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Mourning Dove Breeding Habitat Status Adjacent to Federal Survey Routes

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FINAL REPORT

W-117-R-2

Mourning Dove Breeding Habitat Status Adjacent to Federal Survey Routes

Submitted by:

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August 1995

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FINAL REPORT

State of Illinois

W-117-R-2, Study 1

Project Period: 1 July 1992 through 30 June 1995

Study 1: Mourning dove breeding habitat status adjacent to federal survey routes

Prepared by Robert J. Gates, John L. Roseberry, and Alan Woolf
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Need: Annual harvest of mourning doves exceeds all other species of gamebirds in the U.S. and in Illinois. Despite the popularity and importance of mourning doves as gamebirds, methods to estimate fall flights and age/sex composition of the annual harvest have not been developed or implemented. Harvest regulations are based almost entirely on breeding population indices derived from federal call-count survey routes. There is evidence from these surveys that breeding populations have declined recently throughout much of the U.S. Loss and deterioration of habitats due to intensive agriculture and changes in land use practices have been associated with declining populations of other upland gamebirds. Habitat deterioration and land use changes have been suggested as causes of population declines that have been observed in mourning doves. However, harvest regulations continue to be relatively liberal, and excessive harvest may contribute at least partially to downward population trends. Comparative analyses of habitat and population status and trends at regional scales are needed to begin evaluating the relative importance of harvest vs. habitat influences on mourning dove breeding populations in Illinois.

Objectives:

1. Classify and map land use and availability of mourning dove breeding habitats within 0.8 km of federal call-count routes in Illinois for 1 year in each of 3 time periods; 5 years after establishment of routes (1964-68), 10-14 years later (ca. 1976-1980), and present (1988-1993).

2. Quantify and analyze the current status and recent changes in habitat and land use patterns that have occurred surrounding federal call-count routes in Illinois since they were established.

3. Compile and analyze breeding population trends from call-count data obtained from federal survey routes in Illinois.

4. Relate breeding population indices and trends derived from federal survey routes to changes in habitat, land use, and mourning dove harvest parameters in Illinois.

5. Provide recommendations to improve population and habitat management for mourning doves in Illinois and suggest future research needs.

EXECUTIVE SUMMARY

The project, Mourning Dove Population and Habitat Investigations, originally was 2 years in duration and scheduled for completion 30 June 1994. An amendment was approved April 1994 to extend the duration and date from 30 June 1994 to 30 June 1995. This project final report presents findings and conclusions that address all objectives of the study. Objectives 1 and 2 are addressed in Job 1.1, objectives 3 and 4 are addressed in Job 1.2, and the conclusions and recommendations which are the substance of this report are presented in Job 1.3.

This report is organized by job. Job 1.1 deals with geographic and temporal changes in land use surrounding mourning dove call-count routes in Illinois during 1965-1988. Temporal

and geographic analyses of breeding population indices from call-counts during 1966-1992 are presented in Job 1.2. Presentation of Job 1.2 concludes with discussion of land use changes in relation to breeding population trends. Job 1.3 presents conclusions and management implications based on results of this investigation. Scanned photography and habitat classifications are archived in a Geographic Information System at the Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, IL.

ACKNOWLEDGMENTS

Numerous people contributed to this study. We wish to thank D. D. Dolton and W. L. Kendall, U. S. Fish and Wildlife Service, Office of Migratory Bird Management for providing call-count data and advice on study design and analyses. Laboratory staff and students who contributed to the project included Shannon Horn (Graduate Research Assistant), Tracy Evans (Researcher II), MaryJo Woodruff (Researcher II), Tara Gibbs (Student Worker), Ann Walch (Student Worker), and Ross Blank-Libra (Technician). We especially thank Illinois Department of Natural Resources Upland Wildlife Program staff Larry David and John Cole for their efforts and support.

JOB 1.1. **Classification and Analysis of Habitats and Land Use**

Objectives: (1) Classify and map land use and availability of mourning dove breeding habitats within 0.8 km of federal call-count routes in Illinois for 1 year in each of 3 time periods; 5 years after establishment of routes (1964-1968), 10-14 years later (ca. 1976-1980), and present (1988-1993); and (2) quantify and analyze the current status and recent changes in habitat and land use patterns that have occurred surrounding federal call-count routes in Illinois since they were established.

INTRODUCTION

Mourning dove (Zenaida macroura) breeding populations are monitored annually through a nationwide call-count survey conducted between 20 May and 5 June by states in cooperation with the U.S. Fish and Wildlife Service (FWS). Illinois contains 20 call-count routes located along randomly selected secondary roads. Each route is 32 km long with listening stops at 1.6-km intervals along the route. The number of doves heard calling during a 3-minute time period is recorded at every stop. The number seen at and between each stop is recorded separately. Breeding population trends are estimated from total number of doves heard. This information is used to set annual harvest regulations (Dolton 1993). Data from these call-counts indicate that populations have been declining in portions of the Western,

Central, and Eastern Management Units over a 30-year period (Dolton 1995). However, Sauer et al. (1994) and Dolton (1995) concluded that Illinois dove population indices have remained stable over this time period. This project examines land use change as one possible factor associated with breeding population trends of mourning doves in Illinois. Our goals were to: 1) evaluate the current status and recent changes in habitat availability and quality for mourning doves in Illinois, and 2) investigate relationships between temporal and regional variation in habitat availability and mourning dove population indices and long-term trends in Illinois.

METHODS

Aerial Photography

Land use within 0.8 km of call-count routes was manually interpreted from black and white, panchromatic aerial photographs with acetate overlays. Four to 6 aerial photographs were typically required to provide coverage of each route. We tried to obtain the most uniform photographic coverage possible for each route during years closest to the beginning, middle, and end of the period beginning when current call-count routes were first established (1966), to when this project was first conceived (1992). Consistent coverage was available only near the end of this time period (1988) from Agricultural Stabilization and Conservation Service (ASCS) black and white, panchromatic photographs (1:40,000 scale) that were acquired from Morris

Library, Southern Illinois University at Carbondale. We used the Aerial Photography Summary Record System (APSRS) to identify photography providing coverage during the early and middle years of the 1966-1992 time period. Review of the APSRS data base revealed that photographic coverage of the Illinois call-count routes during the early and middle years was inconsistent with respect to year, season, and scale (Tables 1 and 2). We used available photographs that were most consistent with respect to scale and spectral quality within ranges of years during the early (1965-1973) and middle (1977-1982) time periods. Black and white panchromatic photographs from ASCS (1:40,000 scale) provided coverage for 18 of 20 routes during 1977-1982; black and white panchromatic photographs, from ASCS (1:20,000 scale) also provided coverage for 19 of 20 call-count routes during 1965-1973. Alternative sources were substituted for ASCS photographs to provide coverage of the remaining routes (Tables 1 and 2).

Photograph Interpretation

Aerial photographs were interpreted separately for each route, based primarily on criteria in Avery (1977) and Lillesand and Kiefer (1987). Eighteen surface features were identified including cropland, herbaceous vegetation, deciduous and coniferous hedgerow, deciduous and coniferous closed canopy forest, deciduous and coniferous open canopy forest, permanent water, homestead, urban, orchard/nursery, herbaceous and wooded drainage, golf course, barren, wetland, and road/railway. These

18 features were later combined into 7 feature classes described below.

Cropland.--This class included annually tilled uplands planted with row crops or small grains. Rows appearing as alternating light and dark bands indicated cultivation or tillage (Avery 1977). Homogenously textured features without visible rows were classified as cropland if evidence of haying (e.g. hay bales) was not obvious.

Herbaceous.--This class included pastures, hay fields, grasslands, early idle old fields, and herbaceous drainages. Features devoid of woody vegetation were generally classified as herbaceous land if they lacked evidence of cultivation. Smooth (no crop rows) or plaid (mowed hay fields) textured features were classified as herbaceous land (Avery 1977). Presence of cattle paths or stock-watering ponds aided in distinguishing pasture from row cropland. Non-woody features <10 m wide where surface water was absent were interpreted as herbaceous drainages.

Closed Canopy Forest.--This class consisted of forests or woodlots where tree canopies provided continuous ground coverage. Coniferous closed canopy forest was distinguished from deciduous closed canopy forest by differences in tone and texture (Am. Soc. Photogram. 1960). Forest features were classified as deciduous forest unless the distinction between deciduous and coniferous trees was obvious.

Open Canopy Forest.--This class included idle mid- to late succession old fields where woody vegetation was present, and

other areas such as pastured woodlots where tree canopies did not completely obstruct the ground layer. Also included were orchards and nurseries that were characterized by uniform spacing of trees. When possible, coniferous was distinguished from deciduous open canopy forest, but no distinction was made between deciduous or coniferous trees in orchards and nurseries.

Hedgerow/woody Riparian.--Hedgerows included any linear strip of woody vegetation ≤25 m wide. Such features often were located within or adjacent to row crop or herbaceous lands. Woody riparian features included drainages that were distinguished from herbaceous drainages by presence of woody vegetation. Woody riparian features appeared similar to hedgerows, but were distinguished by their nonlinear meandering course, or when a drainage ditch was visible within the feature.

Water/wetlands.--This feature class included areas that were permanently or semipermanently inundated with surface water. Permanent water included ponds, lakes, rivers, streams, and ditches ≥10 m in width where surface water was visible throughout the feature. Lakes and ponds were characterized by distinct shorelines. Streams and rivers were identified by their meandering courses. Drainage ditches were defined as narrow linear corridors passing through or between fields and used to drain surface water. Grassy waterways and vegetated zones surrounding cropland ditches were included in the herbaceous feature class. Semipermanent wetlands were identified by presence of emergent vegetation (e.g. Typha spp. and/or

Phragmites spp.) that was typically interspersed with open water. Forested features were also included in this category if surface water was visible.

Developed.--This feature class included non-agricultural areas that were heavily impacted by human habitation and other activities (urban, golf course, homestead, roads, railways, and barren). Homesteads included residences, surrounding yards, and associated structures (barns, garages, swimming pools, etc.). These features were typically marked on county maps that were consulted during interpretation. Urban was defined as areas where most of the land was covered by construction, including towns, cities, suburbs, and commercial/industrial complexes isolated from urban areas (i.e. airports). Subdivisions, villages, towns, and cities were separated from homesteads based on aggregation of physical structures. Urban features were generally depicted on county maps, minimizing subjectivity in defining boundaries. Barren was defined as land devoid of vegetation with limited capacity to support life, including active mines, construction sites, gravel pits, and livestock feed lots. Roads and railways were recognizable as thin, light gray lines that were identified on county maps. Adjacent herbaceous and woody vegetation was included in classes listed above.

Digitization.--Aerial photographs of the routes from 1988 were digitized using a color optical scanner and the Map and Image Processing System (MIPS, MicroImages, Inc., Lincoln, NE). Scanning at 79 dots/cm produced raster images with 25 m^2 ground

resolution. Scanned images were mosaiced using MIPS and georeferenced to the Universal Transverse Mercator (UTM) projection. The call-count route was digitized as a vector line over the mosaiced images, and a 0.8-km buffer surrounding the route was overlayed as a vector polygon. The buffer zone was plotted to a binary raster to limit digitization of surface features within the buffer zone.

Surface features interpreted from 1988 aerial photographs were digitized by tracing their borders and assigning them to 1 of 18 feature types. The 1988 classified images were then manually edited to incorporate changes identified after interpretation of photographs from the 1977-1982 time period. The 1977-1982 classified images were similarly edited to include changes identified in 1965-1973 photographs. This procedure minimized the time needed to repeatedly scan and digitize each photograph.

Data Analyses

Each of the 20 call-count routes was assigned to 1 of 3 geographic regions of Illinois, based on their locations within the 10 wildlife management units (WMU) recognized by the Illinois Department of Natural Resources (Table 3). The north-central region included routes (n = 10) within counties located in the Grand Prairie and Northeast Moraine WMU's; the southern region included routes (n = 6) within the Mississippi Border-North, Southern Plain, and Wabash Border WMU's; and the west-central

region included routes (n = 4) within the Mississippi Border-North, Western Prairie, and Central Sand Prairie WMU's (Fig. 1). Only the Shawnee Hills and Northwest Hills WMU's were not represented in the 20 Illinois call-count routes.

Feature class composition was expressed as percentages within each route and time period. We compared percent composition of feature classes among 3 time periods (1965-1973, 1977-82, and 1988) across all 20 routes, and within each of the 3 geographic regions (north-central, west-central, and southern). Similarly, we compared differences in land use among the 3 geographic regions with percent feature class composition averaged across years within routes, and separately within years. We also determined absolute changes in total areas of each feature class for each route among all time periods (1 vs. 2, 2 vs. 3, and 1 vs. 3). Changes in total areas of each feature class were averaged for each region and compared separately for each of the 3 time periods.

A change detection analysis was conducted to determine transformations of individual picture elements (pixels) among the 7 feature classes during successive time periods. Each 25-m^2 raster image pixel was assigned a number from 01 to 18 corresponding to an individual feature type. Classified images of each call-route were co-registered, overlaid, and merged, forming a 32-bit raster image comprised of individual pixels with digital values that represented feature type sequences in successive time periods. A spatial manipulation language (SML)

program converted raster data to a text file for output to a database. Database summaries provided estimates of total areas of each feature type that remained unchanged along each route, and areas of each feature type that were converted to another feature type in succeeding time periods. These data were later aggregated into the 7 feature classes described previously to produce 2 change detection matrices for each call-count route; one representing changes during 1965-1973 to 1977-1982 (interval 1), the other representing changes during 1988-1982 to 1988 (interval 2). The 40 matrices were combined by adding elements within regions, so that changes could be compared among regions within the 2 time intervals.

Data did not meet the assumption of normality so we used Kruskal-Wallis tests to compare percent feature class composition among and within regions and time periods. Kruskal-Wallis tests also were used to compare mean changes in total areas of each feature type between time periods among regions, and between time periods within and across regions. Dunn's test (Dunn 1964) was used to separate differences among more than 2 groups when global tests were significant. With only 20 call-count routes in Illinois, statistical tests had relatively low power, and were therefore conservative in detecting differences. The objective of this study was to identify possible relationships between land use and population changes, so we accepted a higher Type I error rate to minimize Type II error. Consequently, statistical comparisons were conducted with $\alpha = 0.10$.

RESULTS

Total areas of each feature class surrounding call-count routes in north-central, west-central, and southern regions are summarized in Appendixes A, B, and C, respectively. Comparisons of regional and temporal variation in land use surrounding Illinois call-count routes that follow are based on data summarized in Appendixes A-C.

Regional Differences

Mean (averaged over 3 time periods) percent area surrounding call-count routes differed among geographic regions for cropland (Wilcoxon test, $\underline{X}^2 = 6.69$, df = 2, $\underline{P} = 0.035$), closed canopy forest ($\underline{X}^2 = 9.01$, df = 2, $\underline{P} = 0.011$), hedgerow/woody riparian, ($\underline{X}^2 = 10.89$, df = 2, $\underline{P} = 0.004$), and herbaceous ($\underline{X}^2 = 7.19$, df = 2, $\underline{P} = 0.028$) feature classes. Percent cropland, closed canopy forest and hedgerow/woody riparian also differed among regions within each time period ($\underline{X}^2 \geq 5.25$, df = 2, $\underline{P} \leq 0.072$). Open canopy forest also differed among regions during 1977-1982 ($\underline{X}^2 = 5.74$, df = 2, $\underline{P} = 0.057$), and the herbaceous class differed among regions during 1965-1972 and 1988 ($\underline{X}^2 \geq 5.15$, df = 2, $\underline{P} \leq 0.076$). Combining time periods, routes in north-central Illinois were surrounded by more cropland, less closed canopy forest, and less hedgerow/woody riparian habitat than routes in southern Illinois (Dunn's test, $\underline{P} \leq 0.10$; Table 4). North-central routes also were surrounded by less herbaceous habitat than west-central routes (Dunn's test, $\underline{P} < 0.10$). Feature class composition did not

differ between southern and west-central routes (Dunn's test, $P > 0.10$).

Temporal Changes

Cropland and closed canopy forest surrounding call-count routes increased from 1965-1973 to 1988 in all regions, while open canopy forest and herbaceous habitats declined (Fig. 2). Net changes were greatest for cropland, the feature class that comprised the largest proportion of area surrounding routes (Table 4). However, with net change expressed as percent of total area present during 1965-1973, increases in cropland were small; $\bar{x}$ = 1.9% for north-central, $\bar{x}$ = 4.5% for west-central, and $\bar{x}$ = 6.9% for southern routes (Appendixes A-C). Closed canopy forest comprised 5.4% of total area surrounding call routes during 1965-1973, but mean percent change was substantial. Closed canopy forest increased by means of 29.2% in north-central, 41.8% in west-central, and 1.5% in southern Illinois. Open canopy forest comprised a smaller percent (3.4%) of total area during 1965-1973, but declined by means of 42.5% in north-central, 48.6% in west-central, and 56.2% in southern Illinois. Comprising 11.3% of total area, herbaceous declined by means of 35.0% in north-central, 12.8% in west-central, and 17.7% in southern Illinois.

Net changes in hedgerow/woody riparian and water/wetland were small, but these feature classes comprised <1% of total area surrounding call routes (Table 4). Percent losses of

hedgerow/woody riparian habitat averaged by region amounted to 30.2% in north-central, 18.4% in west-central, and 7.3% in southern Illinois (Appendixes A-C). Water/wetland increased by means of 4.4% in north-central, 11.1% in west-central, and 3.9% in southern Illinois. Developed (3.9% of total area) increased by means of 16.4% and 4.7% in north-central and southern Illinois, but declined by a mean of 9.4% in west-central Illinois.

Temporal patterns of land use change were similar before and after 1977-1982 (Figs. 3-4), with some exceptions. There was a smaller ($\underline{X}^2 = 3.00$, $\underline{P} = 0.083$) mean net increase (combining all routes) in cropland during interval 1 (43.2 ha/route) than during interval 2 (105.0 ha/route). The change in mean hedgerow/woody riparian area was greater ($\underline{X}^2 = 11.25$, $\underline{P} < 0.001$) during interval 2 (-6.4 ha/route) than during interval 1 (+0.6 ha/route).

North-central Illinois routes lost 18.3 ha cropland/route during interval 1 but gained 106.5 ha cropland/route during interval 2 ($\underline{X}^2 = 4.17$, $\underline{P} = 0.041$). Closed canopy forest surrounding north-central routes increased more ($\underline{X}^2 = 2.77$, $\underline{P} = 0.096$) during interval 1 (39.9 ha/route) than during interval 2 (10.7 ha/route). Herbaceous declined 19.0 ha/route during interval 1, compared to a loss of 114.0 ha/route during interval 2 ($\underline{X}^2 = 3.02$, $\underline{P} = 0.082$). Hedgerow/woody riparian area surrounding routes in west-central Illinois increased by 4.9 ha/route during interval 1, but declined by 12.3 ha/route during interval 2 ($\underline{X}^2 = 5.33$, $\underline{P} = 0.021$). Net changes in feature class

composition did not differ between intervals in southern Illinois ($\underline{X}^2 \leq 2.56$, $\underline{P} \geq 0.109$).

Routes in all 3 regions generally experienced similar ($\underline{X}^2 \leq 4.38$, $\underline{P} \geq 0.112$) changes in areas of each feature class during each interval (Figs. 3-4). Mean net changes in feature class area differed among regions only for open canopy forest and hedgerow/woody riparian during interval 2 ($\underline{X}^2 \geq 5.46$, $\underline{P} \leq 0.065$). Routes in the west-central region lost more open canopy forest (87.1 ha/route) than routes in the north-central region (27.4 ha/route), and more hedgerow/woody riparian area (12.3 ha/route) than routes in the north-central (4.8 ha/route) and southern (5.1 ha/route) regions during interval 2 (Dunn's test, $\underline{P} < 0.10$).

Net changes in feature class area (Figs. 2-4) were small in relation to total land area within 0.8 km of call-count routes. Consequently, net changes in feature class areas did not generally cause percent feature class composition (Table 4) to differ among the 3 time periods ($\underline{X}^2 \leq 2.33$, df = 2, $\underline{P} \geq 0.312$). Only percent open canopy forest differed among time periods with regions combined ($\underline{X}^2 = 4.96$, df = 2, $\underline{P} = 0.084$) declining from 3.4% during 1966-1973 to 1.6% in 1988 (Dunn's test; $\underline{P} < 0.10$). There were no differences ($\underline{X}^2 \geq 2.67$, df = 2, $\underline{P} \geq 0.264$) in percent feature class composition among time periods within regions.

Change Detection

Change detection analyses revealed that 81.4-89.6% of the area surrounding call-count routes in each region remained in the same feature class during interval 1 (Tables 5-7). Larger proportions of land surrounding call-routes remained unchanged during interval 2 (86.9-93.2%). Changes in feature class composition were greatest surrounding routes in west-central Illinois (13.1-18.6%), followed by southern (9.6-17.1%) and north-central Illinois (6.8-10.4%). Estimates of land area that experienced no change in feature class were conservative because some changes could be attributed to inexact interpretation and digitization of feature boundaries.

The following paragraphs separately describe changes in land use that occurred surrounding routes in each region during intervals 1 and 2. Changes from one feature class in an earlier time period to a feature class in the following time period were expressed as percentages obtained by dividing individual row/column elements by their respective column totals in Tables 5-7. Similarly, prior composition of a given feature class in a later time period was expressed as percentages obtained by dividing individual row/columns elements by their respective column totals in Tables 5-7.

North-central Region.--Cropland surrounding north-central Illinois routes declined 183 ha during interval 1 with 95.1% remaining unchanged. Conversion of cropland to herbaceous (4.0%) barely exceeded amounts converted to cropland from other feature

classes. The 43,594 ha of cropland present in 1977-1982 included 4.0% that was herbaceous and <1.0% each that was a different feature class during 1965-1973. Cropland increased 1,065 ha during interval 2, when 98.1% of cropland remained unchanged and only 1.5% was converted to herbaceous cover. Cropland present in 1988 consisted of 3.9% that was previously herbaceous, and <0.1% each of other feature classes.

Open canopy forest declined 346 ha during interval 1. Only 43.9% of open canopy forest remained unchanged, while 33.6% became closed canopy forest, 10.9% changed to herbaceous, 5.3% was converted to cropland, and 4.8% was developed. The 923 ha of open canopy forest in 1977-1982 included 18.0% that was previously herbaceous, 7.2% that was cropland, 7.1% that was closed canopy forest, 3.1% that was developed, and 2.7% that was water/wetland. Open canopy forest declined an additional 273 ha during interval 2, when 51.6% remained unchanged. Open canopy forest changed to closed canopy forest (18.0%), developed (16.7%), herbaceous (7.5%), or cropland (5.6%). Open canopy forest present in 1988 included 12.4% that was herbaceous, 10.0% that was closed canopy forest, 3.1% that was cropland, and 1.0% that was hedgerow/woody riparian during 1977-1982.

Closed canopy forest increased by 399 ha during interval 1; 84.4% of the feature class remained intact, 5.2% became open canopy forest, 2.5% changed to herbaceous, and 2.2% was converted to cropland. The 1,668 ha of closed canopy forest in 1977-1982 was previously open canopy forest (26.0%), herbaceous (6.9%), or

water/wetland (1.2%). Closed canopy forest increased 109 ha during interval 2 when 91.4% remained intact, 3.9% became open canopy forest, and 2.4% changed to herbaceous. Closed canopy forest in 1988 included lands that were previously open canopy forest (9.3%), herbaceous (2.5%), and hedgerow/woody riparian (1.2%).

There was little change (-8 ha) in hedgerow/woody riparian during interval 1, despite only 69.2% of the feature class remaining unchanged. Hedgerow/woody riparian was converted to cropland (16.7%), herbaceous (7.6%), and closed (3.3%) and open (1.4%) canopy forest, but losses were offset by additions from other feature classes. The 262 ha of hedgerow/woody riparian in 1977-1982 included lands that were previously cropland (13.5%), herbaceous (9.4%), or closed (3.2%) and open (1.9%) canopy forest. Hedgerow/woody riparian declined 48 ha during interval 2; 67.1% remained intact, 13.2% was converted to cropland, 8.4 and 2.4% became closed or open canopy forest, 7.2% changed to herbaceous, and 1.4% was developed. These losses were only partially offset by additions from other feature classes. Hedgerow/woody riparian in 1988 was previously classified as cropland (7.4%), herbaceous (4.8%), or open (3.3%) and closed (2.2%) canopy forest.

Herbaceous declined by 189 ha during interval 1, when 50.7% of the feature class remained unchanged. The rest was mostly converted to cropland (38.6%), developed land (3.3%), or open (3.7%) and closed (2.6%) canopy forest. The 4,295 ha of

herbaceous present in 1977-1982 included lands that were previously cropland (40.3%), closed canopy forest (3.3%), or water/wetland (1.7%). An additional 1,135 ha of herbaceous was lost during interval 2, when only 54.1% of the feature class was intact. Herbaceous lands in 1977-1982 changed to cropland (40.5%), developed (2.0%), or open (1.9%) and closed (1.0%) canopy forest. Herbaceous lands in 1988 were previously cropland (20.6%) and open (2.2%) and closed (1.3%) canopy forest.

Water/wetland declined 89 ha during interval 1, when 58.2% of the feature class was unchanged. Water/wetland changed mostly to herbaceous (22.6%), open (7.6%) and closed (6.0%) canopy forest, cropland (4.1%), and developed (1.4%). The 243 ha of water/wetland present in 1977-1982 included lands previously classified as herbaceous (10.3%), closed (4.0%) and open (1.0%) canopy forest, cropland (2.9%), or developed (2.4%). Water/wetland declined 13 ha during interval 2, when 81.2% of the feature class was unchanged. Water/wetland was converted mostly to herbaceous (14.5%), cropland (2.6%), and closed canopy forest (1.1%). Water/wetland in 1988 included lands that were previously herbaceous (5.4%), closed canopy forest (1.9%), and cropland (1.2%).

Developed land increased by 436 ha during interval 1; 94.3% of the feature class was left intact, 2.7% was converted to cropland, 1.4% became open canopy forest, and 1.2% changed to herbaceous. The 2,529 ha of developed land present in 1977-1982 included lands previously classified as cropland (10.6%),

herbaceous (5.9%), or closed (2.6%) and open (2.5%) canopy forest. An additional 307 ha was developed during interval 2, when 97.9% of the feature class remained intact. Only 1.2% of developed land was converted to cropland. Developed in 1977-1982 included lands previously classified as open canopy forest (5.4%), cropland (3.7%), and herbaceous (3.0%).

West-central Region.--Cropland surrounding west-central Illinois routes increased 35 ha during interval 1 when 90.1% remained intact. Conversion of cropland to herbaceous (9.3%) was offset by an equivalent change of herbaceous to cropland (9.4%). Cropland remained relatively (95.2%) intact during interval 2, with 4.4% converted to herbaceous. Another 617 ha was added to 14,640 ha of cropland present in 1977-1982. This increase was mostly due to conversion of herbaceous to cropland; 7.6% of cropland in 1988 was previously herbaceous.

Open canopy forest declined 129 ha during interval 1. Only 54.1% of open canopy forest remained intact; 30.7% became closed canopy forest, 9.5% changed to herbaceous, and 4.2% was converted to cropland. These losses were partially offset by conversion of other feature classes to open canopy forest. The 811 ha of open canopy forest in 1977-1982 included 28.0% that was herbaceous, 6.6% that was closed canopy forest, and 1.8% that was cropland. Open canopy forest declined 349 ha during interval 2. Only 44.0% remained intact, 31.3% became closed canopy forest, 15.7% changed to herbaceous, and 7.3% was converted to cropland. Open canopy

forest in 1988 included 10.7% that was previously herbaceous, 6.2% that was closed canopy forest, and 4.2% that was cropland.

Closed canopy forest increased 229 ha during interval 1, largely due to conversion from open canopy forest. Closed canopy forest was 85.9% intact, 5.9% changed to open canopy forest, 5.1% became herbaceous, and 1.6% was converted to cropland. The 1,139 ha of closed canopy forest in 1977-1982 included land that was previously open canopy forest (25.4%) and herbaceous (4.4%). Closed canopy forest increased 207 ha during interval 2; 90.0% of the feature class remained intact, 3.7% became herbaceous, 3.1% was converted to cropland, and 2.5% changed to open canopy forest. Closed canopy forest in 1988 included lands that were previously open canopy forest (18.9%), herbaceous (1.9%), hedgerow/woody riparian (1.5%), and cropland (1.0%).

Hedgerow/woody riparian increased 20 ha during interval 1. Hedgerow/woody riparian was 75.7% unchanged; 12.7% was converted to cropland, 4.8% became herbaceous, and 4.3 and 2.0% changed to closed and open canopy forest. The 181 ha of hedgerow/woody riparian in 1977-1982 included lands that were previously herbaceous (17.0%), cropland (8.7%), or closed (3.3%) and open (2.7%) canopy forest. Hedgerow/woody riparian declined 49 ha during interval 2, when 53.5% of the feature class was intact. The rest was converted to cropland (20.2%), herbaceous (12.1%), or closed (11.1%) and open (2.4%) canopy forest. Hedgerow/woody riparian in 1988 included lands that were previously cropland

(10.4%), herbaceous (5.8%), open canopy forest (5.0%), closed canopy forest (4.0%), and developed (1.2%).

Herbaceous declined 77 ha during interval 1; only 48.5% remained intact, 41.0% was converted to cropland, and 6.8% and 1.5% became closed and open canopy forest. Losses would have been greater except that the 3,250 ha of herbaceous in 1977-1982 also included 41.6% that was previously cropland, 3.8% that was developed, and 2.7% and 1.4% that was open and closed canopy forest. Herbaceous again declined during interval 2 (371 ha) when 60.6% was unchanged, 35.8% was converted to cropland and 1.5% became open canopy forest. Herbaceous in 1988 also included lands that were converted from cropland (22.2%), open (4.4%) and closed (1.5%) canopy forest, and developed (2.5%).

Water/wetland increased 17 ha during interval 1; 88.4% remained intact; 8.6% changed to herbaceous and 1.9% was converted to cropland. Conversion of other feature classes to water/wetland exceeded losses. The 245 ha of water/wetland in 1977-1982 included lands that were previously cropland (9.2%) herbaceous (5.9%), or developed (1.0%). Water/wetland remained 95.9% intact during interval 2, only 2.4% changed to herbaceous. There was an additional 14 ha of water/wetland in 1988, consisting of land that was previously herbaceous (5.9%), open canopy forest (1.3%), and cropland (1.0%).

Developed declined 95 ha during interval 1, with 83.2% remaining unchanged, 12.6% becoming herbaceous, and 3.5% converted to cropland. The 885 ha of developed land present in

1977-1982 included lands previously classified as cropland (3.2%) and herbaceous (2.9%). Developed declined an additional 74 ha during interval 2; 87.0% was unchanged, 8.2% became herbaceous, and 3.4% was converted to cropland. Developed in 1988 included lands that were previously herbaceous (2.4%) and cropland (1.7%).

Southern Region.--Cropland surrounding routes in the southern region increased 1,013 ha during interval 1. Cropland was relatively intact (92.8%), but 6.2% changed to herbaceous. The 22,385 ha of cropland in 1977-1982 included lands that were previously herbaceous (8.9%) and open canopy forest (1.1%). Cropland declined 412 ha during interval 2; 95.9% of cropland was unchanged, 3.6% became herbaceous. Cropland in 1988 mostly included lands that were previously herbaceous (3.9%).

Open canopy forest declined 321 ha during interval 1, when 46.7% was unchanged. Open canopy forest mostly changed to closed canopy forest (25.3%), cropland (13.4%), or herbaceous (12.6%). The 1,161 ha of open canopy forest in 1977-1982 included lands that were previously closed canopy forest (20.6%), herbaceous (15.5%), or cropland (2.9%). An additional 476 ha of open canopy forest was lost during interval 2 when 46.7% was unchanged, 33.5% became closed canopy forest, 10.2% changed to herbaceous, and 7.9% was converted to cropland. These losses were not offset by conversion of other feature classes to open canopy forest. Open canopy forest in 1988 included lands that were previously

herbaceous (9.6%), closed canopy forest (5.7%), and cropland (4.0%).

Closed canopy forest declined 127 ha during interval 1, when 81.9% was unchanged, 6.8% was converted to cropland, 6.4% became open canopy forest, and 3.8% became herbaceous. The 3,591 ha of closed canopy forest in 1977-1982 included lands that were previously open canopy forest (10.4%) and herbaceous (3.0%). Closed canopy forest increased 227 ha during interval 2 when 94.7% remained intact, 1.7% was converted to cropland, and 1.4% changed to herbaceous. Closed canopy forest in 1988 included lands that were previously open canopy forest (10.1%) and herbaceous (1.0%).

There was no change in hedgerow/woody riparian during interval 1; 76.5% remained intact, 14.2% was converted to cropland, 5.9% changed to herbaceous, and 1.8% and 1.2% became closed and open canopy forest. These losses were offset by conversion from other feature classes. The 524 ha of hedgerow/woody riparian in 1977-1982 included lands that were previously cropland (10.4%), herbaceous (7.6%), and closed (3.5%) and open (2.2%) canopy forest. Hedgerow/woody riparian declined 36 ha during interval 2; 84.8% remained intact, 5.8% was converted to cropland, 3.6% changed to herbaceous, 4.4% and 1.2% became closed and open canopy forest, and 3.6% was developed. Hedgerow/woody riparian in 1988 included lands that were previously cropland (3.4%), closed canopy forest (2.6%), and herbaceous (2.1%).

Herbaceous declined 622 ha during interval 1, when only 47.4% remained intact. Herbaceous changed mostly to cropland (45.2%) or open (4.0%) and closed (2.4%) canopy forest. Changes of other feature classes to herbaceous partially offset losses. The 3,872 ha of herbaceous cover present in 1977-1982 included 34.2% that was previously cropland, 4.8% that was open canopy forest, and 3.7% that was closed canopy forest. Herbaceous declined 212 ha during interval 2 when 67.5% remained intact and 28.5% was converted to cropland. An additional 1.7% and 1.0% changed to open and closed canopy forest. Conversion of other feature classes to herbaceous exceeded losses. Herbaceous present in 1988 included 22.3% that was previously cropland, 3.2% that was closed canopy forest, and 1.3% that was closed canopy forest.

Despite little change (+8 ha) during interval 1, only 70.6% of water/wetland was unchanged. Conversions to herbaceous (12.4%), cropland (7.4%), closed (4.4%), and open (3.3%) canopy forest were offset by changes of other feature classes to water/wetland. The 209 ha of water/wetland in 1977-1982 included 12.4% that was herbaceous, 9.5% that was cropland, and 4.6% and 4.4% that was closed and open canopy forest. Water/wetland increased by 36 ha during interval 2, when 91.6% remained unchanged, 4.1% became herbaceous, and 2.6% was converted to cropland. Water/wetland in 1988 included 10.9% that was previously closed canopy forest (10.9%), herbaceous (6.0%), and cropland (3.5%).

Developed increased 48 ha during interval 1; 93.6% remained intact, 2.9% became herbaceous, and 2.8% was converted to cropland. Conversion from other feature classes surpassed losses; 1,147 ha of developed in 1977-1982 included lands that were previously cropland (5.7%) and herbaceous (2.5%). Developed changed little (-5 ha) during interval 2 when 94.4% was unchanged, and only small areas were converted to herbaceous (2.8%) and cropland (2.2%). Developed lands in 1988 included lands that were previously herbaceous (2.2%) and cropland (1.8%).

DISCUSSION

Some consistent patterns emerged from analyses of land use surrounding mourning dove call-count routes in Illinois. First, most of the variation in land use surrounding routes was geographical rather than temporal. Geographical differences among routes were broadly representative of statewide variation in land use patterns (Illinois Conservation Needs Committee 1970). North-central Illinois routes were characterized by a more intensely agricultural landscape dominated by row cropland and herbaceous cover, with limited amounts of woody vegetation. West-central and southern Illinois routes were surrounded by less cropland and more herbaceous and woody cover than north-central Illinois routes. Southern Illinois routes were further distinguished from north-central and west-central Illinois routes in having more than twice the amount of closed canopy forest. However, land use surrounding routes in all regions was still

predominantly agricultural, consisting of >80% cropland and herbaceous and <2% of water/wetland. There was <5% permanent human development, reflecting the predominantly rural landscapes in which call-count routes were established. Less than 20% of the area surrounding call-count routes experienced changes in land use between successive time periods. More change occurred before 1977-1982 than occurred later. Overall landscape stability was attributed mostly to small proportional changes in row cropland, the most extensive land use type surrounding call-count routes throughout Illinois. Nevertheless, substantial net changes occurred in herbaceous, closed and open canopy forest, and hedgerow/woody riparian, although these land use types comprised much smaller proportions of surrounding areas than did cropland. Changes in these land use types were indicative of changing land use patterns since mourning dove call-count routes were established in Illinois.

There was considerable interchange between cropland and herbaceous that likely indicated periodic idling and return to production of annually tilled cropland. Net losses of cropland that occurred during 1965-1973 to 1977-1982 in north-central Illinois (18 ha/route), and during 1977-1982 to 1988 in southern Illinois (69 ha/route), were due almost entirely to conversion to herbaceous cover. These changes were consistent with short-term (1-2 years) diversions of cropland to fallow fields or other uses that occurred in Illinois under federal agriculture set-aside programs in effect during the 1960's and early 1970's (Warner and

Onstad 1994). The largest increases in cropland occurred during 1965-1973 to 1977-1982 in southern Illinois (169 ha/route) and during 1977-1982 to 1988 in north-central Illinois (106 ha/route). These increases were due almost entirely to conversion of herbaceous to cropland, although some open canopy forest also became cropland in southern Illinois during the earlier time period. Cropland surrounding west-central routes increased during 1965-1973 (9 ha/route) and 1977-1982 (154 ha/route), almost entirely due to cultivation of herbaceous lands.

Most pronounced were changes in herbaceous cover. North-central and west-central Illinois each lost 19 ha/route of herbaceous cover during 1965-1973 to 1977-1982, mostly due to conversion to cropland. Losses also occurred to open and closed canopy forest, and to developed land use types in north-central and west-central Illinois. Losses were greater in southern Illinois, where herbaceous lands declined 104 ha/route, mostly due to conversion to cropland, but some herbaceous land also succeeded to closed and open canopy forest. Greater losses of herbaceous land occurred in north-central (113 ha/route) and west-central (93 ha/route) Illinois during 1977-1982 to 1988. Herbaceous was converted mostly to cropland and open canopy forest in west-central Illinois, and to cropland, developed, and open and closed canopy forest in north-central Illinois. Net loss of herbaceous land in southern Illinois was lower during 1977-1982 to 1988, averaging 35 ha/route. Nearly all of the loss

of herbaceous land was accounted for by conversion to cropland in southern Illinois.

Generally greater net losses of herbaceous during 1977-1982 to 1988 reflected the relatively small acreages of cropland that were enrolled in short-term or intermediate (3-5 year) federal set-aside programs in Illinois during the mid 1970's to mid 1980's (Warner and Onstad 1994). Relatively small acreages of Illinois farmland were enrolled in intermediate or long-term (>5 years) set-aside programs after the mid-1960's. Long-term diversion of cropland from production did not begin until the Conservation Reserve Program (CRP) was implemented under the 1985 Food Securities Act (Farm Bill). Consequently, we detected very little conversion of cropland to herbaceous cover from 1988 aerial photographs. Interpretation of more recent aerial photography would likely reveal the full impact of CRP on land use changes surrounding mourning dove call-routes. We expect that substantial acreages of cropland were converted to herbaceous cover during the late 1980's to early 1990's, especially in southern and west-central Illinois where there was greater participation in CRP than in north-central Illinois (Roseberry and David 1994).

Nearly as predominant were changes in woody cover during 1965-1973 to 1988. Open canopy forest declined during both time intervals in each regions of the state. Loss of open canopy forest was mostly due to conversion to closed canopy forest, reflecting succession of idle shrublands and savannahs to more

mature forest types. Much smaller proportions of open canopy forest were also lost to herbaceous, cropland, and/or developed land use types.

Loss of open canopy forest was more than offset by increases in closed canopy forest and/or hedgerow/woody riparian in north-central and west-central Illinois, so total woody cover increased by 4 and 30 ha/route, respectively, in these regions during 1965-1973 to 1977-1982. Conversions of herbaceous and water/wetland in north-central Illinois, and herbaceous and cropland in west-central Illinois, caused increases in closed canopy forest that exceeded losses of open canopy forest. However, closed canopy forest declined in southern Illinois with conversion to crop and herbaceous lands, and reversion to open canopy forest. The result was that total woody cover surrounding southern Illinois routes declined 75 ha/route during 1965-1973 to 1977-1982.

Open canopy forest continued to decline due to succession to closed canopy forest and clearing to herbaceous and cropland during 1977-1982 to 1988. Gains of closed canopy forest did not keep pace with losses of open canopy forest and hedgerow/woody riparian. Consequently, woody cover declined in all regions, with net losses of 48 ha/route occurring in southern and west-central Illinois, and 21 ha/route in north-central Illinois. Hedgerow/woody riparian was converted mostly to cropland and herbaceous in all regions, although some also became incorporated with patches of closed and open canopy forest.

Increases in woody cover surrounding call-count routes in north-central and west-central Illinois during 1965-1973 to 1977-1982 can be at least partially attributed to changing agricultural practices. Iverson and Schwartz (1994) reported that forested area in Illinois increased 10% between 1962 and 1985, primarily due to reduced cattle production and subsequent conversion of hayland and pasture to secondary forest. South-central Illinois was the only region where Iverson and Schwartz (1994) noted a decline in forest cover between 1962 and 1985. We also observed losses of closed canopy forest surrounding call-count routes in southern Illinois during 1965-1973 to 1977-1982. However, contrary to Iverson and Schwartz (1994) we found a net loss of woody cover in all regions between 1977-1982 and 1988.

Modest increases in water/wetland occurred in southern (7 ha/route) and west-central (8 ha/route) Illinois during 1965-1973 to 1988, despite widespread drought that occurred in the midwestern United States in 1988 (Roseberry 1989). Water/wetland increased due to conversion from a variety of land use types including cropland, herbaceous, closed and open canopy forest, and developed. Water/wetland declined 10 ha/route in north-central Illinois during 1965-1973 to 1988, mostly due to conversion to herbaceous, closed and open canopy forest, cropland, and developed. Losses of water/wetland in north-central Illinois could have been due to drainage associated with intensified agriculture in the region. Losses of water/wetland in north-central Illinois declined during 1977-1982 to 1988,

perhaps due to elimination of direct and indirect government support for wetland drainage and greater emphasis on conservation of this diminishing resource. A cynical but more plausible conclusion is that very little wetland area was left to drain in north-central Illinois after 1977-1982. Increases in water/wetland in west-central and southern Illinois were likely associated with construction of small ponds, lakes, and other impoundments. Other changes could have been associated with variations in moisture conditions between different photograph acquisition dates.

Changes in developed lands surrounding call-count routes during 1965-1973 to 1988 probably reflected changes in size and distribution of the human population in rural regions of Illinois. Developed land increased 74 ha/route in north-central Illinois, largely through development of cropland and herbaceous during 1965-1973 to 1977-1982, and development of open canopy forest and cropland during 1977-1982 to 1988. West-central Illinois lost 42 ha/route of developed land during 1965-1973 to 1988, almost entirely due to conversion to herbaceous and cropland. Changes in developed land surrounding southern Illinois routes were minimal (7 ha gained/route).

Changing land use patterns surrounding mourning dove call-count routes during 1965-1988 generally paralleled statewide trends previously documented for Illinois (Illinois Department of Energy and Natural Resources 1994). Other changes also have occurred that we were unable to detect from aerial photography.

Agricultural practices have changed in Illinois since the mid-1960's. Similar to other midwestern states, Illinois agriculture has shifted from small farms that produced a diversity of crops including cattle and small grains, to larger more specialized cash grain operations (Warner and Onstad 1994). Corn and soybean production has increased with declines in small grain acreages and dramatic increases in acreages planted to soybeans since the 1960's. Other changes also have occurred, including implementation of conservation tillage and increased application of agricultural pesticides.

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Table 1. Dates of black and white aerial photographs acquired for complete coverage of federal mourning dove call-count survey routes in Illinois from 1965-1973.

Route	Month(s)	Year(s)
Cass	October	1969
Champaign	September	1966
Champaign/Ford	October	1966
Christian	August-September	1968
Crawford	September	1966
Dekalb	August	1970
Edgar	October	1966
Ford/Livingston	September/May	1966/1967
Franklin/Saline	October	1965
Fulton	October	1969
Greene	September	1968
Grundy/LaSalle	June	1967
Henry/Knox	June/October	1969/1970
Lee/Bureau	August/May	1969/1971
McHenry	October	1967
Mercer/Henderson	June/October	1969/1970
Perry/Washington	January-February	1973
Pike	September	1968
Washington	July-August	1968
Woodford/McLean	June	1969

Table 2. Dates of black and white aerial photographs acquired for complete coverage of federal mourning dove call-count survey routes in Illinois from 1977-1982.

Route	Month(s)	Year(s)
Cass	September	1978
Champaign	September	1982
Champaign/Ford	September-October	1982
Christian	June	1978
Crawford	September	1981
Dekalb	September	1979
Edgar	June	1982
Ford/Livingston	April	1978/1979
Franklin/Saline	August	1980
Fulton	September	1978
Greene	August-September	1978
Grundy/LaSalle	April	1977
	November	1978
Henry/Knox	September	1979
Lee/Bureau	September	1979
McHenry	October/May	1980/1981
Mercer/Henderson	September	1979
Perry/Washington	September/October	1978/1980
Pike	September-October	1978
Washington	July/September	1978
Woodford/McLean	September	1979

Table 3. Distribution of mourning dove call-count routes among Department of Natural Resources Management Units in Illinois.

Wildlife Management Unit	Land Area		Call-count Routes	
	Km^2	%	No.	%
Grand Prairie	52,019	36	9	45
Southern Plain	23,452	16	3	15
Western Prairie-Forest	14,254	10	2	10
Mississippi Border-South	13,517	9	2	10
Mississippi Border-North	7,757	5	1	5
Central Sand Prairie	4,099	3	1	5
Wabash Border	6,664	5	1	5
Northeast Moraine	8,177	6	1	5
Northwest Hills	9,290	6	0	0
Shawnee Hills	5,156	4	0	0
TOTAL	144,388	100	20	100

Table 4. Mean (SE) percent composition of feature classes within 0.8 km of mourning dove call-count routes for 3 regions of Illinois during 3 time periods, 1965-1988.

Region Feature Class	1965-1973	1977-1982	1988	All Periods
North-central (n=10)				
Cropland	81.8 (3.1)	81.5 (3.6)	83.5 (3.7)	82.3 (3.4)
Closed Canopy Forest	2.4 (0.7)	3.2 (0.9)	3.4 (0.9)	3.0 (0.8)
Open Canopy Forest	2.4 (0.7)	1.7 (0.7)	1.2 (0.4)	1.8 (0.6)
Hedge/Woody Riparian	0.5 (0.1)	0.5 (0.1)	0.4 (0.1)	0.5 (0.1)
Herbaceous	8.4 (1.3)	8.1 (1.5)	5.9 (1.3)	7.4 (1.3)
Water/Wetland	0.6 (0.3)	0.4 (0.2)	0.4 (0.1)	0.5 (0.2)
Developed	3.9 (0.5)	4.7 (0.9)	5.2 (1.3)	4.6 (0.9)
West-central (n=4)				
Cropland	69.0 (6.4)	69.4 (8.5)	72.7 (7.4)	70.2 (7.2)
Closed Canopy Forest	4.4 (2.0)	5.5 (2.4)	6.5 (2.6)	5.5 (2.3)
Open Canopy Forest	4.4 (1.6)	3.8 (1.1)	2.2 (0.6)	3.4 (1.1)
Hedge/Woody Riparian	0.8 (0.1)	0.9 (0.1)	0.6 (0.1)	0.8 (0.1)
Herbaceous	15.7 (2.6)	15.2 (4.6)	13.0 (3.5)	14.8 (2.9)
Water/Wetland	1.1 (0.7)	1.1 (0.6)	1.2 (0.7)	1.1 (0.7)
Developed	4.6 (1.5)	4.2 (1.0)	3.8 (0.8)	4.2 (1.1)
Southern (n=6)				
Cropland	65.7 (5.4)	68.3 (4.1)	69.8 (4.9)	67.9 (4.7)
Closed Canopy Forest	11.0 (1.9)	10.6 (1.7)	11.4 (2.1)	11.0 (1.9)
Open Canopy Forest	4.4 (1.0)	3.4 (1.1)	2.0 (0.6)	3.3 (0.9)
Hedge/Woody Riparian	1.6 (0.3)	1.6 (0.3)	1.5 (0.3)	1.6 (0.3)
Herbaceous	13.3 (2.4)	11.9 (1.7)	11.0 (2.1)	12.1 (1.9)
Water/Wetland	1.1 (0.1)	0.6 (0.1)	0.8 (0.1)	0.7 (0.1)
Developed	3.4 (0.3)	3.6 (0.3)	3.5 (0.3)	3.5 (0.3)

Table 4. Continued.

Region Feature Class	1965-1973	1977-1982	1988	All Periods
All Routes (n=20)				
Cropland	74.4 (3.0)	75.1 (3.0)	77.1 (3.0)	75.6 (2.9)
Closed Canopy Forest	5.4 (1.1)	5.9 (1.1)	6.4 (1.2)	5.9 (1.1)
Open Canopy Forest	3.4 (0.6)	2.6 (0.5)	1.6 (0.3)	2.6 (0.5)
Hedge/Woody Riparian	0.9 (0.1)	0.9 (0.1)	0.8 (0.1)	0.8 (0.1)
Herbaceous	11.3 (1.2)	10.6 (1.3)	8.9 (1.3)	10.3 (0.7)
Water/Wetland	0.7 (0.2)	0.6 (0.2)	0.7 (0.2)	0.7 (0.1)
Developed	3.9 (0.4)	4.2 (0.5)	4.4 (0.7)	4.2 (0.3)

Table 5. Changes in feature class composition (%) surrounding 10 mourning dove call-count routes in north-central Illinois between 3 time periods (1965-1973, 1977-1982, and 1988).

Feature Class	Cropland Total[a]	Closed forest	Open forest	Hedge/Woody riparian	Herbaceous	Water/ wetland	Developed	
	1965-1973 to 1978-1981							
Cropland	77.8[b]	<0.1	0.1	0.1	3.2	<0.1	0.5	81.8
Closed Forest	<0.1	2.0	0.1	<0.1	0.1	<0.1	0.1	2.4
Open Forest	0.1	0.8	1.1	<0.1	0.3	<0.1	0.1	2.4
Hedge/Woody Riparian	0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	0.5
Herbaceous	3.2	0.2	0.3	<0.1	4.2	<0.1	0.3	8.4
Water/Wetland	<0.1	<0.1	<0.1	<0.1	0.1	0.4	<0.1	0.6
Developed	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.7	3.9
Total[c]	81.5	3.1	1.7	0.5	8.0	0.4	4.7	100.0
	1978-1981 to 1988							
Cropland	79.9	<0.1	<0.1	<0.1	1.2	<0.1	0.2	81.5
Closed Forest	<0.1	2.8	0.1	<0.1	0.1	<0.1	<0.1	3.1
Open Forest	0.1	0.3	0.9	<0.1	0.1	<0.1	0.3	1.7
Hedge/Woody Riparian	0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	0.5
Herbaceous	3.2	0.1	0.2	<0.1	4.3	<0.1	0.2	8.0
Water/Wetland	<0.1	<0.1	<0.1	<0.1	0.1	0.4	<0.1	0.4
Developed	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.6	4.7
Total[c]	83.4	3.3	1.2	0.4	5.9	0.4	5.3	100.0

[a]Highlighted column totals represent percent feature class composition during the earlier time period.

[b]Highlighted diagonal elements indicate percent areas of each feature class that remained unchanged in successive time periods.

[c]Highlighted row totals represent percent feature class composition during the later time period.

Table 6. Changes in feature class composition (%) surrounding 4 mourning dove call-count routes in west-central Illinois between 3 time periods (1965-1973, 1977-1982, and 1988).

Feature Class	Cropland Total[a]	Closed forest	Open forest	Hedge/Woody riparian	Herbaceous	Water/ wetland	Developed	
	1965-1973 to 1978-1981							
Cropland	62.2[b]	<0.1	0.1	0.1	6.4	0.1	0.1	69.0
Closed Forest	0.1	3.7	0.2	<0.1	0.2	<0.1	<0.1	4.3
Open Forest	0.2	1.4	2.4	<0.1	0.4	<0.1	<0.1	4.4
Hedge/Woody Riparian	0.1	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	0.8
Herbaceous	6.5	0.2	1.1	0.1	7.6	0.1	0.1	15.7
Water/Wetland	<0.1	<0.1	<0.1	<0.1	0.1	1.0	<0.1	1.1
Developed	0.2	<0.1	<0.1	<0.1	0.6	<0.1	3.9	4.6
Total[c]	69.2	5.4	3.8	0.9	15.4	1.2	4.2	100.0
	1978-1981 to 1988							
Cropland	65.9	0.1	0.1	0.1	3.0	<0.1	0.1	69.2
Closed Forest	0.2	4.8	0.1	<0.1	0.2	<0.1	<0.1	5.4
Open Forest	0.3	1.2	1.7	<0.1	0.6	<0.1	<0.1	3.8
Hedge/Woody Riparian	0.2	0.1	<0.1	0.5	0.1	<0.1	<0.1	0.9
Herbaceous	5.5	0.1	0.2	<0.1	9.3	0.1	0.1	15.4
Water/Wetland	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	1.2
Developed	0.1	<0.1	<0.1	<0.1	0.3	<0.1	3.6	4.2
Total[c]	72.2	6.4	2.2	0.6	13.6	1.2	3.8	100.0

[a]Highlighted column totals represent percent feature class composition during the earlier time period.

[b]Highlighted diagonal elements indicate percent areas of each feature class that remained unchanged in successive time periods.

[c]Highlighted row totals represent percent feature class composition during the later time period.

Table 7. Changes in feature class composition (%) surrounding 6 mourning dove call-count routes in southern Illinois between 3 time periods (1965-1973, 1977-1982, and 1988).

Feature Class	Cropland Total[a]	Closed Forest	Open Forest	Hedge/Woody Riparian	Herbaceous	Water/ Wetland	Developed	
	1965-1973 to 1978-1981							
Cropland	60.3[b]	0.1	0.1	0.2	4.0	0.1	0.2	65.0
Closed Forest	0.8	9.3	0.7	0.1	0.4	<0.1	<0.1	11.3
Open Forest	0.6	1.1	2.1	<0.1	0.6	<0.1	<0.1	4.5
Hedge/Woody Riparian	0.2	<0.1	<0.1	1.2	0.1	<0.1	<0.1	1.6
Herbaceous	6.0	0.3	0.5	0.1	6.5	0.1	0.1	13.7
Water/Wetland	<0.1	<0.1	<0.1	<0.1	0.1	0.4	<0.1	0.6
Developed	0.1	<0.1	<0.1	<0.1	0.1	<0.1	3.1	3.4
Total[c]	68.0	10.9	3.5	1.6	11.8	0.6	3.5	100.0
	1978-1981 to 1988							
Cropland	65.3	<0.1	0.1	<0.1	2.5	<0.1	0.1	68.0
Closed Forest	0.2	10.3	0.1	<0.1	0.2	0.1	<0.1	10.9
Open Forest	0.3	1.2	1.6	<0.1	0.4	<0.1	<0.1	3.5
Hedge/Woody Riparian	0.1	0.1	<0.1	1.4	0.1	<0.1	<0.1	1.6
Herbaceous	3.4	0.1	0.2	<0.1	7.9	<0.1	0.1	11.8
Water/Wetland	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	<0.1	0.6
Developed	0.1	<0.1	<0.1	<0.1	0.1	<0.1	3.3	3.5
Total[c]	69.3	11.8	2.1	1.5	11.1	0.7	3.5	100.0

[a]Highlighted column totals represent percent feature class composition during the earlier time period.

[b]Highlighted diagonal elements indicate percent areas of each feature class that remained unchanged in successive time periods.

[c]Highlighted row totals represent percent feature class composition during the later time period.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

JOB 1.2. **Compilation and Analysis of Call Count Data in Relation to Habitat and Land Use Changes**

Objectives: (1) Compile and analyze breeding population trends from call-count data obtained from call-count routes in Illinois; and (2) relate breeding population indices and trends derived from call-count routes to changes in habitat, land use, and mourning dove harvest parameters in Illinois.

INTRODUCTION

Mourning dove population trends are estimated from annual call-count surveys (CCS) using the statistical method of route regression (Sauer et al. 1994, Dolton 1995). Route regression produces linear population trend estimates over specified time intervals that are robust to observer variability, missing data, and regional variation in overall abundance (Geissler 1984, Geissler and Sauer 1990). Route regression is best suited to estimating linear population trends over large geographic regions such as management units, physiographic regions, or states that include at least 20 call-count routes (W. L. Kendall, U.S. Fish Wildl. Serv., pers. commun.).

Although route regression is well-suited to estimating annual population changes or long-term trends over large geographic regions, non-linear trends and geographic variation within regions is obscured. Previously published estimates of

Illinois mourning dove population trends are adequate for examination of population-habitat relationships at coarse temporal and geographic scales. Work conducted under Job 1.1 demonstrated that land use surrounding Illinois call-count routes varied geographically, and that land use changes differed among regions and early vs. late segments of the period 1965-1988. Objective 1 of Job 1.2 was necessary to provide a finer level of analysis corresponding to that done for land use changes under Job 1.1. Consequently, we compared numbers of doves detected along Illinois call-count routes among regions, and examined differences in population trends among regions and between time segments corresponding to dates that aerial photography was available to interpret land use changes. Results of analyses conducted under Job 1.1, and under objective 1 of Job 1.2 were examined to identify relationships between land use patterns and mourning dove breeding population indices from call-count surveys in Illinois.

METHODS

Call-count Analyses

Call-count data spanning the period 1966-1992 were obtained from FWS. Analyses were conducted on numbers of doves seen, heard, and total detected (seen + heard), following route regression methodology. Total doves heard calling, seen, and detected were fit to logarithmic regression models in which observers were class-coded. Because breeding population indices

varied among regions and population trends differed between 1966-1982 and 1983-1992, we conducted separate logarithmic regressions for each time period to compare trends among routes and regions. Separate models were fit for each combination of dependent variables, regions (north-central, west-central, and southern) and time periods (1966-1982 and 1983-1992). Route regression analyses were conducted with the Statistical Analysis System (SAS Institute 1985) by fitting log-transformed dependent variables (heard, seen, and detected) to a linear model that included the effects year and observer (class-coded). Programming followed Geissler (1984) with the following SAS statements:

```
PROC GLM; BY PERIOD REGION; CLASSES ROUTE OBSERVER;
MODEL LOG(TH, TS, TD) = ROUTE YEAR YEAR*ROUTE
ROUTE*OBSERVER/NOINT SOLUTION;
```

where TH = total doves heard calling, TS = total doves seen, and TD = total doves detected (seen and heard). Regression coefficients for each level of YEAR*ROUTE provided trend estimates on the log-scale for individual routes within regions. Trend estimates on the arithmetic scale were obtained from the antilog of YEAR*ROUTE regression coefficients (Collins 1990). The LSMEANS option provided indices of dove abundance (log-scale) along individual call routes by period and region.

A similar model was used to test annual population trends within regions after accounting for differences among routes, and differences in observers within routes. SAS statements were as follows:

```
PROC GLM; BY PERIOD REGION; CLASSES ROUTE OBSERVER;
MODEL LOG(TH, TS, TD) = ROUTE ROUTE*OBSERVER YEAR
    /NOINT SOLUTION;
```

Total doves seen, heard, and detected along call-count routes during 1966-1992 were further examined with a locally weighted scatterplot smoothing technique (LOWESS, Cleveland 1979, 1981) using SYSTAT (Wilkinson 1990). This technique calculated moving averages over years in which the influence of adjacent data points were weighted inversely by the size of residuals and distance along the abscissa. The result is a smoothed set of data points that are fit to raw data with minimal influence of outliers. Non-linear population trends are not necessarily obscured, but dramatic year-to-year fluctuations that may be unrelated to actual population changes are largely ignored (James et al. 1990, Taub 1990). We smoothed raw (not log-transformed) numbers of doves seen, heard, and detected during 1966-1992 by route, then averaged smoothed data points by region for graphical comparisons of population trends among north-central, west-central, and southern Illinois. Smoothing was conducted with a tension factor (f) of 0.50 (Cleveland 1979). Statistical significance of breeding population trends from LOWESS smoothed values for each route, averaged within regions was tested with Spearman's correlation coefficient.

RESULTS

Regional Differences

Numbers of doves seen, heard, and detected along call-count routes during 1966-1992 varied among regions ($X^2 \geq 10.43$, $P \leq 0.005$). More than twice as many doves were seen, heard, and detected in southern Illinois than in north-central Illinois (Dunn's test, $P < 0.10$; Fig. 5). Numbers of doves seen, heard, and detected in west-central Illinois were intermediate and differed from numbers seen, heard, and detected along routes in the other 2 regions (Dunn's test, $P < 0.10$).

Annual Trends

Scatterplots.--Numbers of doves heard calling was loosely correlated ($r = 0.747$, $P < 0.001$) with numbers seen. Correlations varied among regions and time periods, ranging from $r = 0.636$ in southern Illinois to $r = 0.751$ in north-central Illinois ($P < 0.001$) during 1966-1982, and from $r = 0.232$ ($P = 0.759$) in west-central Illinois to $r = 0.650$ ($P < 0.001$) in north-central Illinois during 1983-1988. Smoothed scatterplots of numbers of doves seen and numbers heard also depicted different breeding population trends for some individual routes (see Gates et al. 1994). However, the same trends were evident using doves seen and doves heard when smoothed values were averaged by region (Figs. 6-7).

Scatterplots of total doves detected indicated breeding population trends that differed among individual routes (Appendix

D). Some trends were stable or changed monotonically throughout 1966-1992, whereas others exhibited trends that differed before and after the early 1980's. Several routes had declining population trends through the early 1980's, followed by modest increases during 1983-1992. This pattern was particularly evident in southern Illinois when smoothed values were averaged by year across routes (Fig. 8). Smoothed scatterplots of total doves detected indicated a 57% decline ($\underline{r}_s^2$ = -0.995, $\underline{P}$ < 0.001) in southern Illinois between 1966 and 1982, followed by a 47% increase ($\underline{r}_s^2$ = 1.000, $\underline{P}$ < 0.001) during 1983-1992. A similar decline (33.3%) also occurred during 1966-1982 in west-central Illinois ($\underline{r}_s^2$ = 0.721, $\underline{P}$ < 0.001). This decline was followed by a 55% increase between 1983 and 1992, but with considerable annual variability the trend was not significant ($\underline{r}_s^2$ = 0.436, $\underline{P}$ = 0.208). Smoothed numbers of doves detected changed little (-6.2%) in north-central Illinois ($\underline{r}_s^2$ = 0.080, $\underline{P}$ = 0.760) between 1966 and 1982, but increased 35.3% during 1983-1992 ($\underline{r}_s^2$ = 0.922, $\underline{P}$ < 0.001).

Route Regression.--Negative slope estimates were fit for 14 of 20 call-count routes during 1966-1982 by logarithmic regression of total doves detected on year (Table 8). Annual changes in numbers of doves detected during 1966-1982 ranged from -22.4% to +7.9%/year in north-central Illinois, -13.3% to +17.5%/year for west-central routes, and -16.6% to +3.9%/year in southern Illinois. However, only 5 of 20 routes had significant ($\underline{P}$ < 0.10) declines. Southern Illinois had the largest

proportion of routes (3 of 6) with significant negative population trends, followed by north-central (2 of 10), and west-central (0 of 4) Illinois.

In contrast, 14 of 20 trend estimates had positive slopes during 1983-1992 (Table 8). Annual rates of change ranged from -11.0 to +44.3%/year in north-central Illinois, -6.8 to +25.7%/year in west-central Illinois, and -8.6% to +18.1%/year in southern Illinois. Slope estimates were significant ($\underline{P} < 0.10$) for only 4 of 20 routes during 1983-1988, but in contrast to 1966-1982, all of these were positive and more equitably distributed among regions. Three of the routes (Champaign, McHenry, and Washington) had population trends that changed from negative to positive after 1992.

Combining routes within regions and time periods, total number of doves detected did not change in north-central Illinois during 1966-1982 ($\underline{b} = -0.034$, $\underline{t} = -1.35$, $\underline{P} = 0.180$), but increased 10.4%/year during 1983-1992 ($\underline{b} = 0.099$, $\underline{t} = 2.33$, $\underline{P} = 0.042$). Numbers of doves detected in west-central Illinois did not change during 1966-1982 ($\underline{b} = -0.010$, $\underline{t} = -0.33$, $\underline{P} = 0.745$), or 1983-1992 ($\underline{b} = 0.070$, $\underline{t} = 1.55$, $\underline{P} = 0.139$). Doves detected in southern Illinois declined 6.5%/year during 1966-1982, ($\underline{b} = -0.067$, $\underline{t} = -3.10$, $\underline{P} = 0.003$), then increased 8.8%/year during 1983-1992 ($\underline{b} = 0.084$, $\underline{t} = 1.89$, $\underline{P} = 0.070$).

Separate logarithmic regressions of doves heard and seen (Tables 9 and 10) on year produced results that were similar to analyses conducted with total doves detected (Table 8). Negative

trend estimates were obtained for the majority of routes (14) during 1966-1982; positive trend estimates predominated (11-12) during 1983-1992. However, with doves heard and seen, there were fewer significant ($P < 0.10$) negative trends during 1966-1982, and fewer significant positive trends during 1983-1992 compared with using total doves detected.

DISCUSSION

Breeding Population Trends

Long-term analyses using route regression have indicated stable to increasing population trends of breeding mourning doves in Illinois since the current system of call-count surveys (CCS) was implemented in 1966 (Sauer et al. 1994, Dolton 1995). Route regression analyses of mourning dove population trends from the North American breeding bird survey (BBS) indicated a 1.66% decline per year in Illinois during 1966-1988. Inconsistent trend estimates from CCS and BBS are likely due to differences in timing of surveys, numbers and spatial distribution of routes, and data recorded (Sauer et al. 1994). The BBS is conducted during breeding season of passerine birds, after mourning doves have begun to hatch nests in Illinois (Hanson and Kossack 1963). Consequently, population trends from BBS reflect annual variation in nesting productivity as well as breeding population densities. However, the larger number of BBS routes in Illinois (64) provides greater statistical precision. Additionally, the BBS is based on total numbers of birds detected and does not separate

numbers of birds heard calling from total numbers seen. Mourning dove breeding population trends are estimated by FWS from the CCS using only numbers of doves heard calling.

Long-term population trend estimates over large geographic regions, whether based on CCS or BBS data, can obscure nonlinear and other population trends that occur at smaller spatial and temporal scales where land use and habitat changes might occur. Furthermore, route regression methodology takes a conservative approach to estimating annual rates of population change. Annual differences that occur with changes in observers are discounted under the assumption that such differences are due to varying observer ability to detect doves. Our analyses indicated that mourning dove breeding populations declined through the early 1980's in Illinois, then increased after 1982. These trends were strongest in southern Illinois where breeding population indices were highest, but were also apparent to a lesser degree in west-central Illinois where breeding population indices were intermediate. Breeding population trends were relatively stable, or increased slightly after 1982 in north-central Illinois where mourning dove breeding population indices were lowest. These trends were corroborated by statistical analyses conducted at spatial and temporal scales corresponding to land use changes previously documented under Job 1.1.

Population-Habitat Relationships

The relative consistency of habitat composition surrounding mourning dove call-count routes in Illinois during 1965-1988 was consistent with generally stable statewide breeding population trends reported for the same time period (Sauer et al. 1994, Dolton 1995). Declining breeding population trends during 1966-1982 in southern and west-central Illinois were associated with losses of woody cover, particularly open canopy forest that probably included the most preferred nesting habitats among feature classes that we were able to distinguish (Hanson and Kossack 1963). Changes in crop composition and agricultural practices that we could not identify from aerial photographs may also have reduced availability of wild seeds and small grains that comprise nearly the entire diet of mourning doves (Oberheu and Klimstra 1961, Lewis 1993). Seeds produced by herbaceous plants found in early successional habitats are the most preferred foods of mourning doves (Lewis 1993). Uncultivated herbaceous plant seeds should be especially important during the breeding season when cereal grains are largely unavailable. Thus, losses of herbaceous cover through conversion of idle lands to crop production could reduce availability of food during the nesting season. Losses of woody cover continued, albeit at a slower rate, and conversion of herbaceous cover to cropland accelerated after 1982, yet breeding populations appeared to be increasing. Consequently breeding population trends after 1982

were more difficult to associate with changing land use patterns and habitat availability.

Population Trends in Relation to Statewide Harvest

Estimated harvest of Illinois mourning doves during 1966-1992 ranged from 0.88 million birds in 1979 to 2.19 million birds in 1976 (Preno and Labisky 1971, Anderson and Campbell 1993). Harvest was relatively stable (1.4-2.2 million doves) during 1966-1976, then declined (0.88-1.67 million birds during 1977-1982. We found evidence that breeding population trends also declined during this time period, particularly in southern and west-central Illinois. Declining harvest and breeding populations during 1966-1982 also were concurrent with fewer hunters estimated afield (71-99 thousand) during 1977-1982 compared to 1966-1976 (90-117 thousand). There were few changes in harvest regulations during most years in this time period, with 12 bird daily bag limits and 70 day seasons that opened at noon. Exceptions were 1969 when daily bag was 18 birds and 1982 when the daily bag was raised to 15 doves and season length was temporarily reduced to 45 days.

Harvest regulations stabilized at a 15 bird daily bag with 60 day seasons that opened at noon during 1983-1992 (Anderson and Campbell 1993). Numbers of hunters estimated afield also stabilized at 66-84 thousand hunters during 1983-1992. Despite evidence that we found for increasing breeding population trends during this time period, annual harvest fluctuated widely over a

range from 1.16 million birds in 1985 to 1.96 million birds in 1989. There was no evidence of an increasing harvest trend during 1983-1992, although annual harvest tended to be greater than during 1977-1982, but was not quite as high as in 1966-1976.

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Table 8. Annual trends[a] in numbers of mourning doves seen and heard along 20 call-count routes in Illinois during 1966-1982 and 1983-1992.

Region Route	1966-1982 b[b]	t	P	1983-1992 b	t	P
North-central Illinois						
Champaign	-0.208	-1.76	0.082	0.182	2.13	0.040
Champaign-Ford	0.076	0.97	0.336	0.038	0.39	0.698
Christian	-0.034	-0.56	0.576	-0.116	-1.08	0.288
DeKalb	0.025	0.21	0.836	0.008	0.03	0.977
Edgar	-0.085	-1.34	0.184	-0.036	-0.06	0.956
Ford/Livingston	0.045	0.69	0.493	-0.111	-0.39	0.700
Grundy/LaSalle	-0.153	-0.73	0.469	0.172	1.59	0.121
Lee/Bureau	0.042	0.31	0.760	0.052	0.40	0.690
McHenry	-0.253	-1.79	0.077	0.367	2.63	0.013
Woodford/McLean	-0.046	-0.95	0.344	0.108	0.48	0.636
West-central Illinois						
Cass	-0.027	-0.36	0.722	0.080	0.99	0.341
Fulton	-0.004	-0.12	0.906	-0.001	-0.02	0.982
Henry/Knox	0.161	1.04	0.305	0.229	2.62	0.020
Mercer/Henderson	-0.143	-1.16	0.255	-0.070	-0.42	0.683
Southern Illinois						
Crawford	-0.026	-0.50	0.621	0.166	1.07	0.294
Franklin/Saline	-0.071	-1.94	0.058	0.042	0.16	0.872
Greene	-0.021	-0.46	0.648	0.058	0.76	0.458
Perry/Washington	-0.182	-2.56	0.014	-0.090	-0.58	0.568
Pike	0.038	0.56	0.576	0.060	0.29	0.773
Washington	-0.163	-3.03	0.004	0.139	1.80	0.086

[a]Trend estimates were derived from regressions of the natural logarithm of total doves heard and seen on year, with observer covariables adjusting for differing abilities to detect doves (Geissler 1970, Geissler and Sauer 1990).

[b]Slope estimate on the logarithmic scale.

Table 9. Annual trends[a] in numbers of mourning doves heard calling along 20 call-count routes in Illinois during 1966-1982 and 1983-1992.

Region Route	1966-1982 b[b]	t	P	1983-1992 b	t	P
North-central Illinois						
Champaign	-0.258	-1.97	0.053	0.137	1.40	0.170
Champaign-Ford	0.084	0.96	0.338	0.045	0.40	0.693
Christian	-0.037	-0.56	0.578	-0.137	-1.11	0.274
DeKalb	-0.016	-0.12	0.905	-0.101	-0.34	0.738
Edgar	-0.042	-0.60	0.550	0.059	0.08	0.936
Ford/Livingston	0.025	0.35	0.730	-0.195	-0.59	0.556
Grundy/LaSalle	-0.061	-0.26	0.794	0.150	1.21	0.235
Lee/Bureau	0.277	1.81	0.073	0.067	0.45	0.658
McHenry	-0.337	-2.14	0.035	0.322	2.02	0.052
Woodford/McLean	-0.064	-1.20	0.233	0.231	0.89	0.379
West-central Illinois						
Cass	-0.037	-0.51	0.611	-0.079	0.59	0.565
Fulton	0.047	1.40	0.171	-0.009	-0.08	0.934
Henry/Knox	-0.004	-0.02	0.980	0.205	1.41	0.180
Mercer/Henderson	-0.151	-1.25	0.220	-0.098	-0.35	0.731
Southern Illinois						
Crawford	-0.011	-0.18	0.856	0.151	0.94	0.359
Franklin/Saline	-0.032	-0.78	0.438	-0.033	-0.12	0.905
Greene	0.003	0.07	0.948	0.034	0.42	0.678
Perry/Washington	-0.172	-2.14	0.037	-0.090	-0.56	0.580
Pike	0.006	0.08	0.937	0.231	1.08	0.291
Washington	-0.136	-2.26	0.029	-0.004	-0.04	0.965

[a]Trend estimates were derived from regressions of the natural logarithm of total doves heard and seen on year, with observer covariables adjusting for differing abilities to detect doves (Geissler 1970, Geissler and Sauer 1990).

[b]Slope estimate on the logarithmic scale.

Table 10. Annual trends[a] in numbers of mourning doves seen along 20 call-count routes in Illinois during 1966-1982 and 1983-1992.

Region / Route	1966-1982 b[b]	1966-1982 t	1966-1982 P	1983-1992 b	1983-1992 t	1983-1992 P
North-central Illinois						
Champaign	-0.118	-0.50	0.616	0.171	1.00	0.322
Champaign-Ford	-0.003	-0.02	0.986	0.023	0.12	0.908
Christian	-0.008	-0.07	0.943	-0.058	-0.27	0.789
DeKalb	0.116	0.48	0.631	0.785	1.51	0.142
Edgar	-0.129	-1.02	0.310	-0.174	-0.14	0.892
Ford/Livingston	0.132	1.01	0.315	-0.100	-0.18	0.861
Grundy/LaSalle	-0.128	-0.31	0.759	0.157	0.73	0.472
Lee/Bureau	-0.302	-1.11	0.270	-0.031	-0.12	0.907
McHenry	0.182	0.65	0.520	0.566	2.03	0.050
Woodford/McLean	0.052	0.55	0.587	-0.190	-0.42	0.676
West-central Illinois						
Cass	-0.007	-0.06	0.953	0.084	0.62	0.543
Fulton	-0.106	-1.93	0.063	0.042	0.40	0.698
Henry/Knox	0.270	1.10	0.280	0.272	1.88	0.081
Mercer/Henderson	-0.094	-0.48	0.636	-0.017	-0.06	0.953
Southern Illinois						
Crawford	-0.036	-0.44	0.663	0.175	0.88	0.390
Franklin/Saline	-0.114	-1.98	0.053	0.073	0.22	0.829
Greene	-0.077	-1.06	0.296	0.144	1.45	0.162
Perry/Washington	-0.296	-2.65	0.011	-0.126	-0.63	0.533
Pike	0.077	0.74	0.465	-0.037	-0.14	0.889
Washington	-0.199	-2.37	0.022	0.208	2.08	0.049

[a]Trend estimates were derived from regressions of the natural logarithm of total doves heard and seen on year, with observer covariables adjusting for differing abilities to detect doves (Geissler 1970, Geissler and Sauer 1990).

[b]Slope estimate on the logarithmic scale.

Figure 5

Figure 6

Figure 7

Figure 8

Job 1.3. **Analysis and Report**

Objectives: (1) To analyze results from Jobs 1.1 and 1.2 and to prepare quarterly, annual, and final reports; (2) Provide recommendations to improve population and habitat management for mourning doves in Illinois and suggest future research needs.

CONCLUSIONS

Effects of Land Use on Breeding Populations

We conducted this study to determine changes in land use and habitats along mourning dove call-count routes in Illinois since they were established in 1966. Our second primary objective was to identify relationships (if any) between land use and habitat changes and breeding population indices derived from call-counts. Work conducted under Job 1.1 demonstrated that there were indeed changes in land use patterns surrounding call-count routes that could be identified by interpreting aerial photography. Furthermore, we found geographic and temporal differences in mourning dove breeding population indices determined from call-counts that were associated at a general level with changes in land use. Thus, this study successfully addressed the questions that were posed when it was conceived. However, the question of more general interest that motivated this study, that of direct effects of habitat change on mourning dove breeding populations remains inadequately answered. Results of this and similar

investigations need to be judged in the context of 3 general limitations of such studies; 1) adequacy of data in representing the process being investigated, 2) scale and scope of analysis, and 3) causal inference. We consider these limitations in turn below.

Adequacy of Data.--The question should be raised whether call-counts themselves accurately depict breeding population trends within the state. Analyses conducted by Baskett et al. (1978) generally supported use of the call-count survey technique to monitor broad-scale and long-term breeding population trends. However, the relatively weak correlations we observed between doves seen and doves heard on individual routes suggests that analyses conducted on a route by route basis are suspect. Additionally, the land use classes that we were able to distinguish from aerial photography were probably too generalized to adequately represent the habitat requirements of breeding mourning doves. We interpreted more habitat types (18 classes) than the 7 land use classes that were analyzed, but habitat types were combined for convenience because most of the 18 habitats were poorly represented on individual routes. Furthermore, relative areas of different habitat types may be less important than other expressions of habitat quality such as habitat interspersion and juxtaposition. However, our change detection analysis indicated that the distribution of habitats and overall landscape structure surrounding call-count changed little since routes were established in 1966. Interpretation of land use

change is limited by lack of precise knowledge of the absolute amounts, distribution, and quality of specific habitats required to sustain different population densities of mourning doves. We observed large proportional changes of some habitat types, but these were generally low in relative abundance to begin with. Consequently, it is difficult to attribute changes in breeding population density to even large relative changes in habitats surrounding call-count routes. Examination of population-land use relationships with other data sets such as the North American Breeding Bird Survey and Annual Census of Agriculture is needed to further substantiate the associations that we observed between mourning dove breeding populations and land use.

Scale and Scope.--Other factors that were beyond the scope and scale of this investigation, such as weather patterns or population processes and habitat changes outside the state, could affect mourning dove breeding populations in Illinois. Our approach of stratifying routes into 3 geographic regions that differed with respect to overall land use and population trends revealed patterns that were not necessarily evident at larger (statewide) or smaller (individual route) spatial scales. We found that at a regional level, declining population trends were associated with changes in woody and herbaceous cover during 1966-1982. However, we found no association between land use change and an apparently increasing breeding population trend after 1982. Other factors that we did not directly measure apparently also influence long-term breeding population trends in

Illinois. We considered one of these, annual harvest, but found little or no association with breeding population indices.

Causal Inference.--Finally, merely associating breeding population trends with habitat changes does not prove a cause and effect relationship between land use and mourning dove breeding populations. Intensive field studies are necessary to determine specific habitat conditions that affect breeding populations and reproductive success of mourning doves. Food requirements of nesting doves, foraging patterns during the breeding season, nest site selection, and nesting success in different habitats need to be compared among different landscapes within regions where dove populations are declining, stable, and increasing. Such opportunity exists in Illinois.

Management Implications

With the tenuous nature of associations between land use and breeding populations that we documented in this study, we are reluctant to offer specific suggestions to improve population and habitat management for mourning doves in Illinois. We offer the following generalizations to guide future management decisions and research priorities:

1. Loss of early successional or open woody cover types is of potential concern for the future quality of mourning dove nesting habitat in Illinois. There may little that can be done, however to reverse this change, as loss or changes in quality of woody cover is due to changing agricultural patterns on private

lands and successional changes in forest cover throughout Illinois.

2. Changes in harvest regulations since 1966 do not appear to have influenced mourning dove breeding population trends in Illinois. Breeding populations appear to have increased despite increasing the daily bag limit from 12 to 15 doves in 1982.

3. The current number and regional distribution of call-count routes is probably inadequate to accurately depict mourning dove breeding population trends in Illinois. Current routes are mostly concentrated in north-central Illinois where breeding population indices are lowest and population trends have tended to be relatively stable. Breeding population declines that occurred through the early to mid 1980's in west-central and southern Illinois were not evident in statewide trends, although recent increases are becoming evident. South-central and extreme southern Illinois are the least adequately represented regions of the state despite evidence that these regions contain the highest densities of breeding mourning doves.

4. Call-count routes should be stratified within Illinois on a finer physiographic level than the system originally used to stratify routes nationwide. Coarse levels of stratification obscures regional variation that is important to understanding effects of land use changes on breeding population trends. We found that separating routes into 3 physiographic strata revealed different land use and breeding population trends for separate regions of Illinois. Additional strata in extreme southern and

northern Illinois may also be necessary to depict the full range mourning dove population-habitat relationships in Illinois. North American breeding bird survey data should be analyzed to develop a more efficient system of geographic stratification of call-count routes within the state.

5. Annual monitoring of mourning dove breeding population trends should be expanded to provide better information on relationships between population trends and land use in Illinois. Based on the data population data we examined, a minimum of 10 routes per physiographic stratum seems necessary to obtain statistically valid estimates of breeding population and land use trends. Thus, with 3-5 physiographic strata, a minimum of 30-50 routes are needed to determine land-use and breeding population trends across the state.

6. Intensive field studies should be conducted at several sites across the state during the breeding season to determine specific food and habitat requirements, and the effect of land use practices on nesting habitat quality.

LITERATURE CITED

Baskett, T. S., M. J. Armbruster, and M. W. Sayre. 1978. Biological perspective for the mourning dove call-count survey. Trans. N. Amer. Wildl. Nat. Resour. Conf. 43:163-180.

Appendix A. Total areas (ha) and percent change in land-use and habitat features within 1 km of 10 mourning dove call-count routes in north-central Illinois, 1966-1988.

Route	Year	Feature							
		Row crop	Water/ Wetlands	Closed forest	Hedge/ riparian	Open forest	Developed	Herbaceous	Total
Champaign	1966	4697	1	2	9	6	262	250	5227
	1982	4679	4	3	7	2	324	208	5227
	1988	4763	0	2	4	8	340	111	5227
% change[a]		+1.4	-100.0	0.0	-55.6	+33.3	+29.9	-55.6	
Champaign/ Ford	1966	5021	8	15	5	60	156	148	5412
	1979	5023	8	32	5	36	148	160	5412
	1988	5115	8	41	4	22	150	72	5412
% change		+1.8	0.0	173.3	-20.0	-63.3	-3.8	-51.4	
Christian	1968	4038	24	144	28	117	216	410	4976
	1978	4108	16	217	25	56	225	330	4976
	1988	4117	19	256	21	32	229	301	4975
% change		+2.0	-20.8	+77.8	-25.0	-72.6	+6.0	-26.6	
DeKalb	1970	4710	9	111	18	64	201	382	5496
	1979	4643	10	150	16	24	206	447	5496
	1988	4844	11	153	9	25	209	245	5496
% change		+2.8	+22.2	+37.8	-50.0	-60.9	+4.0	-35.9	
Edgar	1966	3707	16	245	30	162	130	514	4804
	1982	3786	16	307	27	75	122	464	4798
	1988	3936	17	290	27	75	120	333	4798
% change		+6.2	+6.2	+18.4	-10.0	-53.7	-7.7	-35.2	

Appendix A. Continued.

Route	Year	Feature							
		Row crop	Water/ wetlands	Closed forest	Hedge/ riparian	Open forest	Developed	Herbaceous	Total
Ford/ Livingston	1967	4776	25	11	31	75	158	405	5480
	1978	4876	25	42	28	60	150	299	5480
	1988	4956	25	52	25	49	146	228	5479
% change		+3.8	0.0	+372.7	-19.4	-34.7	-7.6	-43.7	
Grundy/ LaSalle	1967	5124	11	38	17	22	213	205	5629
	1978	5159	10	45	12	14	215	174	5629
	1988	5201	10	43	7	13	223	132	5629
% change		+1.5	-9.1	+13.2	-58.8	-40.9	-4.5	-35.6	
Lee/Bureau	1970	4471	8	153	38	99	174	658	5601
	1979	4574	20	122	33	67	249	536	5602
	1988	4713	23	140	23	62	253	383	5596
% change		+5.4	+187.5	-8.4	-39.5	-38.0	-31.2	-41.8	
McHenry	1967	3551	202	255	60	386	456	835	5744
	1980	3265	100	396	67	409	716	792	5744
	1988	3160	69	438	66	220	931	859	5744
% change		-11.0	-65.8	+71.8	-9.1	-43.0	+104.2	+2.9	
Woodford/ McLean	1969	3663	29	296	34	296	134	684	5136
	1979	3462	35	352	41	181	174	890	5136
	1988	3835	36	361	29	145	234	497	5136
% change		+4.7	+24.1	+22.0	-14.7	-51.0	+74.6	-27.3	

[a] Net change between 1966-70 and 1988.

Appendix B. Total areas (ha) and percent change in land-use and habitat features within 1 km of 10 mourning dove call-count routes in west-central Illinois, 1969-1988.

Route	Year	Feature							
		Row crop	Water/ Wetlands	Closed forest	Hedge/ riparian	Open forest	Developed	Herbaceous	Total
Cass	1969	3695	4	394	41	105	122	511	4871
	1978	3648	3	415	42	86	130	547	4870
	1988	3828	3	451	25	45	138	381	4871
% change[a]		+3.6	-25.0	+14.5	-39.0	-57.1	+13.1	-25.4	
Fulton	1969	2735	168	411	52	487	479	1028	5360
	1978	2406	158	575	64	363	376	1419	5360
	1988	2691	168	660	49	208	328	1257	5360
% change		-1.6	0.0	+60.6	-5.8	-57.3	-31.5	+22.3	
Henry/	1969	4543	35	31	26	176	191	696	5698
Knox	1979	4167	61	62	33	172	191	1012	5698
	1988	4491	63	84	24	119	184	734	5698
% change		-1.1	+44.4	+171.0	-7.7	-32.4	-3.7	+5.5	
Mercer/	1970	3632	20	74	43	172	189	1092	5222
Henderson	1979	4418	23	88	42	190	188	273	5222
	1988	4253	25	152	34	90	160	507	5222
% change		+17.1	+25.0	+105.4	-20.9	-47.7	-15.3	-53.6	

[a] Net change between 1969-70 and 1988.

Appendix C. Total areas (ha) and percent change in land-use and habitat features within 1 km of 10 mourning dove call-count routes in southern Illinois, 1965-1988.

Route	Year	Feature							
		Row crop	Water/ Wetlands	Closed forest	Hedge/ riparian	Open forest	Developed	Herbaceous	Total
Crawford	1966	3728	30	516	122	142	214	413	5165
	1981	3810	26	528	105	88	216	393	5166
	1988	3934	59	486	98	81	206	304	5167
% change[a]		+5.5	+96.7	-5.8	-19.7	-43.0	-3.7	-26.4	
Franklin/ Saline	1965	2754	45	673	107	294	218	919	5009
	1980	2925	47	558	114	304	236	824	5009
	1988	2867	47	760	111	88	238	897	5009
% change		+4.1	+4.4	+12.9	+3.7	-70.1	+9.2	-2.4	
Greene	1968	3260	28	447	78	263	186	683	4945
	1978	3140	35	478	81	177	183	852	4945
	1988	3390	34	515	70	127	173	636	4945
% change		+4.0	+21.4	+15.2	-10.3	-51.7	-7.0	-6.9	
Perry/ Washington	1973	4123	42	552	44	193	155	698	5808
	1980	4394	36	609	46	72	155	496	5808
	1988	4450	36	597	45	71	155	454	5808
% change		+7.9	-14.3	+8.2	+2.3	-63.2	0.0	-35.0	
Pike	1968	3117	42	1268	130	535	186	1443	6722
	1978	3848	49	1190	136	483	190	826	6722
	1988	3677	48	1299	137	300	197	1063	6721
% change		+18.0	+14.3	+2.4	+5.4	-43.9	+5.9	-26.3	

Appendix C. Continued.

Route	Year	Feature							
		Row crop	Water/ Wetlands	Closed forest	Hedge/ riparian	Open forest	Developed	Herbaceous	Total
Washington	1968	4391	14	264	44	55	144	337	5249
	1978	4270	16	228	42	38	172	483	5249
	1988	4481	21	212	33	19	178	306	5249
% change		+2.0	+50.0	-19.7	-0.25	-65.5	+23.6	-9.2	

[a] Net change between 1965-73 and 1988.

Appendix D. Scatterplots of total numbers of doves detected along 20 mourning dove call-count routes in Illinois during 1966-1992. Lines indicate the LOWESS-smoothed trend for each route using a tension factor of 0.5. Scatterplots are ordered alphabetically by route name within north-central, west-central, and southern regions, respectively.