td>
</tr>
<tr>
<td>Black Hawk</td>
<td>George Wyth Memorial State Park</td>
<td>prior to 1973</td>
<td>M. Konig IBL 18:37.</td>
</tr>
<tr>
<td>Boone</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
<tr>
<td>Boone</td>
<td>T-38N, R-20W, Sec. 17</td>
<td>17 May 1963</td>
<td>D. Roosa pers. comm.</td>
</tr>
<tr>
<td>Clinton</td>
<td>along Wapsipinicon River</td>
<td>?</td>
<td>T. J. Morrissey IBL 38:73-75.</td>
</tr>
<tr>
<td>Clinton</td>
<td>near Wheatland</td>
<td>1971</td>
<td>E. Copp IBL 41:89.</td>
</tr>
<tr>
<td>Floyd</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
<tr>
<td>Iowa²</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
<tr>
<td>Lee</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
</tbody>
</table>

¹Iowa Bird Life.
²Three locations were shown in Iowa County.
<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Date</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linn</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
<tr>
<td>Lucas</td>
<td>near Russell</td>
<td>1966</td>
<td>H. McKinley</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IBL 36:18,49.</td>
</tr>
<tr>
<td>Marshall³</td>
<td>?</td>
<td>prior to 1921</td>
<td>L. Allen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oologist 38:156.</td>
</tr>
<tr>
<td>Scott</td>
<td>Credit Island</td>
<td>1950</td>
<td>T. J. Morrissey.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IBL 38:73-75.</td>
</tr>
<tr>
<td>Scott</td>
<td>along Wapsipinicon River</td>
<td>?</td>
<td>T. J. Morrissey.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IBL 38:73-75.</td>
</tr>
<tr>
<td>Sioux</td>
<td>mouth of Rock River</td>
<td>1965</td>
<td>P. C. Peterson</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IBL 38:74.</td>
</tr>
<tr>
<td>Van Buren</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
<tr>
<td>Winneshiek</td>
<td>?</td>
<td>prior to 1918</td>
<td>Bailey 1918.</td>
</tr>
<tr>
<td>Winneshiek</td>
<td>near Decorah</td>
<td>1966</td>
<td>D. Koenig</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IBL 36:82.</td>
</tr>
</tbody>
</table>

³At least four nests were found.
APPENDIX B

Areas searched for nests during this study and comments on the quality of habitat for breeding Red-shouldered Hawks. Township, range and section numbers are given for large areas intensively searched on foot or by canoe. Starting and ending points are given for long stretches of river greenbelt examined from canoe, vehicle, or on foot. Relative habitat quality is designated: Good - acceptable habitat where breeding pairs of Red-shoulders were found; Fair - may be acceptable habitat but no evidence of breeding Red-shoulders was found; Poor - habitat is probably not acceptable to breeding Red-shouldered Hawks. Areas are listed alphabetically by county.

<table>
<thead>
<tr>
<th>County</th>
<th>Location</th>
<th>Condition of Habitat and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allamakee</td>
<td>lower Yellow River T-96N, R-3W,</td>
<td>Good: current plans for clearing forest will destroy this habitat.</td>
</tr>
<tr>
<td></td>
<td>Sec. 29,32, 33,34.</td>
<td></td>
</tr>
<tr>
<td>Allamakee</td>
<td>Paint Creek T-96N, R-3W, Sec. 3,</td>
<td>Good: current clearing of forest is destroying this habitat.</td>
</tr>
<tr>
<td></td>
<td>4,9, 10,15.</td>
<td></td>
</tr>
<tr>
<td>Allamakee</td>
<td>Yellow River Forest T-96N, R-3W,</td>
<td>Poor: most of floodplain extremely narrow or cleared.</td>
</tr>
<tr>
<td></td>
<td>Sec. 5,6,7, T-97N, R-3W, Sec. 30,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31, 32, T-97N, R-4W, Sec. 3,6.</td>
<td></td>
</tr>
<tr>
<td>Allamakee</td>
<td>Lock and Dam No. 9 T-97N, R-2W,</td>
<td>Poor: no marsh areas, made up of forest or large open slough.</td>
</tr>
<tr>
<td></td>
<td>Sec. 18.</td>
<td></td>
</tr>
<tr>
<td>County</td>
<td>Location</td>
<td>Condition of Habitat and Comments</td>
</tr>
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<td>-------------</td>
<td>--------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Allamakee</td>
<td>Wexford Creek T-97N, R-2W, Sec. 5, T-98N, R-2W, Sec. 30,31,32.</td>
<td>Fair: forest currently being cleared for grazing and homes, area now is probably too small for breeding Red-shoulders.</td>
</tr>
<tr>
<td>Allamakee</td>
<td>Upper Mississippi Wildlife Refuge T-100N, R-4W, Sec. 11,12,13,14,23,24,26,27,36.</td>
<td>Good: mature floodplain forest with small marsh openings, channelization of Upper Iowa River apparently has destroyed some small marsh areas.</td>
</tr>
<tr>
<td>Allamakee</td>
<td>upper Yellow River, Sixteen to Myron.</td>
<td>Poor: most of floodplain forest cleared.</td>
</tr>
<tr>
<td>Allamakee</td>
<td>Village Creek, Lansing to Waukon.</td>
<td>Poor: most of floodplain forest cleared.</td>
</tr>
<tr>
<td>Benton</td>
<td>Dudgeon Lake Wildlife Management Area T-85N, R-10W, Sec. 4,5,8,9.</td>
<td>Fair: trees small, many large sloughs and fields.</td>
</tr>
<tr>
<td>Boone &amp; Webster</td>
<td>Des Moines River, Ledges State Park to Fort Dodge.</td>
<td>Poor: much of floodplain cleared, greenbelt relatively narrow, few small marshes, much development, especially near Fort Dodge.</td>
</tr>
<tr>
<td>Bremer</td>
<td>Wapsipinicon River, Fredericka to Tripoli.</td>
<td>Poor: primarily narrow greenbelt with few marshes.</td>
</tr>
<tr>
<td>County</td>
<td>Location</td>
<td>Conditions of Habitat and Comments</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Clayton</td>
<td>Bunker Chute T-91N, R-1W, Sec. 22,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23, 24.</td>
<td>Fair: marsh areas lacking, area probably too small for breeding Red-shoulders.</td>
</tr>
<tr>
<td>Clayton</td>
<td>lower Turkey River T-91N, R-1W, Sec. 7, 8, 17, 18, 20, 21, T-91N, R-2W, Sec. 2, 10, 11, 12, 13.</td>
<td>Good: habitat currently being destroyed by encroaching agriculture and forest clearing.</td>
</tr>
<tr>
<td>Clayton</td>
<td>Miners Creek T-92N, R-2W, Sec. 20, 21, 29, 30.</td>
<td>Poor: trees small, few marsh areas, motorcycle trail in only portion containing mature timber.</td>
</tr>
<tr>
<td>Clayton</td>
<td>Sny Magill Creek T-94N, R-3W, Sec. 23, 26.</td>
<td>Good: mature floodplain forest with small marsh openings.</td>
</tr>
<tr>
<td>Clayton</td>
<td>upper Turkey River, Millville to Elkader.</td>
<td>Poor: most of floodplain forest cleared.</td>
</tr>
<tr>
<td>Clinton &amp;</td>
<td>mouth of Wapsipinicon River T-80N, R-5E, Sec. 11, 12, 13, 14.</td>
<td>Good: currently trees are being harvested on all sides of refuge land.</td>
</tr>
<tr>
<td>Scott</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinton</td>
<td>Beaver Slough T-81N, R-6E, Sec. 26, 27.</td>
<td>Poor: trees small.</td>
</tr>
<tr>
<td>Clinton</td>
<td>Elk River T-83N, R-7E, Sec. 20, 29.</td>
<td>Poor: trees small, area probably too small for breeding Red-shoulders.</td>
</tr>
<tr>
<td>Clinton</td>
<td>Heldt Ditch T-83N, R-7E, Sec. 31.</td>
<td>Poor: primarily cornfield.</td>
</tr>
<tr>
<td>Clinton &amp;</td>
<td>lower Wapsipinicon River, Highway 61 to Foletts.</td>
<td>Fair: trees small, relatively narrow greenbelt.</td>
</tr>
<tr>
<td>Scott</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawford &amp;</td>
<td>Boyer River, Missouri Valley to Dennison.</td>
<td>Poor: most of floodplain nonforested.</td>
</tr>
<tr>
<td>Harrison</td>
<td></td>
<td></td>
</tr>
<tr>
<td>County</td>
<td>Location</td>
<td>Condition of Habitat and Comments</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Delaware</td>
<td>Fountain Springs Conservation Area T-90N, R-4W, Sec. 23.</td>
<td>Poor: most of floodplain cleared.</td>
</tr>
<tr>
<td>Delaware</td>
<td>Backbone State Park T-90N, R-6W, Sec. 4,5,8, 9,15.</td>
<td>Poor: floodplain narrow and developed, section 16 not checked.</td>
</tr>
<tr>
<td>Des Moines</td>
<td>mouth of Skunk River T-68N, R-2W, Sec. 5,6,7, T-69N, R-2W, Sec. 29,30, 31,32.</td>
<td>Fair: intensive logging in the last 4 years has removed most large trees.</td>
</tr>
<tr>
<td>Des Moines &amp; Louisa</td>
<td>North of Huron Island T-72N, R-1W, Sec. 3, T-73N, R-1W, Sec. 34.</td>
<td>Fair: few small marshes, probably too small for breeding Red-shoulders.</td>
</tr>
<tr>
<td>Dubuque</td>
<td>Massey T-88N, R-3E, Sec. 14,15, 23.</td>
<td>Poor: entire area developed. I was unable to check Nine Mile Island.</td>
</tr>
<tr>
<td>Dubuque</td>
<td>Julian Dubuque Tomb T-88N, R-3E, Sec. 5,6.</td>
<td>Poor: little floodplain area.</td>
</tr>
<tr>
<td>Dubuque</td>
<td>Little Maquoketa River T-90N, R-2E, Sec. 26.</td>
<td>Poor: industrial development, trees small, few marsh areas.</td>
</tr>
<tr>
<td>Dubuque</td>
<td>White Pine Hollow T-90N, R-2W, Sec. 5,6, 7,8.</td>
<td>Poor: floodplain extremely narrow, heavy intensity of human use.</td>
</tr>
<tr>
<td>Fayette</td>
<td>Brush Creek State Preserve T-92N, R-7W, Sec. 16,17.</td>
<td>Poor: floodplain extremely narrow.</td>
</tr>
<tr>
<td>Fayette</td>
<td>Turkey River, Clermont to Eldorado.</td>
<td>Poor: most of floodplain forest cleared.</td>
</tr>
<tr>
<td>Hardin</td>
<td>Iowa River, Iowa Falls to Steamboat Rock.</td>
<td>Poor: much of floodplain cleared, remaining trees small or in narrow greenbelt.</td>
</tr>
<tr>
<td>Harrison</td>
<td>see Crawford County</td>
<td></td>
</tr>
<tr>
<td>County</td>
<td>Location</td>
<td>Condition of Habitat and Comments</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Howard</td>
<td>Turkey River Access T-98N, R-11W, Sec. 2.</td>
<td>Poor: no marsh area, area probably too small for breeding Red-shoulders.</td>
</tr>
<tr>
<td>Jackson</td>
<td>Pleasant Creek Wildlife Refuge T-85N, R-5E, Sec. 1,2,3,4,10,11.</td>
<td>Fair: large open cornfield and sloughs, many small trees.</td>
</tr>
<tr>
<td>Jackson</td>
<td>Maquoketa River T-85N, R-5E, Sec. 12,13, T-85N, R-6E, Sec. 7.</td>
<td>Poor: river channelized, trees small.</td>
</tr>
<tr>
<td>Jackson</td>
<td>Green Island T-85N, R-6E, Sec. 16,17,18,19,20.</td>
<td>Poor: much floodplain in cropland, channelized and drained.</td>
</tr>
<tr>
<td>Jackson</td>
<td>Tete Du Mort Creek T-87N, R-4E, Sec. 3,4,5,7,8.</td>
<td>Poor: most of floodplain in cropland.</td>
</tr>
<tr>
<td>Louisa</td>
<td>south of Iowa River mouth T-73N, R-1W, Sec. 5,6.</td>
<td>Poor: relatively narrow strip of forest.</td>
</tr>
<tr>
<td>Louisa</td>
<td>mouth of Iowa River T-74N, R-2W, Sec. 34,35, T-73N, R-2W, Sec. 1,2,3.</td>
<td>Fair: few small marshes, made up of forest or large open slough.</td>
</tr>
<tr>
<td>Louisa</td>
<td>Lake Odessa T-74N, R-2W, Sec. 7,8,9,16,17,18,20,21.</td>
<td>Poor: primarily large open fields.</td>
</tr>
<tr>
<td>Louisa</td>
<td>Big Timber Area T-75N, R-2W, Sec. 18,20,21,28,29.</td>
<td>Fair: few small marsh areas, made up of forest or large open sloughs.</td>
</tr>
<tr>
<td>Louisa</td>
<td>also see Des Moines County</td>
<td></td>
</tr>
<tr>
<td>Marshall</td>
<td>Iowa River T-85N, R-19W, Sec. 34,35.</td>
<td>Poor: much of forest cleared, remaining trees small.</td>
</tr>
<tr>
<td>Muscatine</td>
<td>south of Muscatine T-76N, R-2W, Sec. 15,16,21,22,27,33,34.</td>
<td>Poor: primarily cleared, industrial development and in cropland.</td>
</tr>
<tr>
<td>County</td>
<td>Location</td>
<td>Condition of Habitat and Comments</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Muscatine</td>
<td>Mississippi River, Montpeelier to Muscatine</td>
<td>Poor: primarily cleared and developed.</td>
</tr>
<tr>
<td>Scott</td>
<td>west of Buffalo T-77N, R-2E, Sec. 19,20.</td>
<td>Poor: developed.</td>
</tr>
<tr>
<td>Scott</td>
<td>Credit Island T-77N, R-3E, Sec. 3,10.</td>
<td>Poor: primarily cleared and developed.</td>
</tr>
<tr>
<td>Scott</td>
<td>Princeton Wildlife Area T-80N, R-5E, Sec. 23,24, 25,26,35.</td>
<td>Poor: cropland, open prairie, small trees.</td>
</tr>
<tr>
<td>Scott</td>
<td>also see Clinton County</td>
<td></td>
</tr>
<tr>
<td>Webster</td>
<td>see Boone County</td>
<td></td>
</tr>
<tr>
<td>Winneshiek</td>
<td>Cardinal Marsh T-98N, R-10W, Sec. 6,7.</td>
<td>Poor: few trees.</td>
</tr>
<tr>
<td>Winneshiek</td>
<td>Canoe Creek T-99N, R-7W, Sec. 25,26.</td>
<td>Poor: most of floodplain selectively cleared and grazed.</td>
</tr>
<tr>
<td>Winneshiek</td>
<td>Bluffton T-99N, R-9W, Sec. 4,5, 8,9.</td>
<td>Poor: most of floodplain cleared and in cropland.</td>
</tr>
<tr>
<td>Winneshiek</td>
<td>near Fort Atkinson T-96N, R-9W, Sec. 16,17.</td>
<td>Poor: floodplain forest cleared and in pasture.</td>
</tr>
<tr>
<td>Winneshiek</td>
<td>Upper Iowa River, Freeport to Bluffton,</td>
<td>Poor: most of floodplain cleared.</td>
</tr>
</tbody>
</table>
APPENDIX C

Management recommendations for specific federal and state lands in Iowa. Areas are listed alphabetically by county.

<table>
<thead>
<tr>
<th>Location</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allamakee County, lower Yellow River T-96N, R-3W, Sec. 29, 32, 33, 34.</td>
<td>A proposed timber harvest threatens continued Red-shoulder use of this area. This habitat must be preserved if continued Red-shouldered Hawk nesting is desired. The U.S. Fish and Wildlife Service (Gerald M. Nugent, pers. comm.) is currently developing a proposal to acquire and preserve this habitat. If the land will be managed by a federal agency, small prairie areas (1-4 ha) might be maintained by controlled burning. The Yellow River should not be dammed or channelized. Soil conservation should be encouraged in the entire watershed to reduce siltation. The nesting range should be put off limits to hikers and other human disturbances between 15 March and 15 May.</td>
</tr>
<tr>
<td>Allamakee County, Paint Creek, T-96N, R-3W, Sec. 3, 4, 5, 9, 10, 15.</td>
<td>Two pairs were observed here in early March 1978. Clearcutting of a floodplain area the previous winter apparently destroyed some habitat and caused one pair to leave. Development and logging should be discouraged in the entire area. All human disturbances should be restricted in the nesting range between 15 March and 15 May. The Iowa Conservation Commission should acquire all land adjacent to Paint Creek below Yellow River Forest and manage this land as a priority Red-shouldered Hawk management area.</td>
</tr>
</tbody>
</table>
**Location**

Allamakee County,  
Wexford Creek,  
T-97N, R-2W, Sec. 5,  
T-98N, R-2W, Sec. 32.  

Allamakee County,  
Upper Mississippi  
Wildlife Refuge,  
T-100N, R-4W, Sec. 11,  
12,13,14,23,24,26,27,  
36.  

Benton County,  
Dudgeon Lake Wildlife  
Area,  
T-85N, R-10W, Sec. 4,  
5,8,9.  

Bremer County,  
Sweets Marsh and  
Wapsipinicon River,  
T-92N, R-12W, Sec. 2,3,  
12, T-93N, R-12W,  
Sec. 26,27,34,35.  

**Recommendations**

Human encroachment has almost de­
stroyed all habitat except what  
remains on the Fish and Wildlife  
Refuge. This area could attract  
esting Red-shoulders if the refuge  
area was expanded and forest was  
allowed to grow.  

Logging should not be allowed in the  
present nesting ranges. Logging  
small areas less than 4 ha south of  
the Upper Iowa River (Sec. 23,24)  
might encourage the establishment of  
an additional pair. If possible, the  
Corps of Engineers should remove  
wing dams and other obstructions  
restricting the current in backwater  
areas. Dredge spoil should not be  
placed in present nesting ranges.  
All human activities and construction  
disturbances should be restricted  
between 15 March and 15 May (boat  
fishing in larger slouths would not  
interfere with nesting). Soil con­  
servation practices should be  
encouraged to minimize sedimentation.  

This habitat probably could be used  
by nesting Red-shoulders if managed  
for them. Forest should be allowed  
to mature. Some agricultural fields  
should be allowed to go fallow and  
others should be reduced in size,  
especially in floodplain areas near  
the Cedar River. Some small prairie  
areas could be maintained by  
controlled burning.  

This habitat probably could be used  
by nesting Red-shoulders if managed  
correctly. Forest should be allowed  
to mature and no forest cover should  
be removed. If possible, reforesta­  
tion of some adjacent areas would  
have the potential to attract  
breeding Red-shoulders. Small  
prairie and marsh habitats within the  
floodplain might be maintained by  
controlled burning.
<table>
<thead>
<tr>
<th>Location</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clayton County, mouth of Turkey River, T-91N, R-1W, Sec. 7,8, 17,18,20,21, T-91N, R-2W, Sec. 2,10,11,12,13.</td>
<td>Perimeter habitat is being destroyed by encroachment of agriculture and forest clearing. Additional land on the Turkey River floodplain should be acquired by a resource management agency to buffer the present habitat and stop destruction of the floodplain forest. Soil conservation should be encouraged along the Turkey River to reduce siltation. Human disturbances should be restricted between 15 March and 15 May. The Turkey River should not be dammed or channelized. Wing dams that restrict current in the west side channel of the Mississippi River near North Buena Vista should be removed if possible.</td>
</tr>
<tr>
<td>Clayton County, Miner's Creek, T-92N, R-2W, Sec. 20,21,29,30.</td>
<td>Motorcycle trail should be removed and motorcycle use prohibited. Wing dams or any obstructions restricting current in backwater areas should be removed. Forest should be allowed to mature.</td>
</tr>
<tr>
<td>Clayton County, Sny Magill Creek, T-94N, R-3W, Sec. 23, 26.</td>
<td>Apparently, there is no threat of timber clearing in this area. Corps of Engineers should remove all wing dams and other obstructions reducing current in Johnson Slough and other backwater inlets. Human use should be restricted between 15 March and 15 May (boat fishing in larger sloughs would not interfere with nesting).</td>
</tr>
<tr>
<td>Clinton and Scott Counties, mouth of Wapsipinicon River, T-80N, R-5E, Sec. 11, 12,13,14,15.</td>
<td>Forest clearing and development on the periphery of the refuge should be stopped if possible. Land acquisition of adjacent areas would provide buffer habitat. Human disturbances should be restricted between 15 March and 15 May. Soil conservation should be encouraged along the Wapsipinicon River to reduce sedimentation. The Wapsipinicon River should not be channelized or dammed.</td>
</tr>
</tbody>
</table>
### Location

Jackson County, Pleasant Creek Wildlife Refuge, T-85N, R-5E, Sec. 1, 2, 3, 4, 10, 11.

Louisa County, mouth of Iowa River and Lake Odessa Wildlife Management Area, T-74N, R-2W, Sec. 34, 35, T-73N, R-2W, Sec. 1, 2, 3.

### Recommendation

- Corn fields on the Refuge area should be reduced in size if possible. Corps of Engineers should remove wing dams and all obstructions reducing current in backwater areas if possible. Forest should be allowed to mature.

- Open fields should be reduced in size if possible. The area should not be logged, channelized, or dammed if breeding Red-shouldered Hawks are desired.