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Demographics of the Golden-cheeked Warbler (*Dendroica chrysoparia*) on Fort Hood, Texas

by
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The Golden-cheeked Warbler (*Dendroica chrysoparia*) is a federally endangered migratory passerine that has its breeding range contained in the central Texas area that includes Fort Hood. Its listing as endangered in 1991 was a result of the rapid degradation and increasing fragmentation of habitat, causing a decline in their population. To assist in conservation and recovery of the Golden-cheeked Warbler and comply with the Endangered Species Act, environmental managers need information on the demographic parameters of the population on Fort Hood.

Researchers surveyed and documented the Golden-checked Warbler on Fort Hood, Texas between 1991 and 1996. The population remained relatively stable, with a slight decrease in 1996. The average return rate for males banded as adults was 45.5%; for males banded as juveniles the average was 16.9%. Dispersal distances for males banded as adults averaged 223 m. Dispersal distances for males banded as juveniles were significantly greater, with an average of 4,040 m. Densities of territorial males remained relatively stable between 1992 and 1996, with a peak density of 28 males per 100 ha (average of 18 males per 100 ha). Productivity of males within an intensive study area averaged 2.0 young per mated male.

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Foreword

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The authors recognize the following people for their contributions. Howard Weinberg provided insightful discussions concerning the status of the Golden-cheeked Warbler on Fort Hood, and helped with early drafts of this manuscript. Robert Melton helped with the statistics used in this study. Theresa Koloszar assisted in many aspects of data management. Dean Keddy-Hector provided helpful discussions of differences between populations around Austin, TX and Fort Hood. Several individuals were responsible for collecting much of the field data. Mike Stake, Maria Elena Tolle, Deborah Maas-Burleigh, John Styrsky, Edd Paradise, Danny Huffine, Wanda Eckrich, Carrie Bemus, and Jeff Bolsinger conducted the field work during different times of the study. Steve Mackie developed computer applications that facilitated data collection and management, and helped to estimate the amount of Golden-cheeked Warbler habitat present on Fort Hood. Randy Craft reviewed the manuscript. Dennis Herbert, B.R. Jones, Tim Buchanan, Kevin Cagle, and Anne Hamilton of the Natural Resources Branch at Fort Hood assisted in all aspects of data collection, facilitated access, and helped coordinate field activities.

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1 Introduction

Background

The Golden-cheeked Warbler (*Dendroica chrysoparia*) is a federally endangered migratory passerine that has its breeding range contained within the range of Ashe juniper (*Juniperus Ashei*) on the Edward's Plateau of central Texas. Its listing as endangered in 1991 was a result of the rapid degradation and increasing fragmentation of habitat, causing a decline in their population (Benson 1990). Pulich (1976) estimated the breeding population to be approximately 14,950 birds. Wahl, Diamond, and Shaw (1990) believed that their estimation of 4,822 to 16,016 breeding pairs was "unrealistically" high. As of 1995, the species was believed to breed in at least 24 central Texas counties, a reduction of 23% since 1976 (31 counties; Pulich 1976; U.S. Fish and Wildlife Service [USFWS] 1996).

The species is entirely dependent upon the mature Ashe juniper forests of central Texas for its nesting and foraging substrates. The species builds its nests almost entirely from shredded juniper bark at a height of 4 to 5 meters, most commonly in Ashe juniper and occasionally in hardwoods common to the region (e.g., live oak, Texas oak; Pulich 1976). Only mature Ashe juniper trees shred their bark, limiting the Golden-cheeked Warbler to forests with a high proportion of juniper trees older than 40 to 50 years (Pulich 1976). Warblers, however, rarely exist in stands of pure juniper, as they also require hardwoods for foraging substrate. Early in the season, they forage most frequently in deciduous hardwood trees, primarily oaks, then switch to juniper as a principal foraging substrate later in the season (Beardmore 1994). For a more detailed description of the Golden-cheeked Warbler and its habitat, see Pulich (1976).

Fort Hood, Texas is located partially in both Bell and Coryell counties in east central Texas. Vegetative cover on the installation varies with slope, aspect, moisture, and previous use (e.g., cattle grazing and military activities), and consists of grassland, open savannah, hardwood thickets, and dense juniper-oak stands. For a more detailed habitat description of Fort Hood, see Tazik and Cornelius, 1993. Within its 87,890 hectares (ha) is approximately 16,000 ha of Golden-cheeked Warbler habitat.

The Golden-cheeked Warbler was listed as endangered in 1991 under the Endangered Species Act (ESA) of 1973, as amended. To assist in conservation and recovery of the Golden-cheeked Warbler and comply with the ESA, environmental managers need information on the demographic parameters of the population on Fort Hood. In 1991, these demographics were not available.

Quality and amount of warbler habitat appeared stable on Fort Hood between 1991 and 1995 (Figure 1). However, in February of 1996, a large wildfire destroyed approximately 4,300 ha (25%) of warbler habitat, mostly in the northern and northeastern sections of Fort Hood (Figure 2). A separate study was initiated to investigate the effects of this fire on warbler return rates and dispersal distance; males affected by the fire were not reported in this paper, and their numbers were not used in analyses of return rate or dispersal distance.

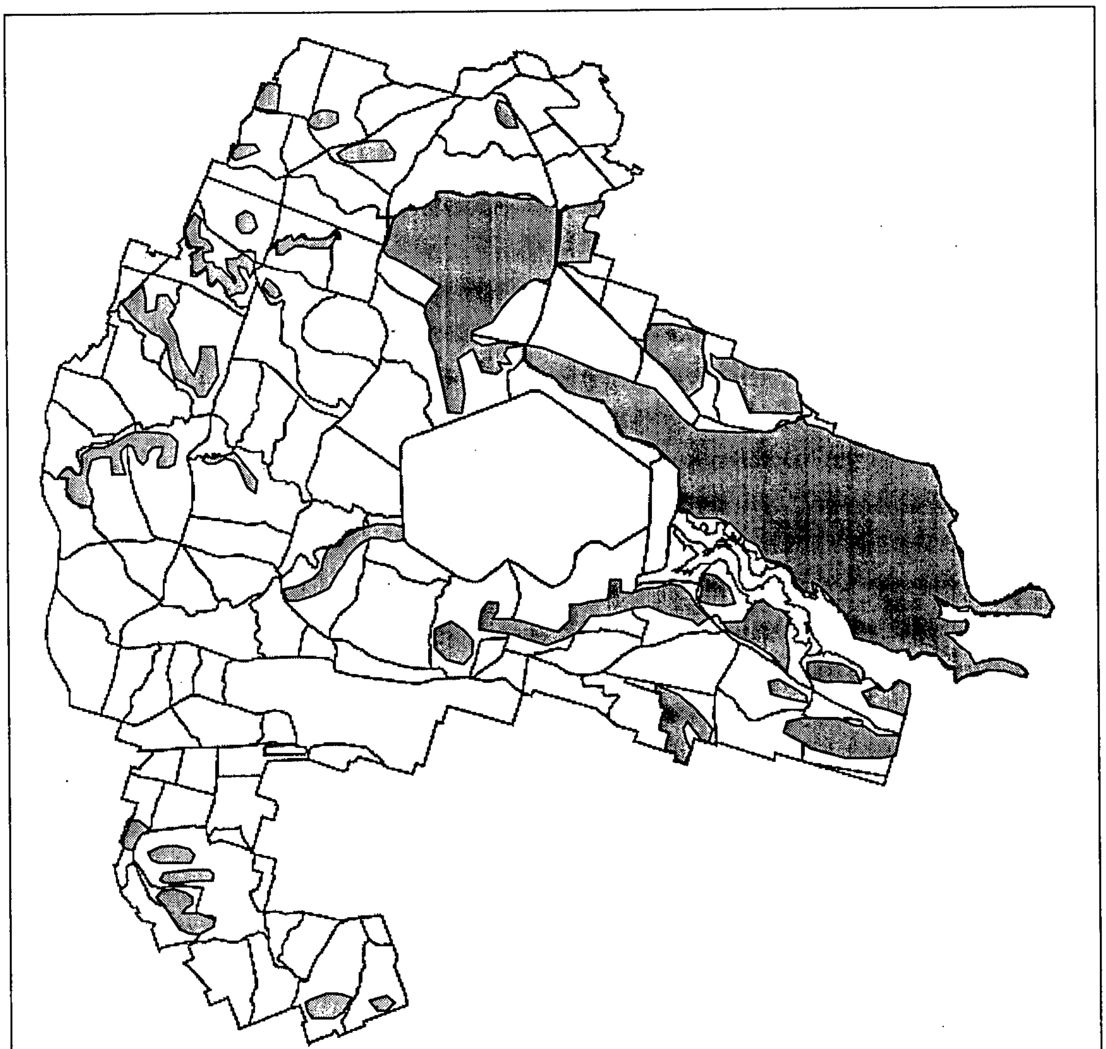


Figure 1. Map of Fort Hood, TX, showing approximate extent of Golden-cheeked Warbler habitat, including areas burned in February 1996. (1 cm ~ 2,900 meters.)

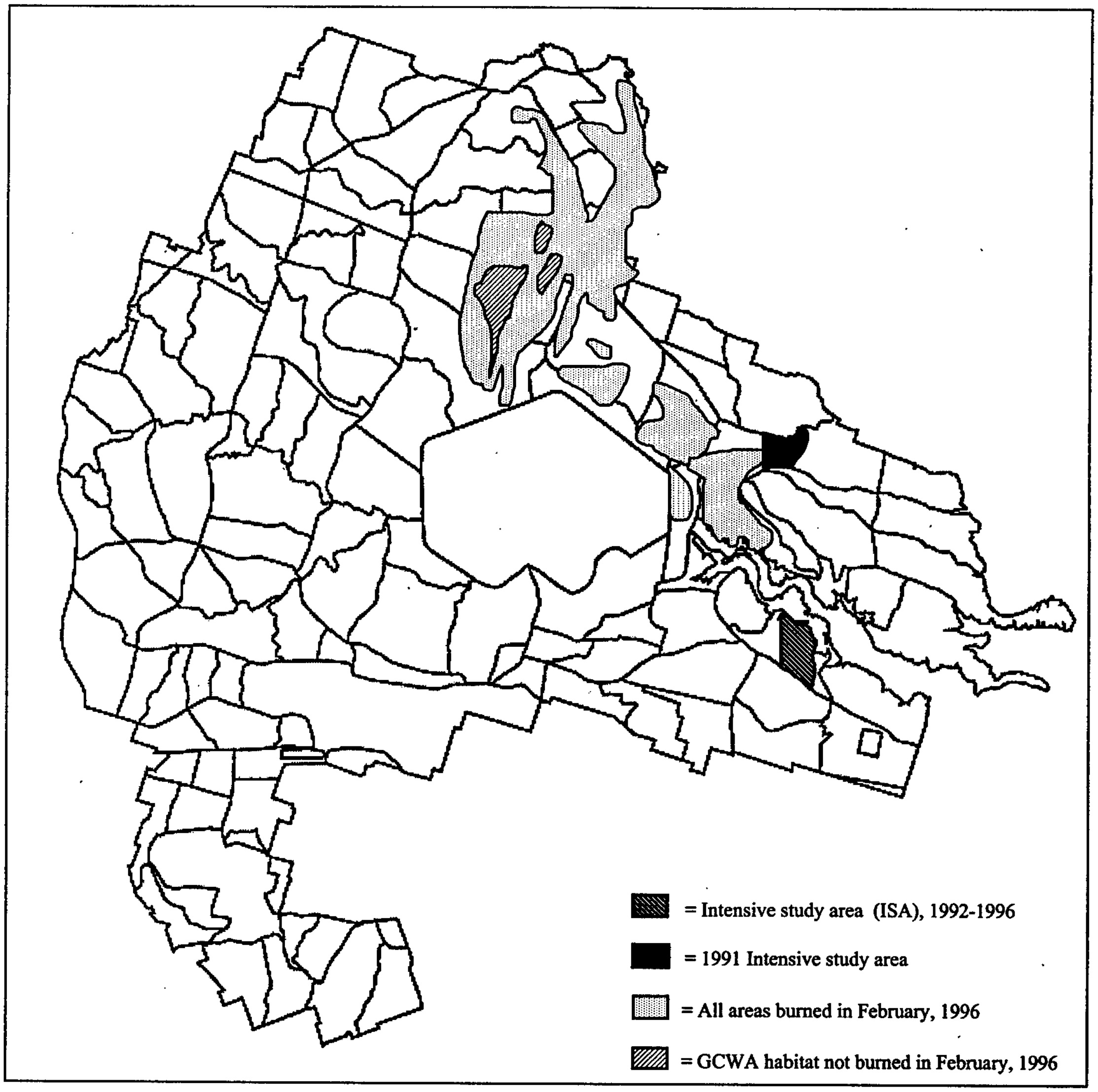


Figure 2. Map of Fort Hood, TX, showing approximate locations of intensive study area (ISA) and areas burned in February 1996 fire. (1 cm ~ 3,100 m.)

Objectives

The objectives of this work were to determine and document (1) demographic parameters (return rates, dispersal distances, productivity, and mated status) affecting population status and (2) occurrence of the Golden-cheeked Warbler on Fort Hood, Texas.

Approach

Research on the Golden-cheeked Warblers was conducted on Fort Hood, Texas between 1991 and 1996. Landsat MSS data were integrated with a Geographic Information System (GIS) application, Geographic Resources Analysis Support

System (GRASS), to suggest potential warbler habitat. Researchers then surveyed these areas, documenting the presence or absence of habitat, and numbers of birds seen or heard. Researchers also established an intensive study area in 1991, banding Golden-cheeked Warblers, and determining territory, mated status, and productivity. The research work consisted of systematically surveying possible Golden-cheeked Warbler habitat, color-banding adults, and monitoring an intensive study area to determine species productivity. Data from these studies were compiled and analyzed, and recommendations were made regarding the monitoring and management of the Golden-cheeked Warbler population on Fort Hood, Texas. Study methods are described in Chapter 2 of this report and in Hayden, Jetté, and Weinberg (in prep.).

Mode of Technology Transfer

This research contributes to a fundamental understanding of the ecology of the endangered Golden-cheeked Warbler, and serves as an example of a proactive approach to endangered species management on Army lands. This and other related reports are being transmitted to military, land, and wildlife managers at Fort Hood, TX; Headquarters, U.S. Army Forces Command (HQ FORSCOM); and the Department of the Army for use in ESA compliance efforts.

2 Methods

This chapter provides a brief overview of research methods between 1991 and 1996. For a detailed description of field methods used in this study, see Hayden, Jetté and Weinberg (in prep.).

Data Collection

The research focus changed in the years following the project's initiation in 1991. The focus shifted from a survey of the entire population of Golden-cheeked Warblers to documenting specific demographic and life history characteristics. This change of focus allowed collection of detailed information regarding return rates, dispersal distances, productivity, mated status, and age structures.

In 1991, a study area was established at the boundary of training areas 2 and 3A. It was necessary to change the location of the study area the following year due to difficulties accessing the site. A new intensive study area (13B, hereafter referred to as the Intensive Study Area [ISA], Figures 2 and 3) with an approximate area of 178 ha was established in 1992 in the eastern side of training area 13B. The 13B/ISA is relatively isolated from other patches of warbler habitat. It is enclosed on the north and northeast by Lake Belton, on the south by pasture, and on the southeast by savannah (open, partially wooded grassland). To the west of the study area is a combination of grassland (west) and stands of pure juniper (southwest) that were unoccupied by warblers. The northwestern section of the study area was attached to more extensive warbler habitat by a "corridor" of warbler habitat.

Golden-cheeked Warblers were captured using mistnets and playbacks of recorded songs and calls. Individuals were banded, aged, and sexed according to Pyle, et al. (1987) and Hayden, Jetté, and Weinberg (in prep). For a review of warbler-specific mistnetting techniques, see Hayden, Jetté, and Weinberg (in prep); and Weinberg, Jetté, and Cornelius (1996). The methods used to age and sex adult warblers during banding were refined during the course of this study. In 1992, it was found that adult plumage characteristics could reliably be used to age to the "second year" (SY) or "after-second-year" (ASY) age classes rather than the general age class of "after-hatch-year" (AHY) used by Pyle, et al. (1987).

Figure 3. Map of the ISA (training area 13B) with Golden-cheeked Warbler habitat shown by a thick white line. (1 cm ~ 100 m.)

However, the AHY age class was still used on Fort Hood after June 15 since most adults were in molt by then and could not be reliably aged. The majority of males banded in a given year were aged more specifically than "AHY" (i.e., to SY or ASY) beginning at 18% in 1992 and increasing to 96% in 1993, remaining high for the rest of the study.

Sex determination of "hatch year" (HY) birds was not as reliable as it was for adults, as individuals were captured at different stages of their sex-specific plumage development. Males could be reliably sexed much earlier than females, because at a young age males generally show the distinct beginning to the dark throat and chest that is characteristic of adult males. If the HY bird was captured late enough in the season (or late enough in the individual's development), it could be reliably sexed, regardless of its sex. Table 1 shows the total number of HY birds captured between 1991 and 1996, separated by sex. The ratio of banded, known-sex hatch year birds was approximately 1.86:1 (male:female), with 17% of the total HY capture population labeled as "unknown-sex." Since it is unknown if males and females return and disperse at the same rates, only known-sex hatch year individuals were used to analyze hatch year return rates and dispersal distances.

Return rates were estimated as the ratio of banded males that were found by searching to the total of those searched for (including both found and not found). Previously banded male Golden-cheeked Warblers were searched for by returning to the last location the bird was sighted (or banded). Males resighted by this method were categorized as having been "searched for." If a banded male was resighted opportunistically (e.g., was not being searched for at the time it was found), the resighting was considered an "incidental" find. Dividing returning birds into categories was necessary to evaluate bias in different approaches to return rate estimations. The use of opportunistically resighted males would bias the estimated return rate toward a higher-than-realistic figure.

Table 1. Total number of HY Golden-cheeked Warblers captured yearly on Fort Hood, including the ISA and non-ISA training areas.

Year	Male	Female	Unknown	Total Captured
1991	2	0	6	8
1992	27	8	20	55
1993	16	6	9	31
1994	47	30	8	85
1995	56	34	7	97
1996	22	12	4	38
Total	170	90	54	314

A third resighting category consisted of those territorial males within the ISA. The ISA was considered separately because of the increased detection rate due to the intensive monitoring procedures. Therefore, the inclusion of the ISA in the overall return rate estimation would also bias the results. All males resighted are listed in Appendix A, which is sorted by resight type. All males searched for and not found are listed in Appendix B.

Site fidelity was estimated by calculating dispersal distance between years. Dispersal distance was determined by Pythagorean's theorem, using the original and resighting locations to obtain a straight-line distance. If a banded bird was resighted in more than one year, the dispersal distance for the first resighting was that between the original banding location and the resighting location; the dispersal distance for the second (and subsequent) resighting was between the first resighting location and the second (or third, etc.). Between 1992 and 1995, researchers chose males to search for, based upon location. For example, field technicians decided in which training area they were going to work on a particular day, and looked at previous years' maps of banding and resighting locations within that training area to have a starting point for searching. In 1996, however, this protocol changed somewhat. A list was established prior to the season, with band combinations and locations of certain males to be searched for. This list included both older and newly banded males, in order to obtain a broader mix of specific age-class return rates, rather than just for those younger males banded in recent years.

Productivity within the intensive study area was estimated by documenting the number of hatch year warblers being fed (by both males and females) on each territory each year. In 1992, specific numbers of HY were not always recorded for each territory within the ISA, as was standard protocol in later years. As these methods differed from those in later years, these data were excluded when analyzing overall and age-specific productivity. Productivity for 1992 was gathered from Bolsinger and Hayden (1992). Also, data from the 1991 season was not used for overall and age-specific productivity because birds weren't aged to specific age classes in 1991, different data were recorded in the baseline year, and because it was in a different location (Training Areas 2 and 3A vs. the ISA).

Data recorded for observations of males outside the ISA generally included only their location and band combination. For those males found within the ISA, however, more detailed demographic data were collected, including the following: presence or absence of a female, number of HY birds observed (and whether or not they were being fed), location of a nest (whenever possible), and territory boundaries (determined by the males regularly visiting certain areas and engaging in singing bouts and fights with neighboring males).

Data Analysis

Differences in return rates and mated status were analyzed by chi-square tests of differences. Any chi-square test that violated Cochran's rule of small sample sizes had data lumped into adjacent categories until it no longer violated this assumption. For all tests conducted, a chi-square test of heterogeneity was used before attempting to lump years together. If the calculated value in the heterogeneity test was not significant, the years were lumped, and were not considered to be statistically different. If the calculated value in the heterogeneity test was significant, the years were not lumped, as they were considered statistically different.

Second year male percentages were calculated by dividing the number of banded SY males in the population (including newly banded males and returning HYs) by the total number of known-age banded adult males in the population (e.g., AHY, HY, and U-age males were excluded from these calculations).

When analyzing dispersal distances, the age classes of 3-year (3Y) vs. 4-year (4Y) vs. "after 4-year" (A4Y+; which included A4Y, 5Y, A5Y, 6Y, and A6Y age classes) were tested by a Kruskal-Wallis test to determine whether the age classes dispersed differently. These age classes were chosen to reduce possible overlap between "unknown" ages; for example, the ASY age class may contain males in the 4Y, 5Y, etc. age classes. The Kruskal-Wallis test was also used to determine significance in dispersal distances between the following groups: (1) HY and adult males, (2) HY and adult females, and (3) ISA "chance" find and searched-for males.

Return rates for 1992 were not calculated, as a separate list of males searched for and not found was not maintained. It was also not noted in 1992 if resighted males were found by "chance" or were searched for. "Annual return rate" refers to males banded one year that were searched for the next year.

All tests were performed in Excel 5.0 and/or SPSS, version 6.1 for the PC.

3 Results

Return rates

Annual Return Rates

Return rates were evaluated for the years 1992-93, 1993-94, 1994-95, and 1995-96. Overall annual return rate of adult Golden-cheeked Warbler males in the ISA was 51.8% (n = 83; Table 2, Figure 4; Appendices A, B, and C). Annual return rates ranged between 31.3% (n = 32) in 1996 to 72.2% (n = 18) in 1995. The return rate of 31.3% in the ISA in 1996 is considered low, as the return rate for 1992 through 1995 was 64.7% (n = 51, Table 2). When tested by chi-square, these differences were significant ($\chi^2 = 14.75$, df = 3, $P = 0.002$).

Annual return rates of males in non-ISA training areas were consistently and significantly lower than those within the ISA, with an overall rate of 42.7% (n = 185, $\chi^2 = 8.35$, df = 3, $P = 0.039$; Table 2, Figure 4; Appendices A and B). The highest annual return was 52.8% (n = 72) in 1994. The lowest rate was in 1996, with 29.8% (n = 57).

Table 2. Annual return rates for adult male Golden-cheeked Warblers.*

Year banded	Year resighted	ISA return rate	Non-ISA return rate	Combined return rate
1992	1993	60% (20)	48.6% (37)	52.6% (57)
1993	1994	61.5% (13)	52.8% (72)	54.1% (85)
1994	1995	72.2% (18)	31.6% (19)	51.4% (37)
1995	1996	31.3% (32)	29.8% (57)	30.3% (89)
All years		51.8% (83)	42.7% (185)	45.5% (268)

* This table excludes AHY and HY males. (n) = Number of adult males banded that were searched for in the following year.

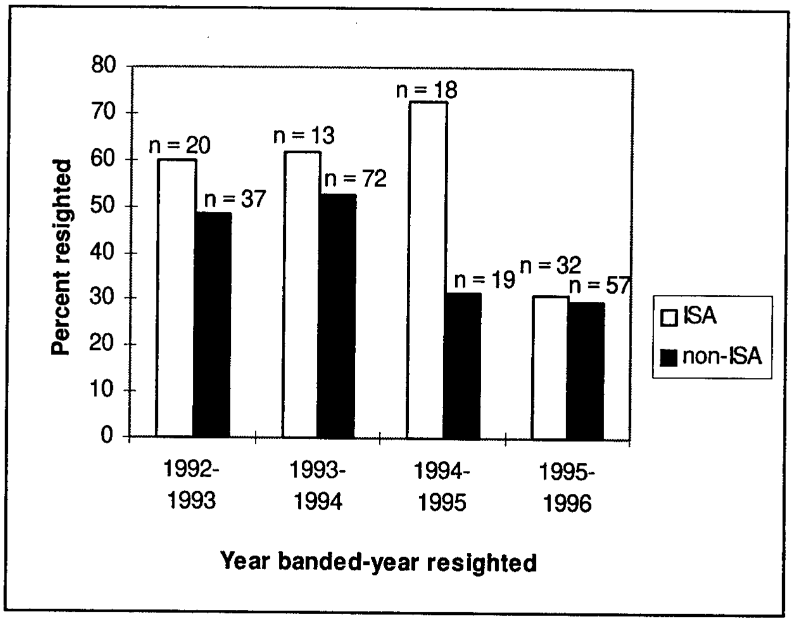


Figure 4. Annual return rates for newly banded ISA and non-ISA males on Fort Hood.

While the overall annual return rate was lower for non-ISA training areas than for the ISA (42.7%, n = 185, and 51.8%, n = 83, respectively), it was not statistically different (χ^2 = 1.57, df = 1, P = 0.21). When the ISA and non-ISA return rates were lumped by year (test of heterogeneity: χ^2 = 6.12, df = 4, P = 0.19), it was found that the difference between years was significant, with the 1996 overall return rate the lowest at 30.3% (n = 89), and the 1994 overall return rate the highest at 54.1% (n = 85, χ^2 = 12.48, df = 3, P = 0.006.

Overall, 228 males were resighted at least one time; 51 males at least two times; 17 males at least three times; and four males were resighted four times (Appendix A).

Overall Return Rates

When looking at all adults present and territorial within the ISA one year that returned the next, the Golden-cheeked Warbler male had an overall return rate of 48% (n = 127), with a low of 30% (n = 50) in 1996 and a high of 65.6% (n = 32) in 1995 (Table 3, Appendices A and C). This among year difference was significant (χ^2 = 12.03; df = 3, P = 0.007). When the age classes were tested separately among years, SY and ASY return rates were both significantly different (SY: χ^2 = 7.85, df = 3, P = 0.049; ASY: χ^2 = 10.67, df = 3, P = 0.014; Table 3; Figure 5). SY males returned with the highest frequency in 1994, at 81.8%, and the lowest in 1996, with 30%. All ASY males returned with the highest frequency in 1995, at 76.5%, and the lowest in 1996 with 30%. Overall rates of return, however, did not differ significantly when divided into separate age classes: SY males returned at 49.1% (n = 53) whereas all ASY lumped together returned at 48.6% (n = 70, χ^2 = 1.017, df = 1, P = 0.90). When the age classes were further divided into specific age groups (of SY, 3Y, ASY, A3Y, and 4Y+), there were still no significant differences in overall return rates ($P > 0.05$). ASY males returned most frequently at 57.7% (n = 26), and A3Y males returned the least at 36.4% (n = 11, χ^2 = 1.50, df = 4, P = 0.83).

Table 3. Return rates for ISA males present and territorial for 1-year periods between 1992 and 1996.*

Age Class	1992-1993	1993-1994	1994-1995	1995-1996	All years
SY	3/7 = 42.9%	9/11 = 81.8%	8/15 = 53.3%	6/20 = 30%	26/53 = 49.1%
All ASY	7/11 = 63.6%	5/12 = 41.7%	13/17 = 76.5%	9/30 = 30%	34/70 = 48.6%
ASY	7/9 = 77.8%	1/2 = 50%	3/3 = 100%	4/12 = 33.3%	15/26 = 57.7%
3Y		1/3 = 33.3%	6/8 = 75%	2/8 = 25%	9/19 = 47.7%
A3Y	0/2 = 0%	3/6 = 50%	1/1 = 100%	0/2 = 0%	4/11 = 36.4%
4Y+			3/4 = 75%	3/8 = 38%	6/12 = 50%
4Y			1/1 = 100%	2/5 = 40%	3/6 = 50%
A4Y			2/3 = 66.7%	0/1 = 0%	2/4 = 50%
5Y				1/1 = 100%	1/1 = 100%
A5Y				0/1 = 0%	0/1 = 0%
AHY	1/4 = 25%	0/1 = 0%	1/1 = 100%	0/0 =0%	2/6 = 33.3%
All ages	11/22 = 50%	14/23 = 60.9%	21/32 = 65.6%	15/50 = 30%	61/127 = 48%

* Numbers indicate those found divided by those present and territorial previous year. "Age Class" refers to age at banding or most recent observation. "ASY" in this table refers only to returning AHY males, and newly banded ASY males. "All ASY" is a total of all banded males, excluding SY and AHY.

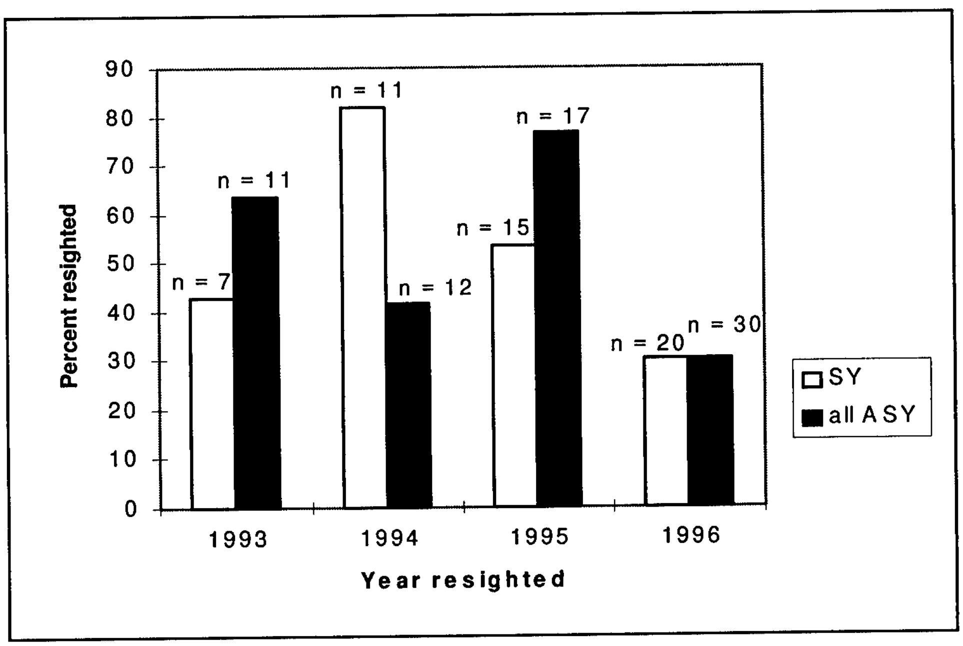


Figure 5. Return rates for adult males within the ISA, by age and year.

As with the ISA, there was a significant difference among years in average return rates for males outside the ISA (all ages combined, $\chi^2 = 23.56$, df = 3, $P = 0.00003$), with an average of 32.9% (n = 350), and a range of 19.2% (1996, n = 120) to 51.1% (1994, n = 88, Table 4, Figure 6). Unlike the ISA, however, there was a significant difference in return rates between age classes outside the ISA for all years combined; SYs returned more frequently (47.2%, n = 72) than all ASYs combined (28%, n = 225, $\chi^2 = 8.31$, df = 1, $P = 0.004$). When all age classes were considered separately (SY, 3Y, 4Y, ASY, A3Y, A4Y+), the difference was still significant ($\chi^2 = 12.98$, df = 5, $P = 0.024$).

Table 4. Return rates for searched-for males in non-ISA training areas for 1-year periods between 1992 and 1996.*

Age class	1992-1993	1993-1994	1994-1995	1995-1996	All years
SY	4/7 = 57.1%	15/27 = 55.6%	6/12 = 50%	9/26 = 34.6%	34/72 = 47.2%
All ASY	8/28 = 28.6%	24/42 = 57.1%	18/62 = 29%	13/93 = 14%	63/225 = 28%
ASY	5/17 = 29.4%	17/29 = 58.6%	5/26 = 19.2%	8/34 = 23.5%	35/106 = 33%
3Y	0/2 = 0%	2/4 = 50%	4/8 = 50%	1/11 = 9.1%	7/25 = 28%
A3Y	3/9 = 33.3%	4/8 = 50%	4/11 = 36.4%	0/19 = 0%	11/47 = 23.4%
4Y		1/1 = 100%	0/1 = 0%	0/12 = 0%	1/14 = 7.1%
A4Y+			4/6 = 67%	4/17 = 24%	8/23 = 35%
A4Y			2/3 = 66.7%	2/11 = 18.2%	4/14 = 28.6%
5Y			0/1 = 0%	0/0 = 0%	0/1 = 0%
A5Y			2/2 = 100%	2/4 = 50%	4/6 = 66.7%
6Y				0/2 = 0%	0/2 = 0%
AHY	9/14 = 64.3%	8/19 = 42.1%	1/7 = 14.3%	1/1 = 100%	19/41 = 46.3%
U age	2/5 = 40%				2/5 = 40%
All ages	23/68 = 33.8%	45/88 = 51.1%	24/74 = 32.4%	23/120 = 19.2%	115/350 = 32.9%

* All males searched for, including those banded prior to previous season. Numbers listed are those found divided by those searched for. "Age Class" refers to age at first banding or most recent observation. "All ASY" is a total of all banded males, excluding SY, AHY, and those of unknown age at banding. "U age" refers to unknown age at banding.

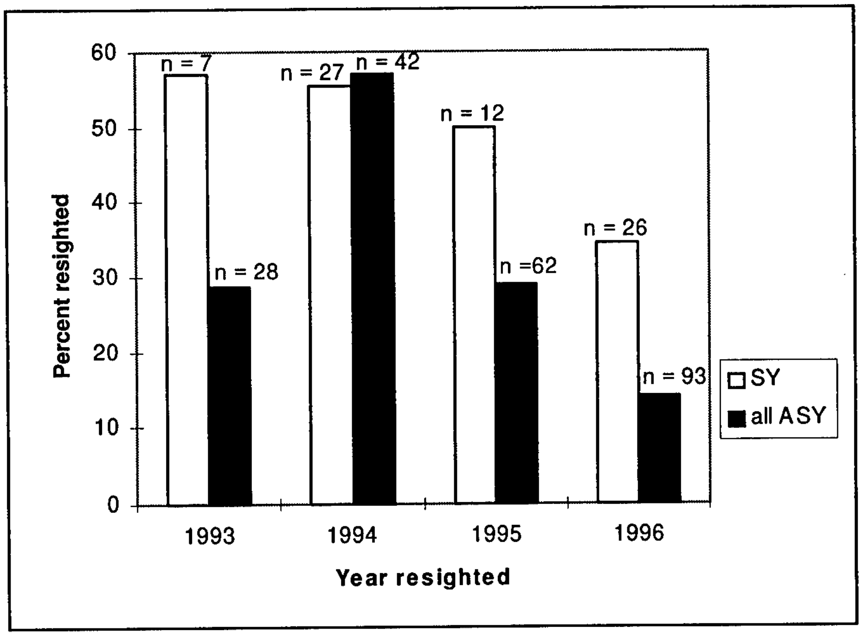


Figure 6. Return rates for non-ISA adult males, by age class and year.

Adult female Golden-cheeked Warblers were resighted at 18.3% (*n* = 60 banded between 1991 and 1995; Table 5 for dispersal distances; Appendix D). Of the two females banded in 1991, one was resighted; the one female banded in 1992 was not resighted nor were any of the four banded in 1993. Three (15.8%) of the 19 females banded in 1994 were resighted, and 20.6% (*n* = 34) of those banded in 1995 were resighted. One female was resighted twice (Appendix D).

HY resighting rates were generally much lower than observed adult returns. HY males were resighted at an average of 16.9% (*n* = 148, Table 6 and Appendix E), ranging from 11.1% (*n* = 27) in 1993, to two of two HYs returning in 1992. HY females were resighted at an average of 9% (*n* = 78, Table 6 and Appendix F), with rates ranging from no returns in 1993 (*n* = 8) and 1994 (*n* = 6), to 11.8% (*n* = 34) in 1996.

Table 5. Dispersal distances for all female Golden-cheeked Warblers banded as adults.*

Age at resight	n	Mean (m; S.D.)	Median (m)	Range (m)	Number located at each distance ≥ 300 m	≥ 1 km	≥ 3 km
3Y	1	316	316	316	1 (100%)	0	0
A3Y	4	135 (47)	141	100 - 200	0	0	0
A4Y	2	883 (172)	883	762 - 1005	2 (100%)	1 (50%)	0
ASY	4	231 (95)	253	100 - 316	1 (25%)	0	0
Total	11	322 (294)	224	100 - 1005	4 (36%)	1 (9%)	0

* (%) = Percent of that age class resighted at or beyond that distance from either their banding location or observation in the previous year.

Table 6. Return rates for all hatch year (HY) Golden-cheeked Warblers.*

Year banded	Male	Female
1991	2/2 = 100%	0/0
1992	3/27 = 11.1%	0/8
1993	3/16 = 18.8%	0/6
1994	10/47 = 21.3%	3/30 = 10%
1995	7/56 = 12.5%	4/34 = 11.8%
All years	25/148 = 16.9%	7/78 = 9.0%

* Numbers indicate those found divided by total number banded. Intensive study area-banded HY birds are included in this list, regardless of where they were resighted. Unknown-sex HY birds are not included in this list.

Dispersal Distances

Observed dispersal distances for all male Golden-cheeked Warblers banded as adults (including the second resighting of four HY males that were resighted twice (i.e., from 3Y to 4Y) ranged from 0 m to 3,523 m, with an average distance of 223 m (n = 268, median = 141, S.D. = 307, Table 7). While the dispersal distance differences for the 3Y, 4Y, and A4Y+ (A4Y, 5Y, A5Y, 6Y, A6Y) age classes were not significant (Kruskal-Wallis test χ^2 = 3.93, 1 df, P = 0.14), there was a trend toward 3Y males being resighted farther (n = 80, average = 268 m, median = 141, S.D. = 282) from their original banding locations than the 4Y males (n = 20, average = 162 m, median = 100, S.D. = 157). Although A4Y+ males were resighted at an average distance of 262 m (n = 43, median = 121, S.D. = 552), this may have been due to three males that were found at much greater distances than the others (Appendix A). Excluding these three males, the average resighting distance for A4Y+ males was 152 m (n = 40, median = 100, S.D. = 120).

Dispersal distances were classified into three groups: ISA resightings, searched-for males, and those males that were "chance" finds (Table 8 and Appendix A). These three groups showed a significant difference in dispersal distance that was most likely due to the methods used to find them (Kruskal-Wallis test χ^2 = 14.16, df = 2, P = 0.0008). "Chance" find males were observed at the greatest average distance (304 m, median = 200 m, S.D. = 480, n = 66); ISA males were resighted at an average distance of 277 m (median = 200 m, S.D. = 310, n = 65); searched-for males were resighted at the shortest average distance of 146 m (median = 100 m, S.D. = 141, n = 137).

Table 7. Dispersal distances summarized by age class for male Golden-cheeked Warblers banded as adults on Fort Hood.*

Age at resight	n	Mean (m; S.D.)	Median (m)	Range (m)	Number located at each distance		
					≥ 300 m	≥ 1 km	≥ 3 km
ASY	37	193 (191)	141	0 - 1000	9 (24%)	1 (3%)	0
3Y	80	262 (282)	141	0 - 1746	29 (36%)	2 (3%)	0
A3Y	86	167 (209)	100	0 - 1456	15 (17%)	1 (1%)	0
4Y	20	162 (157)	100	0 - 510	4 (20%)	0	0
A4Y+	43	268 (552)	121	0 - 3523	8 (19%)	2 (5%)	1 (2%)
A4Y	23	353 (734)	141	0 - 3523	5 (22%)	2 (9%)	1 (4%)
5Y	5	125 (55)	100	100 - 224	0	0	0
A5Y	9	126 (116)	100	0 - 316	2 (22%)	0	0
6Y	1	0	0	0	0	0	0
A6Y	5	277 (147)	224	200 - 539	1 (20%)	0	0
AHY	2	193 (191)	549	0 - 1000	2 (100%)	0	0
Overall	268	223 (307)	141	0 - 3523	67 (25%)	6 (2%)	1 (0.4%)

* Known dispersal distances only. This table also includes four HY "second" resightings incorporated into their respective resight-age categories – i.e., they were resighted as SY, then as 3Y (or later). This table excludes 1996 fire-displaced males. (%) = % of that age class resighted at, or beyond that distance from a previous resighting location, or from their original banding location (whichever occurred later).

Table 8. Dispersal distances for adult males banded in the intensive study area (ISA), banded males searched for, and banded males observed opportunistically ("chance-find").*

Resight type	n	Mean (m; S.D.)	Median (m)	Range (m)	Number located at each distance		
					# ≥ 300 m	# ≥ 1 km	# ≥ 3 km
ISA	65	277 (310)	200	0 – 1746	24	3	0
Chance	66	304 (480)	200	0 - 3523	22	3	1
Search	137	146 (141)	100	0 - 781	21	0	0

* This table excludes fire-displaced males and HY first resights. It includes only males with known dispersal distances.

The average resighting distances for male Golden-cheeked Warblers banded as HY (4,040 m, median = 3317, S.D. = 4,777, n = 25) was significantly greater than for adult males (223 m, S.D. = 308, n = 284, Kruskal-Wallis test χ^2 = 53.68, df = 1, P = 0.000; Tables 7 and 9, and Appendix E). Nineteen (76%) of the resighted HY males were observed 1 kilometer or more from their original banding locations (n = 25) compared with only 2% of adult males (n = 268, Table 7). This difference in proportion dispersing farther than 1 km was significant (χ^2 = 155.60, df = 1, P = 0.000).

The average resighting distance for adult females was 322 m (median = 224 m, S.D. = 294, n = 11; Table 5 and Appendix D). The range of these resighted females was 100 m to 1,005 m. The average resighting distance for female Golden-cheeked Warblers that were banded as HY was 1,525 m (n = 7, median = 856, S.D. = 1,388, range of 0 m to 3,448 m; Table 10 and Appendix F) from their original banding locations. This difference in resighting distances between adult and HY females was significant (Kruskal-Wallis test $\chi^2 = 5.62$, df = 1, $P = 0.018$).

Detection of Territorial Males

Density within the ISA steadily increased from 1992 through 1995, peaking at 28.1 males per 100 ha in 1995 (50 territorial males within 178 ha, Table 11), then dropping to 18.0 males per 100 ha in 1996 (32 territorial males). The annual average between 1992-1996 was 18.8 males per 100 ha (S.D. = 6.91).

Numbers of territorial males detected postwide (including the ISA) also fluctuated between 1991 and 1996, averaging 584 males (S.D. = 219.79, Table 12). The highest number detected was 915 males, in 1996; the lowest was 383 males, in 1992. The number of training areas in which males were detected also fluctuated somewhat, with an average of 37.7 (S.D. = 4.46), and a range of 31 (1994) to 41 (1991 and 1996).

Table 9. Dispersal distances for all male Golden-cheeked Warblers banded as HY on Fort Hood.*

Age at 1st resight	n	Mean (m; S.D.)	Median (m)	Range (m)	Number located at each distance		
					# ≥ 300 m	# ≥ 1 km	# ≥ 3 km
SY	17	2461	1720	60 - 10004	16 (95%)	12 (71%)	7 (41%)
3Y	5	7864 (7982)	5906	906 - 20082	6 (100%)	5 (83%)	4 (67%)
4Y	1	5573		5573	1 (100%)	1 (100%)	1 (100%)
5Y	1	5557		5557	1 (100%)	1 (100%)	1 (100%)
Total	24	4040 (4777)	3317	60 - 20082	24 (96%)	19 (76%)	13 (52%)

* This table includes only initial resights. The 3 cases in which a male was originally banded as HY and was resighted >1 time are listed in the table of adult male dispersal distances (Table 7). (%) = % of that age class resighted at, or beyond that distance from their original banding location.

Table 10. Dispersal distances for female Golden-cheeked Warblers banded as hatch year (HY).*

Age at 1st resight	n	Mean (m; S.D.)	Median (m)	Range (m)	Number located at each distance		
					# ≥ 300 m	# ≥ 1 km	# ≥ 3 km
SY	6	1785 (1379)	906	0 - 3448	5 (83%)	2 (33%)	2 (33%)
3Y	1	224			0	0	0
Total	7	1525 (1388)	856	0 - 3448	5 (71%)	2 (29%)	2 (29%)

* (n) = % of that age class resighted at, or beyond that distance away from either a previous resighting location, or their original banding location (whichever occurred later).

Table 11. Number of territorial Golden-cheeked Warblers present in the ISA.

Year	Number of territorial males (in 178 ha)	Density per 100 ha
1992	24	13.5
1993	25	14.1
1994	36	20.2
1995	50	28.1
1996	32	18.0
Average	33.4	18.8

Table 12. Number of male Golden-cheeked Warblers detected in all training areas (including the ISA), and the total number of training areas in which males were detected.

Year	Number of males	Number of training areas in which males were detected
1991	515	41
1992	383	40
1993	399	33
1994	499	31
1995	797	40
1996	915	41
Average	584.7	37.7

Age Structures

The percentage of SY males within the ISA averaged 41.7%, ranging from 30.3% to 57.1%. The differences did not vary significantly among years ($\chi^2 = 4.27$, df = 4, $P = 0.37$; Table 13). Observed percentage of SY males was consistently and significantly higher within the ISA than in non-ISA training areas (ISA average = 41.7%, non-ISA average = 27.5%, $\chi^2 = 12.40$, df = 1, $P = 0.0004$; Tables 13 and 14; Figure 7). Although rates in the non-ISA training areas did not vary as widely among years as those within the ISA, the differences were statistically significant (range: 18.5% to 34.7%, average of 27.5%, $\chi^2 = 15.97$, df = 5, $P = 0.007$). When the annual captures of the ISA and non-ISA training areas were lumped together, SY males were captured at a significantly lower rate than ASY males ($\chi^2 = 13.54$, df = 5, $P = 0.019$; Table 15).

Table 13. Age structure of male Golden-cheeked Warblers present in ISA.*

Age class	1992	1993	1994	1995	1996	All years
SY (%SY)	6 (35.3%)	12 (57.1)	17 (44.7)	25 (42.4)	10 (30.3)	70 (41.7)
ASY	9	2	5	13	7	36
3Y		2	9	8	7	26
A3Y	2	5	1	3	4	15
4Y			1	6	2	9
A4Y			5	1		6
5Y				1	2	3
A5Y				2		2
6Y					1	1
AHY	4	1	1		1	7
HY	8	4	10	32	11	59
Total	17	21	38	59	33	168

* Includes all males identified within the intensive study area, regardless of territory status. Neither AHY nor HY are included in % SY calculation.

Table 14. Age structure of male Golden-cheeked Warblers observed outside the ISA.*

Age class	1991	1992	1993	1994	1995	1996	All years
SY (%SY)	23 (33.3%)	23 (31.1)	33 (34.7)	32 (21.9)	72 (33.0)	29 (18.5)	212 (27.5)
ASY	46	34	48	64	97	69	358
3Y		5	5	17	10	22	59
A3Y		12	4	22	16	20	85
4Y			2	3	8	3	16
A4Y			3	6	10	3	22
5Y				1		2	3
A5Y				1	3	5	9
A6Y					2	3	5
7Y						1	1
AHY	15	24	43	20	13	13	128
HY	2	19	12	37	23	11	104
Total	69	74	95	146	218	157	770

* Includes both resighted and newly banded males. Neither AHY nor HY are included in % SY calculation. ISA males are <u>not</u> included in this table. See Table 13 for age classes of ISA males.

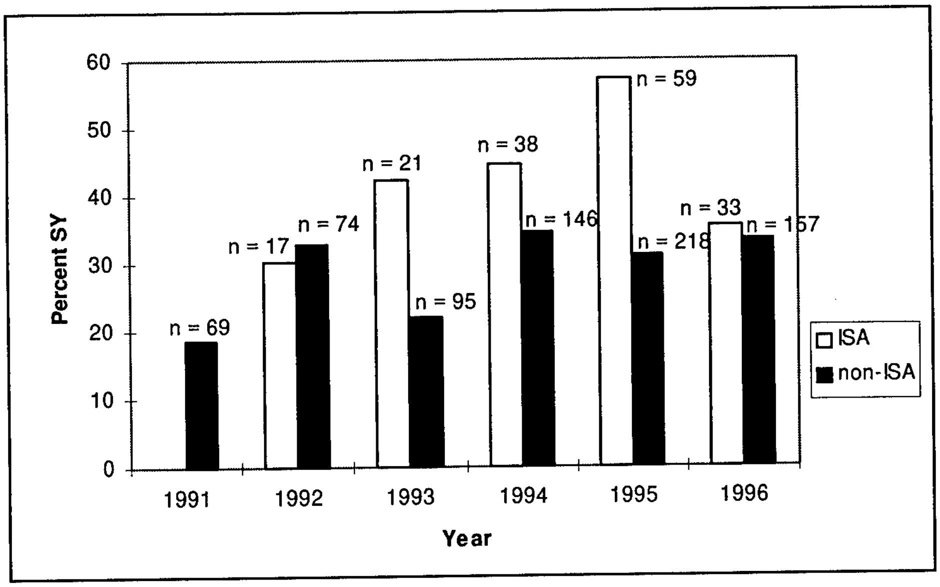


Figure 7. Percentage of SY individuals in the ISA and non-ISA training areas.

Table 15. Total number of males banded by age class on Fort Hood.*

Age class	1991	1992	1993	1994	1995	1996	Total
SY (%SY)	23 (33.3%)	29 (43.3)	44 (53.0)	45 (44.6)	91 (46.7)	32 (30.8)	264 (42.6)
ASY	46	38	39	56	104	72	355
AHY	15	28	42	22	13	14	134
HY	2	27	16	47	56	22	170
U	0	6	0	0	0	0	6
Total	86	128	141	170	264	140	929

* This table includes males captured within the ISA and in non-ISA training areas. "U" = unknown age at banding.

Mated Status Within the Intensive Study Area

Males within the intensive study area mated at an overall frequency of 89% (n = 167, Table 16, Figure 8). SY males mated consistently and significantly less often, at 79% (n = 61, 1992-1996) than ASY males, at 97% (n = 88, $\chi^2 = 14.20$, df = 1, $P = 0.0005$). SY mating percentage ranged from 70% in 1993 to 85% in 1995. ASY mating percentage ranged from 82% in 1992 to 100% in 1993, 1995, and 1996. There was no significant heterogeneity among years, allowing the years to be lumped ($\chi^2 = 2.75$, df = 4, $P = 0.60$).

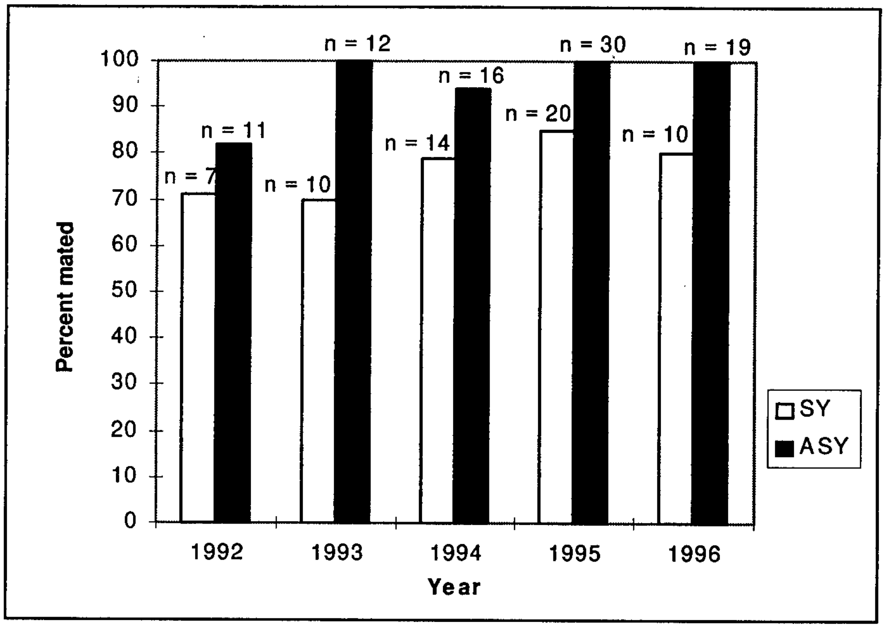


Figure 8. Percent of mated males within the ISA, by age class and year.

Table 16. Percent of ISA males mated, by age class.*

Age class	1992	1993	1994	1995	1996	All years
SY	71% (7)	70 (10)	79 (14)	85 (20)	80 (10)	79 (61)
All ASY	82 (11)	100 (12)	94 (16)	100 (30)	100 (19)	97 (88)
ASY	78 (9)	100 (2)	100 (3)	100 (12)	100 (4)	93 (30)
3Y		100 (3)	100 (8)	100 (8)	100 (7)	100 (26)
A3Y	100 (2)	100 (7)	100 (1)	100 (2)		100 (16)
4Y			100 (1)	100 (5)	100 (1)	100 (7)
A4Y			67 (3)	100 (1)		75 (4)
5Y				100 (1)	100 (2)	100 (3)
A5Y				100 (1)		100 (1)
6Y					100 (1)	100 (1)
AHY	100 (2)				100 (1)	100 (3)
UB	75 (4)	100 (3)	67 (6)		100 (2)	80 (15)
All ages	79 (24)	88 (25)	83 (36)	94 (50)	94 (32)	89 (167)

* (n) = total number of territorial males in that age class. "All ASY" is a total of all banded males, excluding SY and AHY. "UB" = unbanded male.

Productivity

Fecundity within the ISA averaged 2.23 HY per **successful** male (n = 118 successful males including unknown-age and unbanded males, 263 fledglings; excludes 1992), and ranged between 2.08 (1996, n = 25 successful males) to 2.29 (1995, n = 45 successful males; Table 17). Numbers of HY per **territorial** male averaged 1.84 HY per territorial male (n = 143 territorial males), ranging from 1.63 (1996, n = 32 territorial males) to 2.06 (1995, n = 50 territorial males, Table 18).

Table 17. Mean number of young fledged by successful ISA males, by age class and year.*

Age class	1992	1993	1994	1995	1996	All years
SY		2.83 (17)	2.00(20)	2.06 (16)	2.17 (13)	2.18 (83)
All ASY		2.00 (24)	2.36 (33)	2.41 (29)	2.12 (36)	2.26 (163)
ASY		1.50 (3)	2.33(7)	2.33 (12)	1.75 (7)	2.14 (45)
3Y		2.67 (8)	2.29 (16)	2.63 (8)	2.00 (10)	2.39 (55)
A3Y		1.86 (13)	3.00 (3)	1.00 (1)	2.00 (8)	1.92 (25)
4Y			3.00 (3)	2.20 (11)	2.00 (2)	2.29 (16)
A4Y			2.00 (4)	4.00 (4)		2.67 (8)
5Y				2.00 (2)	3.00 (6)	2.67 (8)
A5Y				3.00 (3)		3.00 (3)
6Y					3.00 (3)	3.00 (3)
AHY					2.00 (2)	2.00 (2)
UB		2.00 (4)	2.50 (10)		1.00 (1)	2.14 (15)
All ages	1.69 (27)	2.25 (45)	2.25 (63)	2.29 (103)	2.08 (52)	2.23 (263)

*(n) = total number of young fledged. "All years" column <u>excludes</u> 1992 data. "All ASY" is a total of all banded males, excluding SY and AHY. "UB" = unbanded males.

Table 18. Mean number of young fledged by territorial ISA males, by age class and year.*

Age class	1992	1993	1994	1995	1996	All years
SY		1.70 (17)	1.43 (20)	1.65 (33)	1.30(13)	1.54 (83)
All ASY		2.00 (12)	2.06 (33)	2.33 (70)	1.89(36)	2.12 (163)
ASY		1.50 (3)	2.33 (7)	2.33 (28)	1.75 (7)	2.14 (45)
3Y		2.37 (8)	2.00 (16)	2.63 (21)	1.43 (10)	2.12 (55)
A3Y		1.86 (13)	3.00 (3)	0.50 (1)	2.00 (8)	1.79 (25)
4Y			3.00 (3)	2.20 (11)	2.00 (2)	2.29 (16)
A4Y			1.33 (4)	4.00 (4)		2.00 (8)
5Y				2.00 (2)	3.00 (6)	2.67 (8)
A5Y				3.00 (3)		3.00 (3)
6Y					3.00 (3)	3.00 (3)
AHY					2.00 (2)	2.00 (2)
UB		1.33 (4)	1.67 (10)		1.00(1)	1.36 (15)
All ages	1.13 (27)	1.80 (45)	1.75 (63)	2.06 (103)	1.63 (52)	1.84 (263)

* (n) = total number of young fledged. "All years" column <u>excludes</u> 1992 data. "All ASY" is a total of all banded males, excluding SY and AHY.

Productivity of mated males did not differ significantly between age classes. The average fecundity for **mated** SY males was 1.93 young per mated SY (n = 43 mated SY; Table 19). The average for mated ASY males was 2.15 young per mated ASY (n = 76 mated ASY excluding 1992, t = 0.77, df = 1, P = 0.50; Table 19). Productivity per **successful** male was also very similar between SY (2.18 HY per successful SY, n = 38 successful SY excluding 1992) and ASY males (2.26 HY per successful ASY, n = 72 successful ASY excluding 1992, t = 0.152, df = 1, P = 0.89; Tables 17 and 20). The difference between age classes in productivity per **territorial** male was statistically significant, however, with an average of 1.54 HY per territorial SY (n = 54 territorial SY excluding 1992; Tables 16 and 18) and 2.12 young per territorial ASY (n = 77 territorial ASY excluding 1992, t = 6.45, df = 1, P = 0.008, Tables 16 and 18), due to the lower mating success of SY males versus ASY males. Once mated, however, SY males appeared to be equally successful as ASY males (see success rate information below). See Figure 9 for SY productivity by year.

Although sample sizes were small, there was a slight trend toward males producing more young as they aged. Third-year mated males' productivity was the same as all ASY mated males, with 2.12 HY per mated male (n = 26 3Y males, Table 16). Fourth-year males produced 2.29 HY per mated male (n = 7 4Y males, Table 16), fifth-year males, 2.67 (n = 3 5Y males; Table 16), and the 1 sixth-year male present in the intensive study area produced 3 HY.

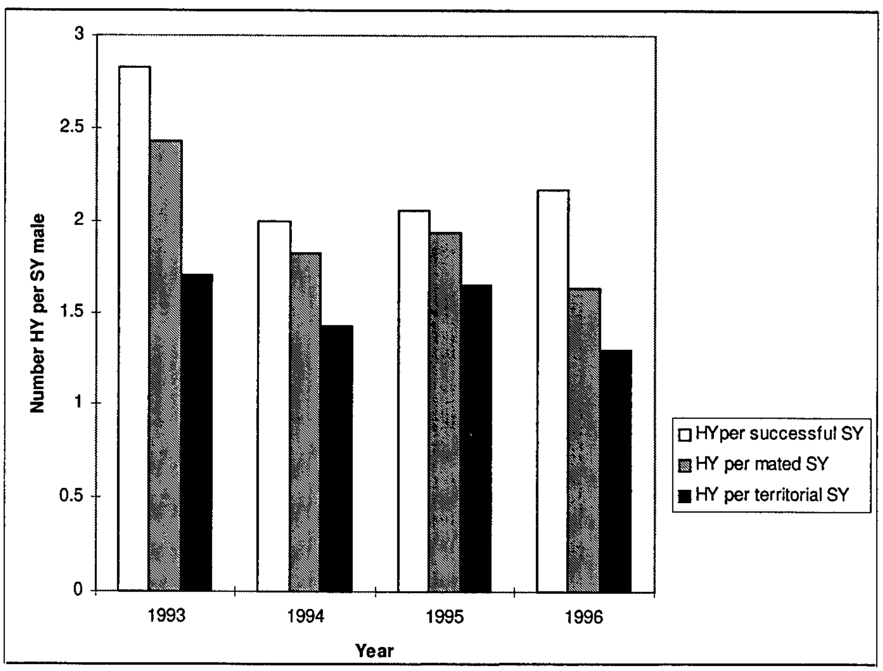


Figure 9. Productivity for ISA SY males, by year.

Table 19. Mean number of young fledged by mated ISA males, by age class and year.*

Age class	1992	1993	1994	1995	1996	All years
SY		2.43 (17)	1.82 (20)	1.94 (33)	1.63 (13)	1.93 (83)
All ASY		2.00 (24)	2.20 (33)	2.33 (70)	1.89 (36)	2.15 (163)
ASY		1.50 (3)	2.33 (7)	2.33 (28)	1.75 (7)	2.14 (45)
3Y		2.67 (8)	2.00 (16)	2.63 (21)	1.43 (10)	2.12 (55)
A3Y		1.86 (13)	3.00 (3)	0.50 (2)	2.00 (8)	1.79 (25)
4Y			3.00 (3)	2.20 (11)	2.00 (2)	2.29 (16)
A4Y			2.00 (2)	4.00 (4)		2.67 (8)
5Y				2.00 (2)	3.00 (6)	2.67 (8)
A5Y				3.00 (3)		3.00 (3)
6Y					3.00 (3)	3.00 (3)
AHY					2.00 (2)	2.00 (2)
UB		1.33 (4)	2.50 (10)		1.00 (1)	1.67 (15)
All ages	1.42 (27)	2.05 (45)	2.10 (63)	2.19 (103)	1.73 (52)	2.04 (263)

*(n) = total number of young fledged. "All years" column excludes data for 1992. "All ASY" is a total of all banded males, excluding SY and AHY.

Table 20. Success rate of ISA Golden-cheeked Warbler males.*

Age class	1992	1993	1994	1995	1996	All years
SY	5/5	6/7	10/11	16/17	6/8	43/48
All ASY	8/9	12/12	14/15	29/30	17/19	80/85
AHY	0/2	0/0	0/0	0/0	1/1	1/3
UB	3/3	2/3	4/4	0/0	1/2	10/12
All ages	16/19	20/22	28/32	45/47	25/30	133/145

*Proportion of mated males that were also successful. "All years" column includes 1992 data.

Success rate (mated males that also reproduced) between the age classes was very consistent. SY males had an overall success rate of 90% (n = 48 successful SY males [including 1992 data], ranging from 75% in 1996 to 100% in 1992; Table 20). ASY males had an overall success rate of 94% (n = 85 successful ASY males [including 1992 data], ranging from 89% in 1992 and 1996 to 100% in 1993). This difference between SY and ASY male mating success was not significant ($\chi^2 = 0.37$, df = 1, $P = 0.54$).

Parasitism

Seven incidents of brown-headed cowbird (BHCO) parasitism of Golden-cheeked Warbler nests were reported since 1991. In 1991, three of six Golden-cheeked Warbler nests located were parasitized (at least two of which fledged cowbird young, Table 21), and an adult male was seen feeding a juvenile BHCO in a cowbird trap. The one nest located in 1992 was not parasitized; in 1993, none of the four nests whose contents were observed were parasitized. There was one instance in 1993, however, of a pair of Golden-cheeked Warblers feeding one BHCO young, as well as at least one (and possibly two) Golden-cheeked Warbler young. In 1994, none of the ten nests were parasitized, and no feeding of BHCO fledglings was observed. Similarly, in 1995, none of the seven nests found were parasitized, and no feeding of BHCO fledglings was observed. In 1996, none of the 11 nests found were parasitized, but there were two occasions during which an adult Golden-cheeked Warbler was found in association with a juvenile BHCO. In one instance, an adult female was seen within inches of the BHCO HY, but did not feed it even though it was begging. In another instance, an adult female was seen feeding a juvenile BHCO.

Table 21. Summary of outcomes for Golden-cheeked Warbler nests located on Fort Hood, 1991-1996.

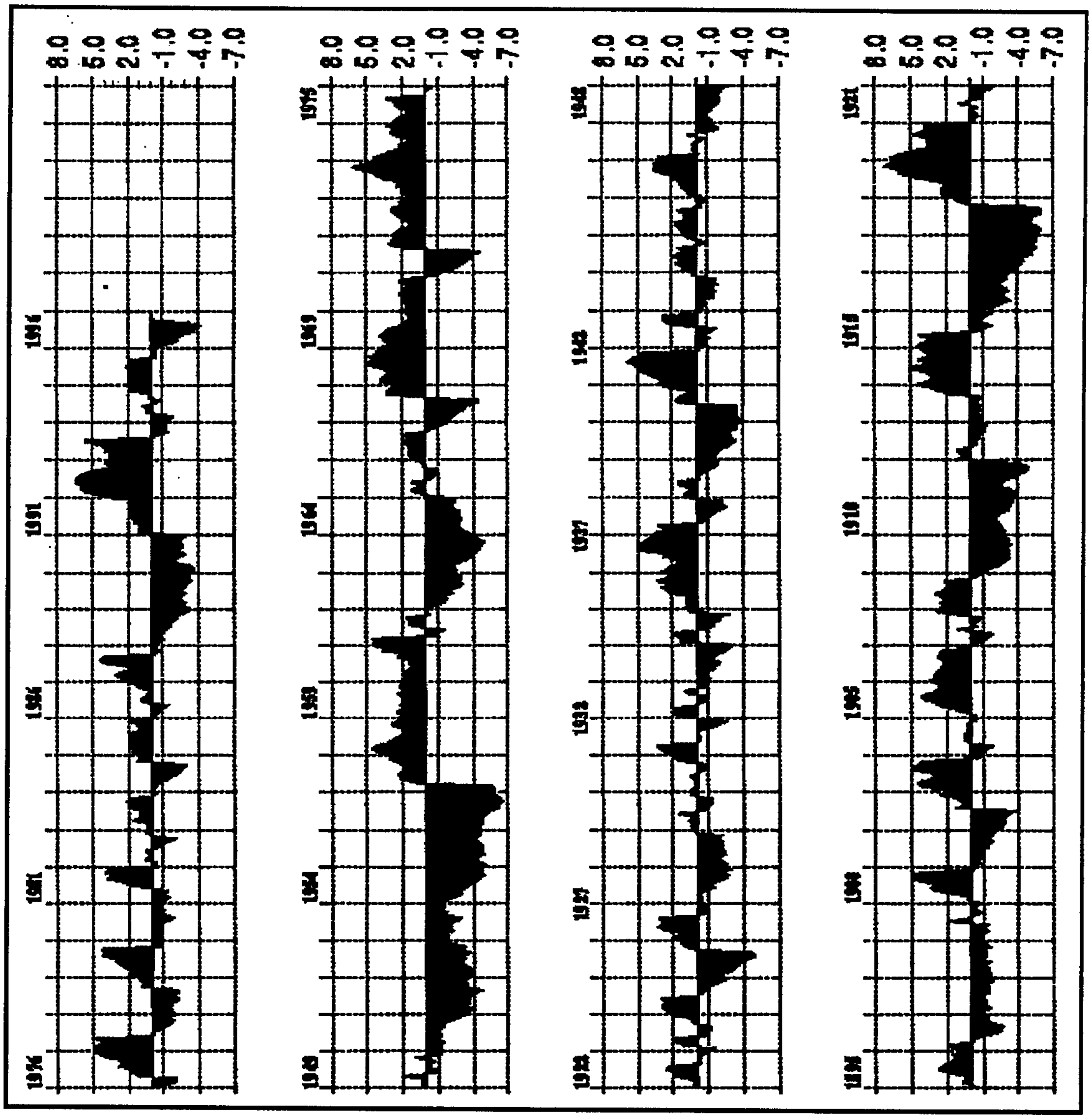
Year	No. found	No. fledged successfully	No. depredated or abandoned	No. parasitized	No. fate unknown
1991	6	3	0	3	3
1992	1	1	0	0	0
1993	7	4	2	0	0
1994	10	10	0	0	0
1995	7	4	1	0	2
1996	11	5	2	0	4
Total	35	27	5	3	9

4 Discussion

Population Trends

Results indicate that the Golden-cheeked Warbler population on Fort Hood, Texas steadily increased through 1995, when most population measurements were at their peak. Return rates were at their highest within the intensive study area in 1995, and were average for non-ISA training areas. Territorial males were at their greatest density within the ISA, and above average for all training areas combined. The proportion of the population that was SY was above average for both inside and outside the study area, indicating a young, growing population. All measurements of productivity within the study area were at their highest since the study began, also indicating a growing population. However, 1996 showed decreases in many population indices. Return rates and proportions of SY in the population were at their lowest for all males, both within and outside the study area. Similarly, all measurements of productivity, including success rate, were also at their lowest since 1992. Because no baseline warbler demographic data was available before 1991, and because of the steady increase between 1992 and 1995, followed by the sharp decrease in 1996, no long term population trends can be discerned at this time. Data collected in the years 1991 through 1996 on Fort Hood demonstrate a capacity for high annual variability. While there were several possible reasons for the observed decreases in population parameters in 1996, there was no apparent cause for the increases between 1991 and 1995.

One possible explanation for the decreases of 1996 may be the stress caused by severe weather in the spring and summer of 1996. According to the Palmer Drought Severity Index, there was a "severe to extreme drought" in the spring and summer of 1996 (Figure 10, Appendix G). When these drought conditions were combined with the slightly cooler than average temperatures and significantly lower than average relative humidity that were prevalent when the Golden-cheeked Warblers were migrating north, and when they returned to Fort Hood in March, a higher death rate might be expected due to stress caused by food and water shortages (see Table 22 for weather data). This hypothesis, though, is not supported, as the return rate in a Texas Parks and Wildlife Department (TPWD) study less than 100 miles south of Fort Hood did not show a similar decrease, although they generally had similar weather patterns



PSDI Classifications for Dry and Wet Periods	
4.00 or more	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet
0.49 to –0.49	Near normal
-0.50 to –0.99	Incipient dry spell
-1.00 to –1.99	Mild drought
-2.00 to –2.99	Moderate drought
-3.00 to –3.99	Severe drought
-4.00 to –4.99	Extreme drought

Figure 10. Monthly averages of the Palmer Drought Severity Index (PDSI) for Texas, Division 7 (of which Fort Hood is a part), from 1895 to 1996. For a detailed description of this index, see Appendix G.

Table 22. Mean daily temperatures and relative humidities for the month of March for Fort Hood from 1994-1996.*

	1994	1995	1996	Overall
Mean March daily temperature	68.7°	64.0°	63.4°	65.4°
Temperature range	40.5° - 86.2° S.D. = 13.43	33.1° - 89.4° S.D. = 14.64	41.5° - 83.5° S.D. = 14.37	33.1° - 89.4°
Mean March daily Relative Humidity[a]	48.7%	58.5%	38.2%	48.5%
Relative Humidity range	21% - 99% S.D. = 21.5	22% - 91% S.D. = 20.0	16% - 99% S.D. = 19.7	16% - 99% S.D. = 21.85

[a] = significant difference by ANOVA ($F_{(2,92)}$ = 7.714; P = 0.001). Data compliments of Natural Resources Branch, Fort Hood (unpublished data).

(D. Keddy-Hector, Adjunct Professor, Austin Community College, Professional Communication).

Another hypothesis concerns the stress and damage caused by the extensive fire that destroyed nearly 4,300 ha of Golden-cheeked Warbler habitat (approximately 25% of the warbler habitat on Fort Hood; Figures 1 and 2) in the northeastern section of Fort Hood in February, 1996. Upon their return, many birds would have found that their territories were either entirely or partially burned. Locating and establishing new territories may have taken valuable time and resources (i.e., fat stores) that the birds may not have had after their migration. Some of the more dominant, newly displaced males that had previously held territories within the area of the fire may have displaced less dominant males that had held territories within nearby areas. All of these sudden movements and displacements may have increased territory border fights, and the need for males to increase "patrols" of their territory borders. This, in turn, may have decreased foraging time and efforts to attract and defend a mate and or care of nestlings and fledglings. Males that maintained partially burned territories may have experienced a shortage of food. Any of these scenarios could cause an increase in mortality.

This hypothesis, however, does not explain population dynamics observed in other areas across Fort Hood. For example, there was no evidence that fire-displaced warblers affected demographic parameters in the ISA (a dispersal distance of 3 to 4 kilometers). The percentage of SY males did not decrease significantly within the study area due to the influx of older, more dominant fire-displaced males (assuming that SYs were less dominant than older males). While the percentage did decrease slightly, it was not significant (Table 13). Secondly, some of the males within the fire region were color-banded in years prior to the fire; if a significant number of these males moved south into the study area and nearby regions, their chance of detection was high, and only one of these males was found there. (This male was found in habitat adjacent to the study area. He was originally banded as an HY, however, so his movement may be accounted for equally as well by HY dispersal patterns as by fire-related dispersal). Thirdly, if fire-displaced males in turn displaced study area males, it is assumed that these newly displaced males from within the study area would also establish a territory in the nearest suitable habitat. Researchers did not find this to be true, however, as all adjacent habitat was searched, and no males previously territorial within the study area were found.

Productivity within the intensive study area remained relatively stable between 1992 and 1996, suggesting that fecundity may not have a strong effect on the adult population of the immediate area, which varied during the same time period. One possible explanation for this lack of strong effect may be caused by the biology of the species, particularly the dispersal of the young away from their natal territories. One possible hypothesis for their dispersal pattern is inbreeding avoidance (Greenwood 1984). It may be inherent in many birds to disperse away from their natal territories in order to not breed with close kin (i.e., parents or siblings). Juveniles disperse much farther than do adults. Therefore, local productivity likely does not affect adult populations of the natal area in succeeding years. Judging by the long dispersal distances of juveniles and high estimates of juvenile emigration (see **Relevance/Application to Predictive Models**), there may be a significant proportion of Fort Hood-produced young that may not return to Fort Hood.

The significant differences in adult return rate between the ISA and other training areas can possibly be attributed to search effort and detection rate. The monitoring of the ISA was extensive, with near-daily coverage; the detection rate of males within this area probably approached 100%. Outside this area, however, most males were searched for only once or twice. Many things may have occurred during these search times to alter the probability of detection, including circumstances of their breeding cycle, time of day, presence of other singing males, females or HYs, weather effects, lighting, and canopy cover. It may not be uncommon to search for a specific male and consider him "not found" even though he may have been present and neither singing nor responding to the playback tape. Due to the intensive monitoring effort within the ISA, many of these factors were canceled, yielding the most reliable data.

While the cause of the decreased return rate within the intensive study area was unknown, there was a possible explanation for the decrease in other training areas. There was a slight change in searching protocol in 1996. Rather than searching for males picked from all previously banded males (as had been done in 1992 through 1995), it was decided that field technicians would search for prechosen males, which were, in general, older than those that would have been chosen randomly (see Methods section). In general, passerine survival rates level off after the first year, and remain essentially constant, but the probability of surviving to a particular age decreases as the bird ages, due to annual mortality rates (Gill 1990). This leads to a small sample size of older birds, in turn decreasing the possibility of locating survivors.

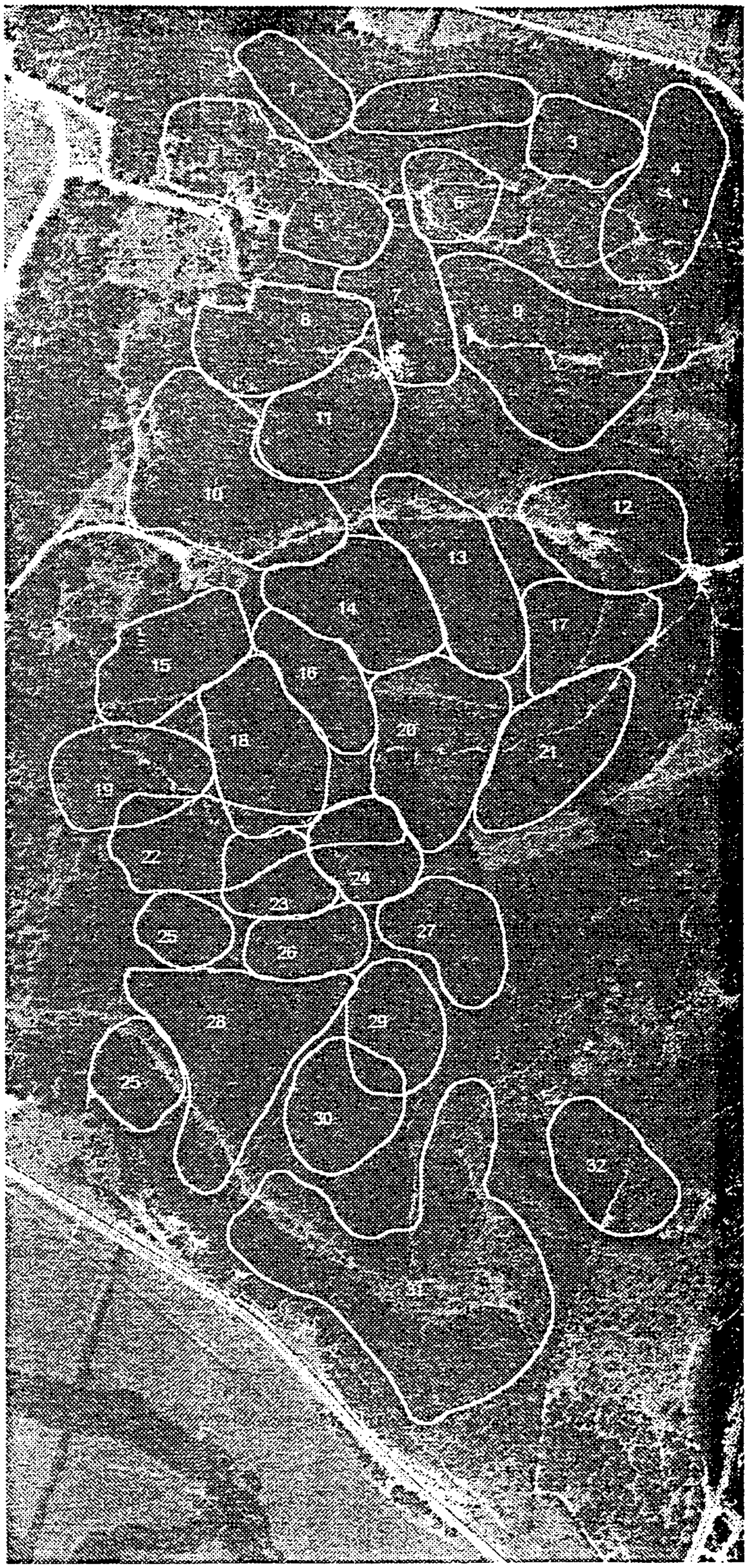
There are two possible reasons for the fact that female band returns were generally lower than that of males. First, adult females may disperse to a greater extent than males (Tables 5 and 7; Gill 1990). Secondly, females are generally very quiet and secretive in their behaviors, making it difficult to observe and determine their identity.

Age-related Differences

While return rates within the ISA did not differ between age classes when years were lumped, those in other training areas did (Tables 3 and 4). This may be partially explained by the differences in detection rates between the areas. Field observations suggest that older males may sing less than younger males, resulting in a lower detection rate for older males outside the ISA; older males within the ISA had the same probability of detection as younger males due to the intense monitoring regimen. Older males returning to non-ISA training areas, therefore, may not have been detected by researchers.

Although not statistically significant, younger males (age 3Y) had the tendency to disperse farther than older males (ages 4Y and A4Y+, Table 3). This idea also had support from data gathered concerning territory boundaries of returning males within the ISA. Three-year-old males seldom defended the same territory as they did during their SY year (42% [10 of 24] of 3Y territories overlapped their SY territory). Most of these SY-3Y territory connections were tenuous though, as only 20% (n = 10) of the overlapping territories actually overlapped at the center (see Figures 11 through 15). Returning ASY males, however, generally defended the same territory as their previous year (85% [22 of 26] of their territories overlap their previous territory). The majority (68%, n = 22) of these connections between years overlapped at their centers. This difference in the frequency of territory overlap by age class was statistically significant (SY vs. ASY, territory overlap: $\chi^2 = 8.21$, df = 1, $P = 0.0041$, SY vs. ASY, centers overlap: $\chi^2 = 4.62$, df = 1, $P = 0.03$).

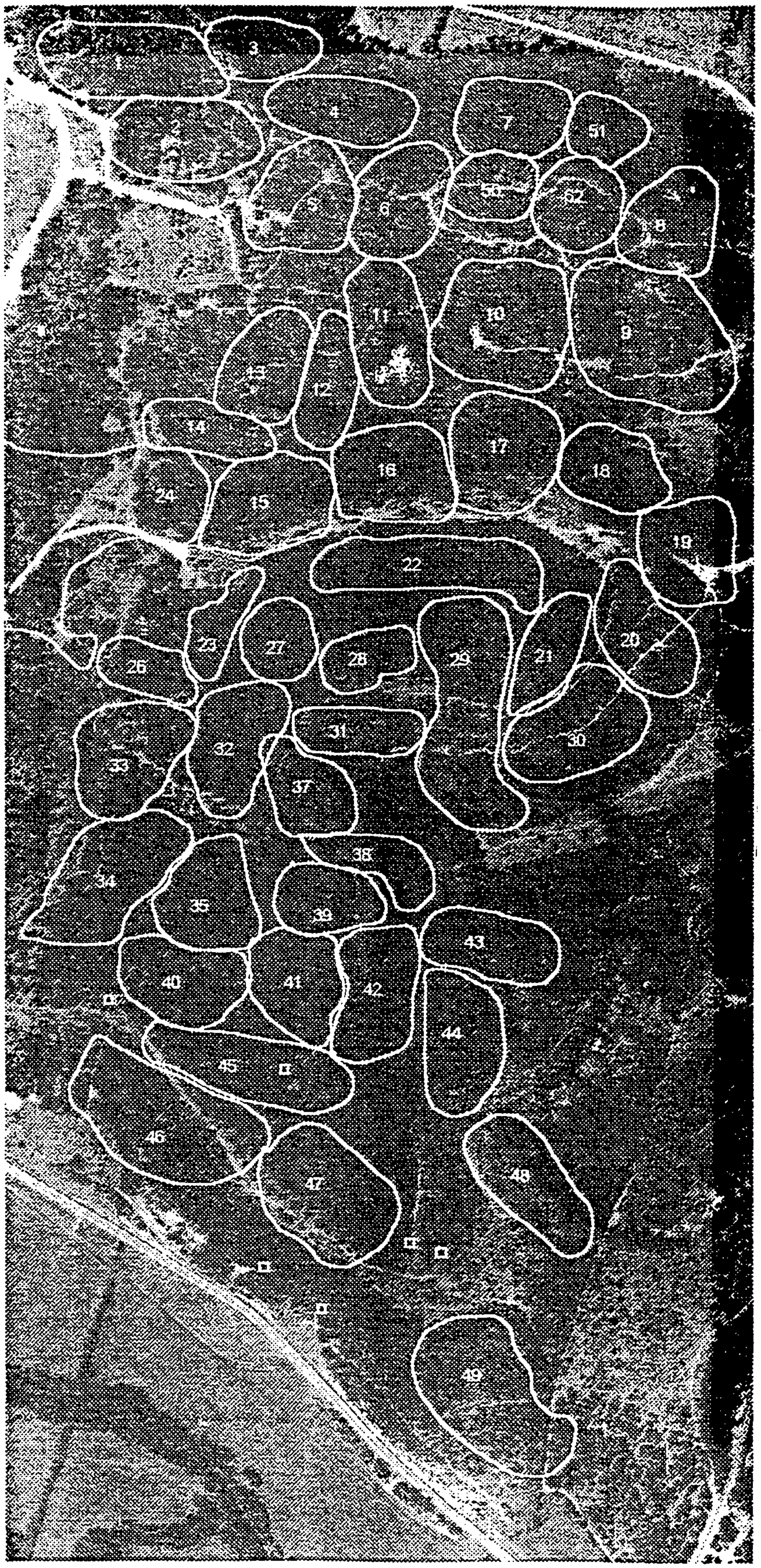
Observed results indicate that SY males had the capacity to reproduce at the same rate as ASY males. Productivity per successful SY was very similar to productivity per successful ASY male (Table 17). Similarly, success rate of mated SY and ASY males was virtually identical (Table 20). The difference, then, in SY fitness can be attributed to difficulty in finding, securing or defending a mate. SY males mated significantly less often than did ASY males (Table 16).



1996

Terr. No.	Age	Mated Status	No. HY
1	SY	Yes	0
2	SY	Yes	1
3	3Y	Yes	2
4	3Y	Yes	0
5	AHY	Yes	2
6	3Y	Yes	2
7	ASY	Yes	1
8	A3Y	Yes	2
9	3Y	Yes	2
10	SY	Yes	4&1
11	UB	Yes	UK
12	SY	Yes	0
13	ASY	Yes	1
14	3Y	Yes	2
15	3Y	Yes	0
16	6Y	Yes	3
17	3Y	Yes	2
18	5Y	Yes	2
19	SY	Yes	1
20	SY	Yes	2
21	SY	Yes	2
22	ASY	Yes	2
23	5Y	Yes	2&2
24	UB	Yes	1
25	SY	Yes	2
26	A3Y	Yes	1&1
27	ASY	Yes	3
28	4Y	Yes	2
29	A3Y	Yes	2
30	A3Y	Yes	2
31	SY	No	-
32	SY	No	-

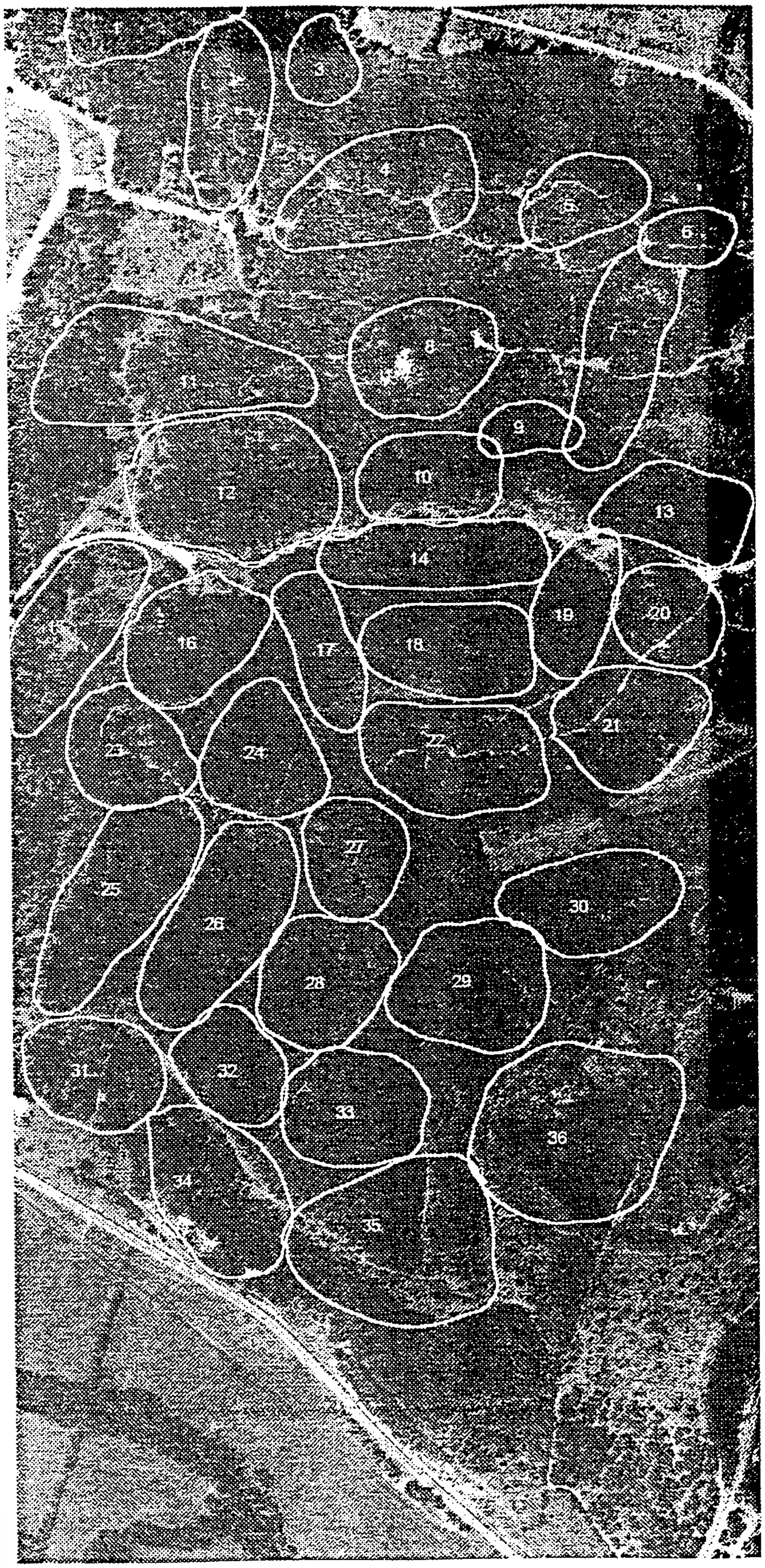
Figure 11. Map of all territorial males within the ISA during 1996. For detailed information, see Appendix C. "UB" = unbanded. "UK" = unknown individual. (1 cm ~ 100 m.)



1995

Terr. No.	Age	Mated Status	No. HY
1	4Y	Yes	2
2	SY	Yes	2
3	SY	Yes	2
4	SY	Yes	2
5	SY	Yes	2
6	A3Y	Yes	0
7	SY	Yes	3
8	ASY	Yes	3
9	SY	Yes	2
10	SY	Yes	2
11	A4Y	Yes	4
12	3T	Yes	1 & 2
13	ASY	Yes	1
14	ASY	Yes	1
15	3Y	Yes	2
16	3Y	Yes	3
17	SY	Yes	2
18	SY	Yes	2
19	SY	Yes	2
20	ASY	Yes	1
21	4Y	Yes	2
22	ASY	Yes	3
23	SY	Yes	2
24	ASY	Yes	2
26	SY	Yes	2
27	5Y	Yes	2
28	4Y	Yes	2
29	ASY	Yes	2
30	SY	Yes	0
31	SY	No	N/A
32	4Y	Yes	2
33	SY	Yes	2
34	A3Y	Yes	1
35	3Y	Yes	1 & 2
37	A5Y	Yes	3
38	3Y	Yes	2
39	4Y	Yes	3
40	SY	No	N/A
41	ASY	Yes	4
42	ASY	Yes	3
43	3Y	Yes	2
44	ASY	Yes	3
45	3Y	Yes	3
46	3Y	Yes	3
47	ASY	Yes	3
48	ASY	Yes	2
49	SY	Yes	3
50	SY	Yes	1 & 1
51	SY	No	N/A
52	SY	Yes	1

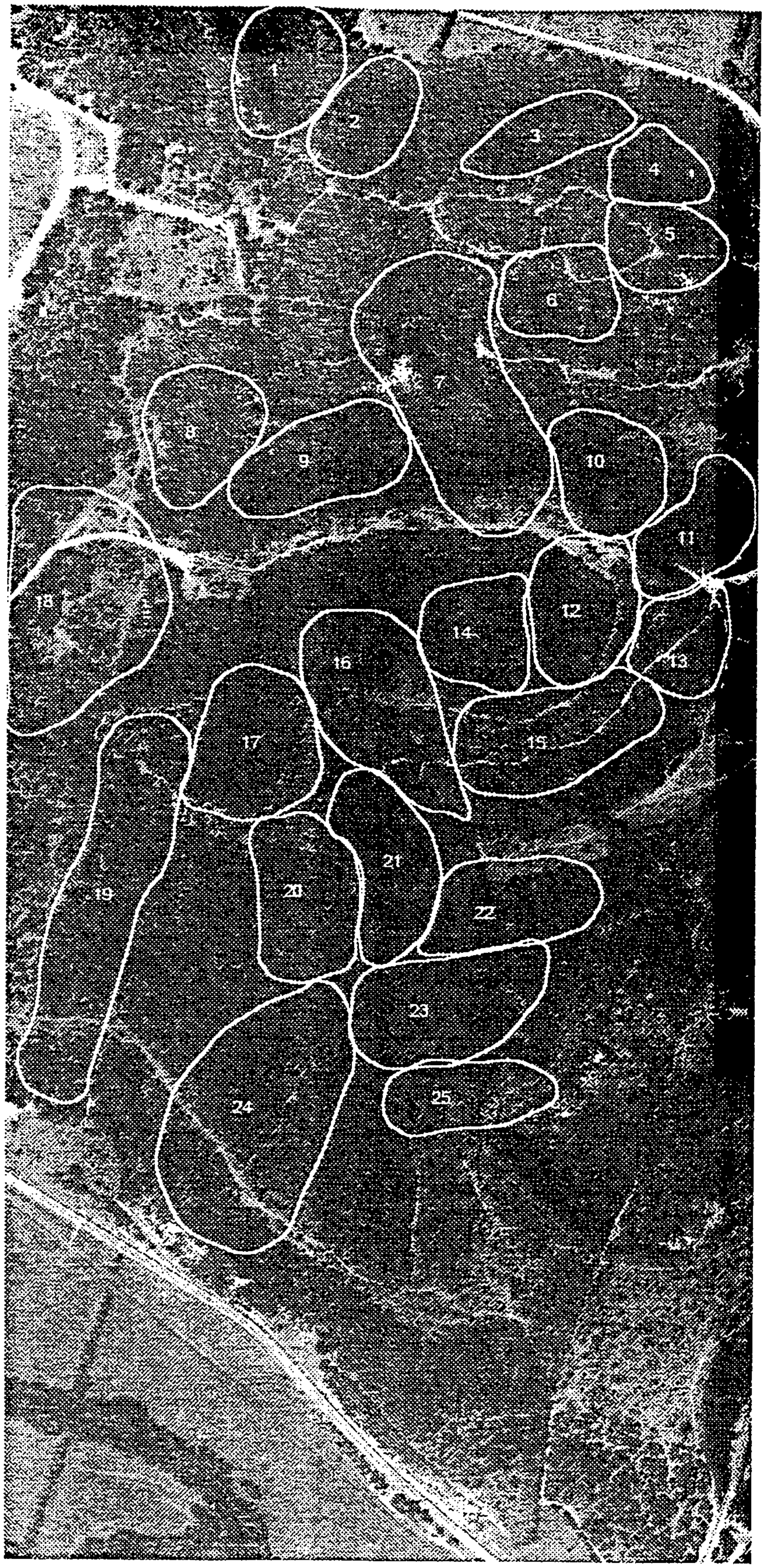
Figure 12. Map of all territorial males within the ISA during 1995. For detailed information, see Appendix C. "UB" = unbanded. "UK" = unknown individual. (1 cm ~ 100 m.)



1994

Terr. No.	Age	Mated Status	No. HY
1	3Y	Yes	0
2	ASY	Yes	3
3	3Y	Yes	4
4	ASY	Yes	2
5	SY	Yes	2
6	UB	Yes	4
7	SY	Yes	2
8	A3Y	Yes	3
9	SY	Yes	0
10	A4Y	Yes	2
11	SY	Yes	1
12	SY	Yes	2
13	SY	Yes	1
14	3Y	Yes	2
15	SY	Yes	1
16	3Y	Yes	1
17	4Y	Yes	3
18	3Y	Yes	2
19	19	Yes	2
20	UB	Yes	1
21	UB	No	N/A
22	SY	Yes	3
23	ASY	Yes	2
24	A4Y	Yes	2
25	SY	Yes	3
26	SY	No	N/A
27	3Y	Yes	2
28	UB	Yes	3
29	3Y	Yes	3
30	SY	No	N/A
31	SY	Yes	2
32	A4Y	No	N/A
33	SY	Yes	3
34	SY	No	N/A
35	UB	Yes	2
36	UB	No	N/A

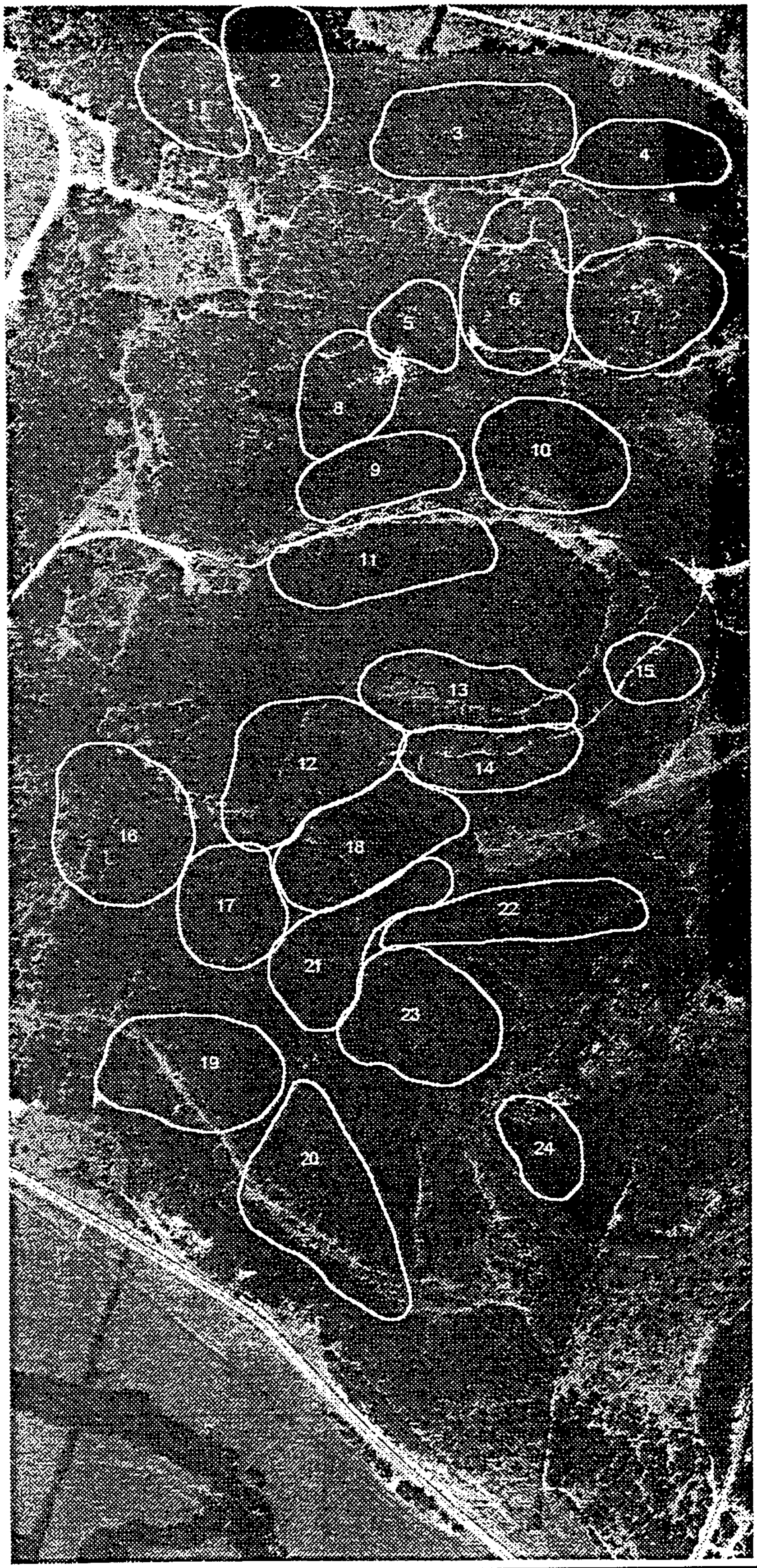
Figure 13. Map of all territorial males within the ISA during 1994. For detailed information, see Appendix C. "UB" = unbanded. "UK" = unknown individual. (1 cm ~ 100 m.)



1993

Terr. No.	Age	Mated Status	No. HY
1	SY	Yes	4
2	ASY	Yes	1
3	ASY	Yes	2
4	UB	Yes	0
5	SY	No	N/A
6	A3Y	Yes	1
7	A3Y	Yes	2
8	SY	Yes	2
9	SY	No	N/A
10	UB	Yes	2
11	SY	Yes	2
12	A3Y	Yes	1
13	SY	Yes	0
14	A3Y	Yes	2
15	SY	Yes	3
16	3Y	Yes	2
17	3Y	Yes	3
18	SY	Yes	4
19	A3Y	Yes	3
20	A3Y	Yes	2
21	3Y	Yes	3
22	A3Y	Yes	2
23	SY	Yes	2
24	SY	No	N/A
25	UB	Yes	2

Figure 14. Map of all territorial males within the ISA during 1993. For detailed information, see Appendix C. "UB" = unbanded. "UK" = unknown individual. (1 cm ~ 100 m.)



1992

Terr. No.	Age	Mated Status	HY Present
1	SY	Yes	Yes
2	ASY	No	N/A
3	AHY	Yes	No
4	UB	Yes	Yes
5	AHY	Yes	No
6	ASY	Yes	Yes
7	UB	No	N/A
8	ASY	Yes	Yes
9	ASY	No	N/A
10	SY	No	N/A
11	UB	Yes	Yes
12	A3Y	Yes	Yes
13	ASY	Yes	Yes
14	A3Y	Yes	Yes
15	UB	Yes	Yes
16	ASY	Yes	No
17	ASY	Yes	Yes
18	ASY	Yes	Yes
19	SY	Yes	Yes
20	SY	Yes	Yes
21	SY	Yes	Yes
22	ASY	Yes	Yes
23	SY	Yes	Yes
24	SY	No	N/A

Figure 15. Map of all territorial males within the ISA during 1992. For detailed information, see Appendix C. "UB" = unbanded. "UK" = unknown individual. (1 cm ~ 100 m.)

Relevance/Application to Predictive Models

Results from a regional population viability workshop (U.S. Fish and Wildlife Service 1996) estimated that HY Golden-cheeked Warbler survival rate must be above 50%, given observed annual fecundities of 0.8 and 1.01 HY per adult male (SY and ASY, respectively), and an estimated average adult survival rate of 57% (AHY) to maintain a stable population. In population viability analysis (PVA) models simulating time until extinction, the use of any HY survival rate below 50% caused the model's population to decline dramatically and become extinct well within the 100 years of simulation (U.S. Fish and Wildlife Service 1996).

The observed return of HYs to their natal area in the ISA was 14.2% (Table 6). Assuming HY survival of 50% to maintain a stable population, the observed HY return rate in the ISA would indicate that at least 76% of surviving HYs must emigrate from their natal area. The greater observed dispersal distance of HYs compared with adult Golden-cheeked Warblers suggests a 76% HY emigration rate is realistically possible. The average dispersal distance for returning HY males was over 4 kilometers, with 41% of all HY resightings at a distance greater than 3 km, and one actually being resighted 20 km from its original banding location. This compares with a mean dispersal distance for adult males of 217 m.

Comparison With Similar Species

Although the overall intensive study area return rate for the Golden-cheeked Warbler (48%) was lower than that for the Kirtland's Warbler (approximately 65%, Mayfield 1992), their ranges were similar. The Kirtland's Warbler return rate ranged between 29% and 82% (Mayfield 1992) whereas the Golden-cheeked Warbler return rate has ranged from 30% to 65.5% within the study area. The Golden-cheeked Warbler's observed return rate was also lower than that of the Black-throated Green Warbler (67%, Morse 1989), the Prairie Warbler (65%, Nolan 1978), the Common Yellowthroat (54%, Roberts 1971) the Black and White Warbler (71%, Roberts 1971) and the American Redstart (71%, Roberts 1971).

The observed Kirtland's Warbler HY return rate of 2.7% (n = 296 as of 1968; Berger and Radabaugh 1968) was much lower than the Golden-cheeked Warbler's (17%, overall HY male return rate). The Golden-cheeked Warbler HY return rate was also high compared to that documented in other species (i.e., 5.8% in the Indigo Bunting [Payne and Payne 1990], 5.0% in the Wood Thrush [Roth and Johnson 1993], and 0.6% in the American Redstart [Sherry and Holmes 1992]).

There are few published studies concerning survival rates of first-year birds. Loery, et al. (1987) reported an average 44% (range of 24% to 66%) HY survival rate for the Black-capped Chickadee (*Parus atricapillus),* a figure that was similar to the estimates for the Golden-cheeked Warbler. This study also stated that the adult chickadee survival rate was, on average, 23% higher than that for HYs, with an overall average of 69% (and a range of 45% to 100%) for 3Y individuals. Loery, et al. (1987) attributed this difference in survival to increased mortality within the first year and/or to increased dispersal. Ryel (1981) calculated the Kirtland's Warbler adult survival rate to be at least 35%. These figures were similar to the warbler's estimated 57% survival for adult males (USFWS 1996).

Golden-cheeked Warbler productivity (2.04 HY per mated male within the ISA) was similar to that documented in several other species. Mayfield (1992) reported the Kirtland's Warbler productivity to be 2.2 fledglings per nest (without Brown-headed Cowbird parasitism). The Prairie Warbler had an estimated productivity of 2.2 fledglings per territory (Nolan 1978), slightly higher than Fort Hood's Golden-cheeked Warbler average of 1.84 HY per territory. Black-throated Green Warbler productivity was also higher, with three (and sometimes four) fledglings per territory (Morse 1993).

Mated status for the Golden-cheeked Warblers within the ISA (89% of the territorial males mated) was comparable to the 92% of the Kirtland's Warbler within prime, wildfire-regrown areas, and 72% of Kirtland's Warblers within plantations (Bocetti 1994).

Average Golden-cheeked Warbler density (0.13 pairs per ha) was much lower than that documented for the Black-throated Green Warbler. Morse (1993) reported that the maximum density was 2.0 pairs per ha in prime habitat. He also reported, however, a minimum of 0.6 pairs per ha in a year of high mortality. The Kirtland's Warbler had a density lower than either species, ranging from 0.048 pairs per ha to 0.07 pairs (Probst and Weinrich 1989, Bocetti 1994). Contrary to highly variable densities found within Fort Hood's ISA between 1992 and 1996, Morse (1989) stated that "Populations of most warblers are surprisingly constant in density from year to year, although they experience temporary and short-term depressions, probably in response to environmental factors...." Holmes et al. (1986) also found that periods of stability were punctuated by pulses in response to outbreaks of caterpillars.

Incidence of Cowbird Parasitism

Rates of parasitism of the Golden-cheeked Warbler on Fort Hood may be misleading, as cowbird control began in 1988, whereas Golden-cheeked Warbler studies did not begin until 1991; no pre-control, baseline data is available. Even though Pulich (1976) reports a very high parasitism rate (58%, 19 of 33 nests parasitized), data suggest that cowbirds currently do not play a major role in Fort Hood warbler nest success. There were seven incidents concerning Golden-cheeked Warblers and cowbirds on Fort Hood since 1991, including three parasitized nests (no parasitized nests since 1991, 9% nest parasitism rate; Table 21).

5 Conclusions and Recommendations

Fort Hood supports a substantial population of the endangered Golden-cheeked Warbler (915 maximum documented males). This population is vital to the survival of the species because it resides under a single land management authority. This continuity of management will assist in the preservation of the remaining habitat and the species as a whole.

A substantial conclusion stemming from this data analysis is the high variability of the Golden-cheeked Warbler population on Fort Hood. During the first 4 years of the study, it appeared that the population was growing, at first slowly, then more rapidly. During 1996, however, this trend reversed, and the population appeared to decline. The long-term trends for this species cannot yet be determined.

Currently, habitat availability is considered the primary limiting factor for warbler populations on Fort Hood. Other potential limiting factors (e.g., cowbird parasitism or predation) appear to be of secondary importance at this time. If cowbird control on the installation is discontinued in the future, this relationship will need to be reevaluated.

It is recommended that demographic parameters are best estimated from data obtained in intensively monitored areas.

It is recommended that these data be collected and updated annually to monitor long-term population changes on Fort Hood. It is also recommended that managers be cautious in making decisions regarding this species based on short-term demographic variability.

References

Alley, W.M. 1984. The Palmer Drought severity index: Limitations and assumptions. Journal of Climate and Applied Meteorology vol. 23: 1100-1109.

Beardmore, C.J. 1994. Habitat use of Golden-cheeked Warblers in Travis County, Texas. Master's thesis. Submitted to the Office of Graduate Studies at Texas A&M University. December, 1994. 59 pp.

Benson, R.H. 1990. Habitat area requirements of the Golden-cheeked Warbler on the Edwards Plateau. October 1990. Prepared for Texas Parks and Wildlife Department, Department of Engineering Technology, Texas A&M University, College Station, TX.

Berger, A.J. and B.E. Radabaugh. 1968. Returns of Kirtland's Warblers to the breeding ground. Bird-Banding 39(3):161-186.

Bocetti, C.I. 1994. Density, demography and mating success of Kirtland's Warbler in managed and natural habitats. Ph.D. Dissertation submitted to Graduate School of Ohio State University. 139 pp.

Bolsinger, J.S. and T.J. Hayden. 1992. Project status report: 1992 Field studies of two endangered species (the Black-capped Vireo and the Golden-cheeked Warbler) and the cowbird control program on Fort Hood, Texas. Submitted to HQ III Corps and Fort Hood. 79 pp. Copies may be obtained from USACERL, Champaign, IL 61821.

Gill, F.B. 1990. Ornithology. W.H. Freeman and Company Press. New York. 661 pp.

Greenwood, P.J. 1984. Mating systems and the evolutionary consequences of dispersal. Pp. 116-131. *In* The ecology of animal movement. Swingland, I.R., and P.J. Greenwood (eds.). Oxford Univ. Press. 311 pp.

Hayden, T.J., L.A. Jetté, and H.J. Weinberg. in prep. Field monitoring program for endangered avian species on Fort Hood, Texas.

Heddinghaus, T.R. and P. Sabol. 1991. A review of the Palmer Drought Severity Index and where do we go from here? Pp. 242-246. In Proceedings of 7th Conf on Applied Climatology. September 10-13, 1991. American Meteorology Society, Boston.

Holmes, R.T., T.W. Sherry, and F.W. Sturges. 1986. Bird community dynamics in a temperate deciduous forest: Long-term trends at Hubbard Brook. Ecological Monographs 56: 201-220.

Karl, T.R. and R.W. Knight. 1985. Atlas of monthly Palmer hydrological drought indices (1931-1983) for the contiguous United States. Historical Climatology Series 3-7. National Climatic Data Center. Asheville, NC.

Kogan, F.N. 1995. Droughts of the late 1980s in the United States as derived fron MOAA polar-orbiting satellite data. Bulletin of the American Meterological Society 76(5):655-668.

Loery, G., K.H. Pollock, J.D. Nichols, and J.E. Hines. 1987. Age-specificity of Black-capped Chickadee survival rates: Analysis of capture-recapture data. Ecology 68(4):1038-1044.

Mayfield, H.F. 1992. Kirtland's Warbler (*Dendroica kirtlandii*). *In* The Birds of North America, No. 19. A. Poole and F. Gill, Eds. Philadelphia: The Academy of Natural Sciences, Washington, D.C.: The American Ornithologists' Union.

McKee, T.B., N.J. Doesken, and J. Kleist. 1995. Drought monitoring with multiple time scales. Pp. 233-236. *In* Preprints, 9th conference on Applied Climatology. 15-20 January. Dallas, TX.

Morse, D.H. 1989. American warblers: an ecological and behavioral perspective. Harvard University Press, Cambridge, MA. 406 pp.

Morse, D.H. 1993. Black-throated Green Warbler (*Dendroica virens*). *In* The Birds of North America, No. 55. A. Poole and F. Gill, Eds. Philadelphia: The Academy of Natural Sciences, Washington, D.C.: The American Ornithologists' Union.

Nolan, V. 1978. The ecology and behavior of the Prairie Warbler, *Dendroica discolor. Ornithological Monographs no. 25.* 595 pp.

Palmer, W.C. 1965. Meteorological drought. U.S. Dept. of Commerce. Research Paper No. 45.

Payne, R.B. and L.L. Payne. 1990. Survival estimates of Indigo Buntings: Comparison of banding recoveries and local observations. Condor 92:938-946.

Probst, J.R. and J. Weinrich. 1989. Predicting Kirtland's Warbler populations by habitat conditions. Pp. 61-62. *In* U.S. Forest Service. At the Crossroads--Extinction or survival. Proceedings: Kirtland's warbler symposium held in Lansing, MI. Feb. 9-11, 1989. 106 pp.

Pulich, W.M. 1976. The Golden-cheeked Warbler: a bioecological study. Texas Parks and Wildlife Department. Austin, TX. 172 pp.

Pyle, P., S.N.G. Howell, R.P. Yunick, and D.F. DeSante. 1987. Identification guide to North American passerines. Slate Creek Press, Bolinas, CA.

Roberts, J.O.L. 1971. Survival among some North American wood warblers. Bird-Banding 42(3):165-177.

Roth, R.R. and R.K. Johnson. 1993. Long-term dynamics of a Wood Thrush population breeding in a forest fragment. Auk 110(1):37-48.

Ryel, L.A. 1981. Population change in the Kirtland's Warbler, 1981. Jack-Pine Warbler 59:76-91.

Sherry, T.W. and R.T. Holmes. 1992. Population fluctuations in a long-distance neotropical migrant: Demographic evidence for the importance of breeding season events in the American Redstart. Pp. 431-442. *In* Hagan, III, J.M. and D.W. Johnston, eds. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press. Washington, DC. 609 pp.

Smith, D.I., M.F. Hutchinson, and R.J. McArthur. 1993. Australian climatic and agricultural drought: Payments and policy. Drought Network News 5(3):11-12.

Tazik, D.J. and J.D. Cornelius. 1993. Status of the Black-capped Vireo at Fort Hood, Texas, Volume III: Population and nesting ecology. USACERL Technical Report EN-94/01, Vol. III. 106 pp.

U.S. Fish and Wildlife Service. 1996. Golden-cheeked Warbler population and habitat viability assessment report. Compiled and edited by Carol Beardmore, Jeff Hatfield, and Jim Lewis in conjunction with workshop participants. Report of an Aug. 21-24, 1996 workshop arranged by the U.S. Fish and Wildlife Service in partial fulfillment of U.S. National Biological Service Grant No. 80333-1423. Austin, Texas. xii + 48 pp + Appendix.

Wahl, R., D.D. Diamond, and D. Shaw. 1990. The Golden-cheeked Warbler: a status review. Report submitted to Ecological Services, U.S. Fish and Wildlife Service, Fort Worth, TX. 80 pp.

Weinberg, H.J., L.A. Jetté, and J.D. Cornelius. 1996. 1995 Project status report: Field studies of the endangered Black-capped Vireo and Golden-cheeked Warbler, and the cowbird control program on Fort Hood, Texas. Submitted to HQ III Corps and Fort Hood. 78 pp. Copies may be obtained from USACERL, Champaign, IL 61821.

Willeke, G., J.R.M. Hosking, J.R. Wallis, and N.B. Guttman. 1994. The national drought atlas. Institute for Water Resources Report 94-NDS-4. U.S. Army Corps of Engineers.

Appendix A: List of all Adult Males Resighted on Fort Hood

This list is presented by resighting type ("Search type": ISA, incidental, searched for), in order by band number and the number of times each was resighted. For explanation of search types, see Methods section. "Distance (m)" is the distance between observations, either between banding and resighting, or between consecutive resightings.

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
1290-90819	ISA	1	92	AHY	342	485	93	ASY	344	488	361
1290-90819	ISA	2	92	AHY	344	488	94	A3Y	341	485	424
1290-90819	ISA	3	92	AHY	341	485	95	A4Y	342	486	141
1290-90833	ISA	1	93	SY	346	480	94	3Y	343	482	361
1290-90834	ISA	1	93	SY	346	481	94	3Y	344	479	283
1290-90834	ISA	2	93	SY	344	479	95	4Y	343	479	100
1290-90836	ISA	1	93	SY	346	482	94	3Y	345	481	141
1290-90836	ISA	2	93	SY	345	481	95	4Y	345	481	0
1290-90837	ISA	1	93	SY	342	474	94	3Y	343	474	100
1290-90838	ISA	1	93	SY	341	473	94	3Y	341	476	300
1290-90838	ISA	2	93	SY	341	476	95	4Y	342	477	141
1290-90838	ISA	3	93	SY	342	477	96	5Y	342	476	100
1290-90846	ISA	2	93	HY	314	487	95	3Y	315	488	141
1290-90847	ISA	1	93	SY	340	489	94	3Y	338	491	283
1290-90847	ISA	2	93	SY	338	491	95	4Y	338	491	0
1290-90848	ISA	1	93	SY	340	489	94	3Y	340	489	0
1710-25228	ISA	1	92	ASY	340	477	93	A3Y	346	481	721
1710-25242	ISA	1	92	ASY	344	483	93	A3Y	341	484	316
1710-25242	ISA	2	92	ASY	341	484	94	A4Y	343	483	224
1710-25245	ISA	1	92	ASY	339	476	93	A3Y	339	476	0
1710-25245	ISA	2	92	ASY	339	476	94	A4Y	340	478	224
1710-25245	ISA	3	92	ASY	340	478	95	A5Y	341	478	100
1710-25246	ISA	1	92	SY	342	476	93	3Y	341	478	224
1710-25246	ISA	2	92	SY	341	478	94	4Y	341	479	100
1710-25246	ISA	3	92	SY	341	479	95	5Y	341	480	100
1710-25246	ISA	4	92	SY	341	480	96	6Y	341	480	0
1710-25265	ISA	1	92	ASY	344	486	93	A3Y	340	484	447
1710-25265	ISA	2	92	ASY	340	484	94	A4Y	341	474	1005
1710-25265	ISA	3	92	ASY	341	474	95	A5Y	341	473	100

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
1710-25268	ISA	1	92	ASY	344	479	93	A3Y	344	481	200
1710-25380	ISA	1	92	SY	339	472	93	3Y	340	478	608
1710-25381	ISA	1	92	ASY	343	475	93	A3Y	343	475	0
1710-25382	ISA	1	92	ASY	343	478	93	A3Y	340	476	361
1710-25384	ISA	1	92	SY	343	475	93	3Y	342	476	141
1710-25464	ISA	1	93	SY	337	483	94	3Y	339	481	283
1710-25464	ISA	2	93	SY	339	481	95	4Y	340	478	316
1710-25464	ISA	3	93	SY	340	478	96	5Y	339	478	100
1880-64770	ISA	1	91	ASY	344	479	92	A3Y	344	479	0
1880-64771	ISA	1	91	ASY	341	478	92	A3Y	343	478	200
1960-03104	ISA	1	94	ASY	339	489	95	A3Y	340	489	100
1960-03108	ISA	1	94	SY	343	483	95	3Y	343	483	0
1960-03110	ISA	1	94	SY	337	484	95	3Y	341	483	412
1960-03111	ISA	1	94	SY	345	485	95	3Y	339	484	608
1960-03115	ISA	1	94	SY	333	482	95	3Y	342	476	1082
1960-03116	ISA	1	94	ASY	343	487	95	A3Y	341	487	200
1960-03201	ISA	1	94	SY	344	479	95	3Y	336	480	806
1960-03203	ISA	1	94	SY	341	472	95	3Y	348	488	1746
1960-03203	ISA	2	94	SY	348	488	96	4Y	348	488	0
1960-03206	ISA	1	94	SY	338	477	95	3Y	337	473	412
1960-03206	ISA	2	94	SY	337	473	96	4Y	337	473	0
1960-03207	ISA	1	94	SY	345	475	95	3Y	344	475	100
1960-03208	ISA	1	94	SY	342	469	95	3Y	340	478	922
1960-03209	ISA	1	94	ASY	337	478	95	A3Y	338	478	100
1960-03238	ISA	1	94	AHY	343	483	95	ASY	343	483	0
1960-03410	ISA	1	95	SY	346	483	96	3Y	345	480	316
1960-03533	ISA	1	95	ASY	343	469	96	A3Y	341	472	361
1960-03553	ISA	1	95	ASY	346	469	96	A3Y	343	473	500
1960-03634	ISA	2	94	HY	341	477	96	3Y	338	480	424
1960-03709	ISA	1	95	ASY	341	475	96	A3Y	341	475	0
1960-03798	ISA	1	95	SY	343	478	96	3Y	340	481	424
1960-03815	ISA	1	95	SY	346	484	96	3Y	345	486	224
1960-03816	ISA	1	95	SY	347	485	96	3Y	344	485	300
1960-03821	ISA	1	95	ASY	340	485	96	A3Y	340	485	0
1960-03833	ISA	1	95	SY	344	488	96	3Y	345	488	100
1960-03838	ISA	1	95	SY	344	488	96	3Y	342	487	224
1290-90816	Incidental	1	92	AHY	360	556	93	ASY	360	566	1000
1290-90821	Incidental	1	92	AHY	343	483	95	A4Y	308	487	3523
1290-90854	Incidental	2	93	HY	298	486	95	3Y	298	486	0
1480-34250	Incidental	2	91	SY	UK	UK	93	4Y	306	487	UK
1480-34258	Incidental	1	91	ASY	UK	UK	94	A5Y	303	486	UK
1710-25238	Incidental	1	92	ASY	208	583	96	A6Y	206	588	539
1710-25254	Incidental	1	92	ASY	362	533	94	A4Y	362	531	200
1710-25258	Incidental	2	92	SY	339	560	94	4Y	339	561	100
1710-25401	Incidental	1	93	ASY	74	390	94	A3Y	80	388	632
1710-25401	Incidental	2	93	ASY	80	388	95	A4Y	73	392	806
1710-25402	Incidental	1	93	ASY	74	391	94	A3Y	75	393	224
1710-25402	Incidental	3	93	ASY	75	389	96	A5Y	74	392	316
1710-25403	Incidental	1	93	SY	183	643	94	3Y	184	640	316

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
1710-25415	Incidental	2	93	SY	317	563	95	4Y	316	567	412
1710-25420	Incidental	1	93	SY	310	537	95	4Y	315	536	510
1710-25425	Incidental	2	93	SY	312	539	95	4Y	312	540	100
1710-25431	Incidental	1	93	ASY	374	554	95	A4Y	374	554	0
1710-25436	Incidental	2	93	ASY	388	435	95	A4Y	387	435	100
1710-25450	Incidental	1	93	ASY	185	677	94	A3Y	184	678	141
1710-25450	Incidental	2	93	ASY	184	678	95	A4Y	183	678	100
1710-25452	Incidental	2	93	SY	335	491	95	4Y	334	490	141
1710-25452	Incidental	3	93	SY	334	490	96	5Y	333	492	224
1710-25460	Incidental	2	93	ASY	306	486	95	A4Y	305	487	141
1710-25466	Incidental	1	93	ASY	328	485	95	A4Y	328	485	0
1710-25466	Incidental	2	93	ASY	328	485	96	A5Y	327	485	100
1810-28929	Incidental	2	91	SY	UK	UK	93	4Y	242	482	UK
1810-28985	Incidental	2	91	AHY	UK	UK	94	A4Y	122	650	UK
1810-28985	Incidental	3	91	AHY	122	650	95	A5Y	122	650	0
1930-72771	Incidental	2	92	AHY	307	487	94	A3Y	309	488	224
1930-72773	Incidental	2	92	AHY	313	506	94	A3Y	313	506	0
1960-03031	Incidental	1	93	AHY	313	505	94	ASY	314	503	224
1960-03033	Incidental	1	93	AHY	122	649	94	ASY	122	651	200
1960-03049	Incidental	2	93	AHY	346	442	95	A3Y	346	442	0
1960-03060	Incidental	1	93	AHY	362	533	94	ASY	361	534	141
1960-03103	Incidental	1	94	ASY	73	393	96	A4Y	73	394	100
1960-03107	Incidental	1	94	ASY	78	378	95	A3Y	79	376	224
1960-03120	Incidental	1	94	SY	348	466	95	3Y	348	465	100
1960-03123	Incidental	1	94	SY	390	430	95	3Y	391	433	316
1960-03136	Incidental	1	94	ASY	81	377	95	A3Y	78	379	361
1960-03136	Incidental	2	94	ASY	78	379	96	A4Y	80	377	283
1960-03149	Incidental	1	94	AHY	309	486	95	ASY	308	487	141
1960-03153	Incidental	1	94	SY	385	517	95	3Y	385	517	0
1960-03155	Incidental	1	94	ASY	79	388	95	A3Y	77	387	224
1960-03180	Incidental	1	94	ASY	164	601	95	A3Y	164	600	100
1960-03191	Incidental	1	94	ASY	78	379	95	A3Y	74	393	1456
1960-03407	Incidental	1	95	SY	349	468	96	3Y	354	463	707
1960-03413	Incidental	1	95	ASY	342	565	96	A3Y	338	560	640
1960-03421	Incidental	1	95	SY	168	689	96	3Y	167	689	100
1960-03431	Incidental	1	95	SY	92	389	96	3Y	89	389	300
1960-03441	Incidental	1	95	ASY	82	388	96	A3Y	83	388	100
1960-03442	Incidental	1	95	SY	295	455	96	3Y	293	456	224
1960-03484	Incidental	1	95	SY	314	496	96	3Y	320	501	781
1960-03491	Incidental	1	95	ASY	363	522	96	A3Y	364	522	100
1960-03499	Incidental	1	95	SY	319	505	96	3Y	314	506	510
1960-03545	Incidental	1	95	ASY	339	555	96	A3Y	339	556	100
1960-03557	Incidental	1	95	AHY	74	387	96	ASY	75	389	224
1960-03572	Incidental	1	95	ASY	314	503	96	A3Y	313	502	141
1960-03599	Incidental	1	95	AHY	243	481	96	ASY	242	484	316
1960-03604	Incidental	1	94	ASY	159	603	95	A3Y	161	603	200
1960-03608	Incidental	1	94	ASY	168	611	95	A3Y	167	611	100
1960-03622	Incidental	1	94	ASY	169	598	95	A3Y	169	599	100
1960-03623	Incidental	1	94	ASY	175	613	95	A3Y	175	613	0

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
1960-03625	Incidental	1	94	ASY	164	608	95	A3Y	164	609	100
1960-03699	Incidental	1	94	AHY	316	537	95	ASY	315	534	316
1960-03704	Incidental	1	94	AHY	349	443	95	ASY	352	444	316
1960-03713	Incidental	1	95	ASY	331	490	96	A3Y	334	491	316
1960-03719	Incidental	1	95	ASY	328	524	96	A3Y	327	524	100
1960-03763	Incidental	1	95	ASY	156	706	96	A3Y	156	706	0
1960-03807	Incidental	1	95	SY	360	517	96	3Y	362	514	361
1960-03832	Incidental	1	95	SY	331	487	96	3Y	331	485	200
1290-90840	Search	1	93	ASY	319	536	94	A3Y	320	536	100
1290-90843	Search	1	93	SY	339	556	94	3Y	340	555	141
1290-90854	Search	3	93	HY	298	486	96	4Y	299	488	224
1290-90857	Search	1	93	AHY	315	560	95	A3Y	315	558	200
1480-34211	Search	1	91	ASY	331	556	92	A3Y	UK	UK	UK
1480-34221	Search	1	91	ASY	338	562	92	A3Y	UK	UK	130
1480-34226	Search	1	91	ASY	321	499	93	A4Y	321	499	0
1480-34227	Search	1	91	SY	320	498	92	3Y	UK	UK	10
1480-34230	Search	1	91	ASY	233	605	92	A3Y	UK	UK	15
1480-34236	Search	1	91	ASY	306	442	92	A3Y	UK	UK	45
1480-34239	Search	1	91	ASY	386	522	92	A3Y	UK	UK	35
1480-34242	Search	1	91	ASY	316	537	92	A3Y	UK	UK	220
1480-34242	Search	2	91	ASY	UK	UK	93	A4Y	317	537	UK
1480-34242	Search	3	91	ASY	317	537	95	A6Y	316	539	224
1480-34243	Search	1	91	SY	315	539	92	3Y	UK	UK	60
1480-34248	Search	1	91	ASY	UK	UK	92	A3Y	UK	UK	120
1480-34250	Search	1	91	SY	UK	UK	92	3Y	UK	UK	490
1480-34258	Search	2	91	ASY	303	486	95	A6Y	301	486	200
1480-34261	Search	1	91	ASY	UK	UK	92	A3Y	UK	UK	85
1710-25235	Search	1	92	ASY	244	483	93	A3Y	243	482	141
1710-25235	Search	2	92	ASY	243	482	94	A4Y	243	482	0
1710-25235	Search	3	92	ASY	243	482	95	A5Y	244	482	100
1710-25248	Search	1	92	ASY	308	486	93	A3Y	308	487	100
1710-25249	Search	1	92	AHY	374	554	93	ASY	372	557	361
1710-25252	Search	1	92	SY	317	560	93	3Y	317	561	100
1710-25252	Search	2	92	SY	317	561	94	4Y	316	561	100
1710-25256	Search	1	92	SY	363	525	93	3Y	363	525	0
1710-25256	Search	2	92	SY	363	525	94	4Y	362	525	100
1710-25258	Search	1	92	SY	338	561	93	3Y	339	560	141
1710-25259	Search	1	92	SY	339	562	93	3Y	340	563	141
1710-25263	Search	1	92	ASY	363	514	93	A3Y	363	514	0
1710-25267	Search	1	92	ASY	350	442	94	A4Y	352	443	224
1710-25277	Search	1	92	AHY	83	388	93	ASY	82	388	100
1710-25277	Search	2	92	AHY	82	388	94	A3Y	82	388	0
1710-25277	Search	3	92	AHY	82	388	95	A4Y	81	388	100
1710-25277	Search	4	92	AHY	81	388	96	A5Y	81	388	0
1710-25280	Search	1	92	AHY	79	388	93	ASY	79	388	0
1710-25282	Search	1	92	AHY	89	386	93	ASY	88	387	141
1710-25282	Search	2	92	AHY	88	387	94	A3Y	88	388	100
1710-25370	Search	1	92	AHY	74	390	93	ASY	73	391	141
1710-25374	Search	1	92	AHY	317	561	93	ASY	317	561	0

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
1710-25402	Search	2	93	ASY	75	393	95	A4Y	75	389	400
1710-25404	Search	1	93	AHY	184	636	94	ASY	183	637	141
1710-25406	Search	1	93	ASY	201	634	94	A3Y	201	633	100
1710-25410	Search	1	93	SY	208	613	94	3Y	208	613	0
1710-25412	Search	1	93	ASY	317	561	94	A3Y	316	561	100
1710-25412	Search	2	93	ASY	316	561	95	A4Y	315	558	316
1710-25413	Search	1	93	SY	312	565	94	3Y	312	565	0
1710-25414	Search	1	93	SY	311	564	94	3Y	312	565	141
1710-25415	Search	1	93	SY	317	563	94	3Y	317	563	0
1710-25416	Search	1	93	ASY	317	537	94	A3Y	318	536	141
1710-25425	Search	1	93	SY	313	542	94	3Y	312	539	316
1710-25426	Search	1	93	ASY	351	559	94	A3Y	351	559	0
1710-25427	Search	1	93	SY	346	561	94	3Y	346	560	100
1710-25427	Search	2	93	SY	346	560	95	4Y	351	559	510
1710-25432	Search	1	93	SY	373	558	94	3Y	373	557	100
1710-25432	Search	2	93	SY	373	557	95	4Y	373	558	100
1710-25434	Search	1	93	ASY	385	421	94	A3Y	386	422	141
1710-25436	Search	1	93	ASY	388	434	94	A3Y	388	435	100
1710-25440	Search	1	93	SY	387	449	94	3Y	387	449	0
1710-25444	Search	1	93	ASY	122	649	94	A3Y	122	649	0
1710-25446	Search	1	93	ASY	119	654	94	A3Y	119	653	100
1710-25447	Search	1	93	SY	119	654	94	3Y	119	653	100
1710-25452	Search	1	93	SY	334	491	94	3Y	335	491	100
1710-25453	Search	1	93	SY	331	490	94	3Y	332	491	141
1710-25459	Search	1	93	SY	307	484	94	3Y	307	484	0
1710-25460	Search	1	93	ASY	305	486	94	A3Y	306	486	100
1710-25461	Search	1	93	ASY	304	486	94	A3Y	304	485	100
1710-25465	Search	1	93	SY	330	486	94	3Y	331	487	141
1710-25470	Search	1	93	ASY	333	584	94	A3Y	331	584	200
1710-25471	Search	1	93	ASY	333	584	94	A3Y	331	584	200
1710-25471	Search	2	93	ASY	331	584	96	A5Y	328	583	316
1710-25472	Search	1	93	ASY	331	586	94	A3Y	331	584	200
1710-25475	Search	1	93	SY	163	584	95	4Y	162	585	141
1710-25486	Search	1	93	ASY	354	568	94	A3Y	354	568	0
1710-25487	Search	1	93	SY	383	556	94	3Y	384	555	141
1710-25487	Search	2	93	SY	384	555	95	4Y	383	556	141
1710-25491	Search	1	93	AHY	344	563	94	ASY	346	564	224
1810-28925	Search	1	91	ASY	369	562	92	A3Y	UK	UK	400
1810-28926	Search	1	91	ASY	369	562	92	A3Y	UK	UK	20
1810-28929	Search	1	91	SY	245	484	92	3Y	UK	UK	135
1810-28929	Search	3	91	SY	242	482	94	5Y	243	482	100
1810-28947	Search	1	91	AHY	374	555	92	ASY	UK	UK	120
1810-28974	Search	1	91	ASY	316	561	92	A3Y	UK	UK	75
1810-28975	Search	1	91	ASY	317	560	92	A3Y	UK	UK	30
1810-28975	Search	2	91	ASY	UK	UK	93	A4Y	123	652	UK
1810-28980	Search	1	91	SY	308	543	92	3Y	UK	UK	340
1810-28985	Search	1	91	AHY	116	659	92	ASY	UK	UK	110
1810-28985	Search	4	91	AHY	122	650	96	A6Y	123	652	224
1810-28986	Search	1	91	AHY	370	557	92	ASY	UK	UK	25

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
1810-28988	Search	1	91	AHY	364	525	92	ASY	UK	UK	170
1880-64767	Search	1	91	AHY	304	547	92	ASY	UK	UK	15
1880-64769	Search	1	91	AHY	337	557	92	ASY	UK	UK	60
1930-72715	Search	1	92	ASY	242	482	93	A3Y	242	482	0
1930-72715	Search	2	92	ASY	242	482	94	A4Y	243	482	100
1930-72715	Search	3	92	ASY	243	482	95	A5Y	242	482	100
1930-72715	Search	4	92	ASY	242	482	96	A6Y	244	482	200
1930-72724	Search	1	92	ASY	378	558	94	A4Y	378	558	0
1930-72730	Search	1	92	U	345	564	93	AHY	339	559	781
1930-72756	Search	1	92	AHY	352	567	93	ASY	353	566	141
1930-72757	Search	1	92	U	354	568	93	AHY	353	565	316
1930-72771	Search	1	92	AHY	307	488	93	ASY	307	487	100
1930-72773	Search	1	92	AHY	315	505	93	ASY	313	506	224
1930-72773	Search	3	92	AHY	313	506	95	A4Y	314	505	141
1960-03020	Search	1	93	AHY	362	533	94	ASY	361	534	141
1960-03022	Search	1	93	AHY	363	528	94	ASY	363	528	0
1960-03033	Search	2	93	AHY	122	651	95	A3Y	122	652	100
1960-03044	Search	1	93	AHY	389	433	94	ASY	389	432	100
1960-03047	Search	1	93	AHY	349	443	94	ASY	352	443	300
1960-03048	Search	1	93	AHY	347	445	94	ASY	347	439	600
1960-03049	Search	1	93	AHY	346	442	94	ASY	346	442	0
1960-03106	Search	1	94	SY	77	382	95	3Y	77	381	100
1960-03128	Search	1	94	SY	351	559	95	3Y	351	558	100
1960-03137	Search	1	94	ASY	79	377	95	A3Y	79	377	0
1960-03144	Search	1	94	ASY	185	643	95	A3Y	184	643	100
1960-03149	Search	2	94	AHY	308	487	96	A3Y	308	488	100
1960-03174	Search	1	94	SY	313	542	95	3Y	313	542	0
1960-03190	Search	1	94	SY	374	554	95	3Y	374	554	0
1960-03405	Search	1	95	SY	153	322	96	3Y	159	319	671
1960-03416	Search	1	95	SY	156	707	96	3Y	155	705	224
1960-03451	Search	1	95	ASY	166	586	96	A3Y	165	587	141
1960-03480	Search	1	95	ASY	318	500	96	A3Y	318	500	0
1960-03627	Search	1	94	ASY	317	501	95	A3Y	317	501	0
1960-03631	Search	1	94	SY	321	500	95	3Y	321	499	100
1960-03632	Search	1	94	SY	317	497	95	3Y	319	496	224
1960-03640	Search	1	94	AHY	314	503	95	ASY	314	505	200
1960-03644	Search	1	94	AHY	363	527	95	ASY	363	528	100
1960-03760	Search	1	95	SY	165	593	96	3Y	162	594	316
1960-03772	Search	1	95	SY	165	593	96	3Y	165	592	100
1960-03775	Search	1	95	SY	141	649	96	3Y	142	648	141
1960-03777	Search	1	95	SY	156	648	96	3Y	157	649	141
1960-03778	Search	1	95	SY	153	647	96	3Y	156	648	316
1960-03796	Search	1	95	ASY	160	703	96	A3Y	163	701	361
1960-03811	Search	1	95	ASY	367	522	96	A3Y	366	520	224
1960-03823	Search	1	95	ASY	328	484	96	A3Y	330	484	200
1960-03831	Search	1	95	SY	331	485	96	3Y	332	489	412
1960-03841	Search	1	95	ASY	134	646	96	A3Y	134	646	0
1960-03851	Search	1	95	ASY	119	654	96	A3Y	122	655	316
2060-20811	Search	1	95	SY	300	483	96	3Y	297	486	424

Band number	Search Type	No. times resighted	Banding Information				Resighting Information				Distance (m)
			Year	Age	East	North	Year	Age	East	North	
3500-71102	Search	1	95	AHY	123	648	96	ASY	123	652	400

Appendix B: List of all Adult Males Searched for and Not Found on Fort Hood

This list is presented by search type and band number. Also included at the end is a list of males that were searched for and not found one year, but were found in a subsequent year.

Band number	Search Type	Year Banded	Age at Banding	Year Searched	Age Searched
1290-90820	ISA	1992	AHY	1993	ASY
1290-90821	ISA	1992	AHY	1993	ASY
1290-90833	ISA	1993	SY	1995	5Y
1290-90834	ISA	1993	SY	1996	6Y
1290-90835	ISA	1993	SY	1994	3Y
1290-90836	ISA	1993	SY	1996	6Y
1290-90837	ISA	1993	SY	1996	6Y
1290-90847	ISA	1993	SY	1996	6Y
1290-90848	ISA	1993	SY	1995	5Y
1290-90856	ISA	1993	AHY	1994	ASY
1710-25228	ISA	1992	ASY	1994	A5Y
1710-25230	ISA	1992	SY	1993	3Y
1710-25233	ISA	1992	SY	1993	3Y
1710-25234	ISA	1992	ASY	1993	A3Y
1710-25242	ISA	1992	ASY	1995	A5Y
1710-25244	ISA	1992	SY	1993	3Y
1710-25245	ISA	1992	ASY	1996	A6Y
1710-25265	ISA	1992	ASY	1996	A6Y
1710-25268	ISA	1992	ASY	1994	A4Y
1710-25378	ISA	1992	ASY	1993	A3Y
1710-25380	ISA	1992	SY	1994	4Y
1710-25381	ISA	1992	ASY	1994	A4Y
1710-25382	ISA	1992	ASY	1994	A4Y
1710-25384	ISA	1992	SY	1994	4Y
1710-25386	ISA	1992	SY	1993	3Y
1710-25417	ISA	1993	ASY	1994	A3Y
1710-25418	ISA	1993	SY	1994	3Y
1710-25419	ISA	1993	SY	1994	3Y
1880-64770	ISA	1991	ASY	1993	A4Y
1880-64771	ISA	1991	ASY	1993	A4Y
1880-64773	ISA	1991	ASY	1992	A3Y
1880-64783	ISA	1991	ASY	1992	A3Y
1930-72772	ISA	1992	AHY	1993	ASY
1960-03104	ISA	1994	ASY	1996	A4Y
1960-03108	ISA	1994	SY	1996	4Y
1960-03109	ISA	1994	SY	1995	3Y

Band number	Search Type	Year Banded	Age at Banding	Year Searched	Age Searched
1960-03110	ISA	1994	SY	1996	4Y
1960-03111	ISA	1994	SY	1996	4Y
1960-03115	ISA	1994	SY	1996	4Y
1960-03116	ISA	1994	ASY	1996	A4Y
1960-03117	ISA	1994	SY	1995	3Y
1960-03132	ISA	1994	SY	1995	3Y
1960-03201	ISA	1994	SY	1996	4Y
1960-03202	ISA	1994	SY	1995	3Y
1960-03204	ISA	1994	SY	1995	3Y
1960-03207	ISA	1994	SY	1996	4Y
1960-03208	ISA	1994	SY	1996	4Y
1960-03209	ISA	1994	ASY	1996	A4Y
1960-03212	ISA	1994	HY	1996	3Y
1960-03229	ISA	1994	HY	1996	3Y
1960-03238	ISA	1994	AHY	1996	A3Y
1960-03407	ISA	1995	SY	1996	3Y
1960-03408	ISA	1995	SY	1996	3Y
1960-03529	ISA	1995	ASY	1996	A3Y
1960-03530	ISA	1995	ASY	1996	A3Y
1960-03531	ISA	1995	ASY	1996	A3Y
1960-03534	ISA	1995	ASY	1996	A3Y
1960-03535	ISA	1995	ASY	1996	A3Y
1960-03536	ISA	1995	SY	1996	3Y
1960-03537	ISA	1995	ASY	1996	A3Y
1960-03538	ISA	1995	SY	1996	3Y
1960-03547	ISA	1995	SY	1996	3Y
1960-03548	ISA	1995	SY	1996	3Y
1960-03708	ISA	1995	ASY	1996	A3Y
1960-03710	ISA	1995	ASY	1996	A3Y
1960-03801	ISA	1995	SY	1996	3Y
1960-03814	ISA	1995	SY	1996	3Y
1960-03819	ISA	1995	SY	1996	3Y
1960-03820	ISA	1995	SY	1996	3Y
1960-03822	ISA	1995	SY	1996	3Y
1960-03828	ISA	1995	SY	1996	3Y
1960-03829	ISA	1995	SY	1996	3Y
1960-03834	ISA	1995	SY	1996	3Y
1960-03901	ISA	1995	SY	1996	3Y
1290-90817	Search	1992	U	1993	AHY
1290-90840	Search	1993	ASY	1995	A4Y
1290-90841	Search	1993	ASY	1994	A3Y
1290-90842	Search	1993	SY	1994	3Y
1480-34227	Search	1991	SY	1993	4Y
1480-34238	Search	1991	SY	1996	7Y
1480-34252	Search	1991	ASY	1993	A4Y
1480-34253	Search	1991	SY	1993	4Y
1710-25235	Search	1992	ASY	1996	A6Y
1710-25236	Search	1992	SY	1994	4Y
1710-25243	Search	1992	ASY	1993	A3Y
1710-25247	Search	1992	SY	1993	3Y

Band number	Search Type	Year Banded	Age at Banding	Year Searched	Age Searched
1710-25252	Search	1992	SY	1995	5Y
1710-25253	Search	1992	SY	1994	4Y
1710-25255	Search	1992	ASY	1993	A3Y
1710-25257	Search	1992	ASY	1993	A3Y
1710-25260	Search	1992	ASY	1994	A4Y
1710-25262	Search	1992	SY	1993	3Y
1710-25263	Search	1992	ASY	1994	A4Y
1710-25278	Search	1992	ASY	1993	A3Y
1710-25279	Search	1992	ASY	1993	A3Y
1710-25282	Search	1992	AHY	1996	A5Y
1710-25283	Search	1992	AHY	1993	ASY
1710-25374	Search	1992	AHY	1994	A3Y
1710-25379	Search	1992	ASY	1993	A3Y
1710-25403	Search	1993	SY	1996	5Y
1710-25404	Search	1993	AHY	1996	A4Y
1710-25406	Search	1993	ASY	1996	A5Y
1710-25407	Search	1993	SY	1994	3Y
1710-25408	Search	1993	SY	1994	3Y
1710-25411	Search	1993	AHY	1994	ASY
1710-25413	Search	1993	SY	1995	4Y
1710-25416	Search	1993	ASY	1995	A4Y
1710-25421	Search	1993	ASY	1994	A3Y
1710-25423	Search	1993	SY	1996	5Y
1710-25424	Search	1993	SY	1994	3Y
1710-25426	Search	1993	ASY	1995	A4Y
1710-25427	Search	1993	SY	1996	5Y
1710-25428	Search	1993	ASY	1994	A3Y
1710-25429	Search	1993	SY	1994	3Y
1710-25430	Search	1993	SY	1996	5Y
1710-25432	Search	1993	SY	1996	5Y
1710-25433	Search	1993	SY	1994	3Y
1710-25435	Search	1993	SY	1994	3Y
1710-25437	Search	1993	ASY	1994	A3Y
1710-25438	Search	1993	SY	1994	3Y
1710-25439	Search	1993	AHY	1994	ASY
1710-25440	Search	1993	SY	1996	5Y
1710-25442	Search	1993	SY	1994	3Y
1710-25443	Search	1993	SY	1994	3Y
1710-25444	Search	1993	ASY	1995	A4Y
1710-25445	Search	1993	SY	1994	3Y
1710-25446	Search	1993	ASY	1995	A4Y
1710-25447	Search	1993	SY	1995	4Y
1710-25448	Search	1993	ASY	1994	A3Y
1710-25449	Search	1993	ASY	1996	A5Y
1710-25450	Search	1993	ASY	1996	A5Y
1710-25451	Search	1993	ASY	1994	A3Y
1710-25462	Search	1993	ASY	1994	A3Y
1710-25467	Search	1993	ASY	1994	A3Y
1710-25468	Search	1993	ASY	1995	A4Y
1710-25472	Search	1993	ASY	1996	A5Y

Band number	Search Type	Year Banded	Age at Banding	Year Searched	Age Searched
1710-25473	Search	1993	AHY	1994	ASY
1710-25476	Search	1993	SY	1995	4Y
1710-25480	Search	1993	ASY	1996	A5Y
1710-25482	Search	1993	ASY	1994	A3Y
1710-25484	Search	1993	AHY	1994	ASY
1710-25487	Search	1993	SY	1996	5Y
1710-25494	Search	1993	AHY	1995	A3Y
1710-25496	Search	1993	AHY	1995	A3Y
1810-28925	Search	1991	ASY	1993	A4Y
1810-28926	Search	1991	ASY	1993	A4Y
1810-28927	Search	1991	ASY	1993	A4Y
1810-28929	Search	1991	SY	1995	6Y
1810-28935	Search	1991	ASY	1993	A4Y
1810-28947	Search	1991	AHY	1993	A3Y
1880-64774	Search	1991	ASY	1993	A4Y
1930-72709	Search	1992	SY	1993	3Y
1930-72714	Search	1992	ASY	1993	A3Y
1930-72717	Search	1992	ASY	1993	A3Y
1930-72718	Search	1992	ASY	1993	A3Y
1930-72729	Search	1992	U	1993	AHY
1930-72751	Search	1992	AHY	1993	ASY
1930-72758	Search	1992	U	1993	AHY
1930-72759	Search	1992	AHY	1993	ASY
1930-72760	Search	1992	AHY	1993	ASY
1930-72761	Search	1992	AHY	1993	ASY
1930-72771	Search	1992	AHY	1996	A5Y
1960-03014	Search	1993	AHY	1994	ASY
1960-03016	Search	1993	AHY	1994	ASY
1960-03028	Search	1993	AHY	1994	ASY
1960-03031	Search	1993	AHY	1995	A3Y
1960-03032	Search	1993	AHY	1994	ASY
1960-03033	Search	1993	AHY	1996	A4Y
1960-03037	Search	1993	AHY	1996	A4Y
1960-03047	Search	1993	AHY	1995	A3Y
1960-03048	Search	1993	AHY	1995	A3Y
1960-03049	Search	1993	AHY	1996	A4Y
1960-03060	Search	1993	AHY	1995	A3Y
1960-03067	Search	1993	AHY	1994	ASY
1960-03068	Search	1993	AHY	1994	ASY
1960-03069	Search	1993	AHY	1994	ASY
1960-03107	Search	1994	ASY	1996	A4Y
1960-03118	Search	1994	ASY	1995	A3Y
1960-03122	Search	1994	ASY	1995	A3Y
1960-03124	Search	1994	ASY	1995	A3Y
1960-03125	Search	1994	ASY	1995	A3Y
1960-03126	Search	1994	SY	1995	3Y
1960-03134	Search	1994	ASY	1995	A3Y
1960-03137	Search	1994	ASY	1996	A4Y
1960-03139	Search	1994	SY	1995	3Y
1960-03142	Search	1994	ASY	1996	A4Y

Band number	Search Type	Year Banded	Age at Banding	Year Searched	Age Searched
1960-03143	Search	1994	ASY	1995	A3Y
1960-03145	Search	1994	ASY	1995	A3Y
1960-03147	Search	1994	SY	1996	4Y
1960-03150	Search	1994	SY	1996	4Y
1960-03151	Search	1994	SY	1996	4Y
1960-03154	Search	1994	ASY	1996	A4Y
1960-03161	Search	1994	SY	1995	3Y
1960-03162	Search	1994	SY	1996	4Y
1960-03163	Search	1994	ASY	1996	A4Y
1960-03165	Search	1994	SY	1996	4Y
1960-03166	Search	1994	ASY	1995	A3Y
1960-03167	Search	1994	ASY	1995	A3Y
1960-03168	Search	1994	ASY	1995	A3Y
1960-03169	Search	1994	ASY	1996	A4Y
1960-03170	Search	1994	ASY	1996	A4Y
1960-03171	Search	1994	SY	1996	4Y
1960-03181	Search	1994	ASY	1996	A4Y
1960-03187	Search	1994	ASY	1995	A3Y
1960-03188	Search	1994	ASY	1995	A3Y
1960-03190	Search	1994	SY	1996	4Y
1960-03191	Search	1994	ASY	1996	A4Y
1960-03192	Search	1994	SY	1995	3Y
1960-03224	Search	1994	AHY	1995	ASY
1960-03409	Search	1995	ASY	1996	A3Y
1960-03415	Search	1995	ASY	1996	A3Y
1960-03423	Search	1995	SY	1996	3Y
1960-03425	Search	1995	SY	1996	3Y
1960-03444	Search	1995	SY	1996	3Y
1960-03446	Search	1995	ASY	1996	A3Y
1960-03447	Search	1995	ASY	1996	A3Y
1960-03452	Search	1995	SY	1996	3Y
1960-03461	Search	1995	ASY	1996	A3Y
1960-03462	Search	1995	SY	1996	3Y
1960-03612	Search	1994	SY	1995	3Y
1960-03627	Search	1994	ASY	1996	A4Y
1960-03631	Search	1994	SY	1996	4Y
1960-03633	Search	1994	SY	1995	3Y
1960-03639	Search	1994	AHY	1995	ASY
1960-03667	Search	1994	AHY	1995	ASY
1960-03676	Search	1994	AHY	1995	ASY
1960-03703	Search	1994	AHY	1995	ASY
1960-03711	Search	1995	ASY	1996	A3Y
1960-03714	Search	1995	ASY	1996	A3Y
1960-03715	Search	1995	ASY	1996	A3Y
1960-03717	Search	1995	ASY	1996	A3Y
1960-03718	Search	1995	ASY	1996	A3Y
1960-03755	Search	1995	ASY	1996	A3Y
1960-03757	Search	1995	SY	1996	3Y
1960-03758	Search	1995	ASY	1996	A3Y
1960-03761	Search	1995	ASY	1996	A3Y

Band number	Search Type	Year Banded	Age at Banding	Year Searched	Age Searched
1960-03762	Search	1995	ASY	1996	A3Y
1960-03774	Search	1995	ASY	1996	A3Y
1960-03780	Search	1995	SY	1996	3Y
1960-03781	Search	1995	ASY	1996	A3Y
1960-03782	Search	1995	ASY	1996	A3Y
1960-03783	Search	1995	SY	1996	3Y
1960-03784	Search	1995	SY	1996	3Y
1960-03787	Search	1995	SY	1996	3Y
1960-03788	Search	1995	ASY	1996	A3Y
1960-03794	Search	1995	ASY	1996	A3Y
1960-03802	Search	1995	ASY	1996	A3Y
1960-03803	Search	1995	ASY	1996	A3Y
1960-03804	Search	1995	SY	1996	3Y
1960-03805	Search	1995	SY	1996	3Y
1960-03809	Search	1995	ASY	1996	A3Y
1960-03813	Search	1995	SY	1996	3Y
1960-03817	Search	1995	SY	1996	3Y
1960-03826	Search	1995	SY	1996	3Y
1960-03842	Search	1995	SY	1996	3Y
1960-03843	Search	1995	ASY	1996	A3Y
1960-03856	Search	1995	ASY	1996	A3Y

The following males were FOUND in a later year, after being searched for and NOT found:

Band number	Search type	Year Bd	BdAge	Year Search	Age Search
1290-90819	ISA	1992	AHY	1996	A5Y
1710-25254	Search	1992	ASY	1993	A3Y
1710-25420	Search	1993	SY	1994	3Y
1710-25431	Search	1993	ASY	1994	A3Y
1710-25466	Search	1993	ASY	1994	A3Y
1930-72724	Search	1992	ASY	1993	A3Y

Appendix C: List of all Males Located Within the ISA Including Non-territorial Birds

Territory numbers correspond to those listed in Figures 11-15. Two separate numbers listed in the "No. HY" column indicate double brooding. "UK" = unknown male or missing data. "UB" = unbanded male.

1996

Band Combo	Band Number	Age in 1996	Year Banded	Age Banded	1996 Terr. No.	Mated in 1996?	No. HY in 1996
BkPiGrSi	2060-20826	SY	1996	SY	1	Yes	UK
BlPiPiSi	1960-03877	SY	1995	HY	2	Yes	1
BkSiWh	1960-03833	3Y	1995	SY	3	Yes	2
BkSiOrPi	1960-03815	3Y	1995	SY	4	Yes	0
RdSiPiYe	2060-20828	AHY	1996	AHY	5	Yes	2
GrPiMgSi	1960-03838	3Y	1995	SY	6	Yes	2
BkSiMgRd	2060-20602	ASY	1996	ASY	7	Yes	1
YeSiYeGr	1960-03821	A3Y	1995	ASY	8	Yes	2
BkWhMgSi	1960-03816	3Y	1995	SY	9	Yes	2
PiSiOrLa	3500-71111	SY	1995	HY	10	Yes	4&1
GrSiMgYe	2060-20823	SY	1996	SY	12	Yes	0
OrRdGrSi	2060-20912	ASY	1996	ASY	13	Yes	1
OrSiOrBk	1960-03798	3Y	1995	SY	14	Yes	2
BkSiBkBk	1930-03634	3Y	1994	HY	15	Yes	0
WhSi:Ye	1710-25246	6Y	1992	SY	16	Yes	3
WhSiYePi	1960-03410	3Y	1995	SY	17	Yes	2
RdSi:Ye	1710-25464	5Y	1993	SY	18	Yes	2
MgSi:Or	2060-20632	SY	1996	SY	19	Yes	1
BlOrRdSi	2060-20911	SY	1996	SY	20	Yes	2
GrLaYeSi	1960-03861	SY	1995	HY	21	Yes	2
OrRdPiSi	2060-20901	ASY	1996	ASY	22	Yes	2
Bl:WhSi	1290-90838	5Y	1993	SY	23	Yes	2&2
PiPiMgSi	2060-20906	SY	1996	SY	25	Yes	2
BlBlWhSi	1960-03709	A3Y	1995	ASY	26	Yes	1&1
BkSiPiBl	2060-20902	ASY	1996	ASY	27	Yes	3
YeBkMgSi	1960-03206	4Y	1994	SY	28	Yes	2
MgSiBkLa	1960-03553	A3Y	1995	ASY	29	Yes	2
LaBkOrSi	1960-03533	A3Y	1995	ASY	30	Yes	2
GrSiMgMg	2060-20824	SY	1996	SY	31	UK	UK
Si:PiBl	1960-03883	SY	1995	HY	32	No	--
UB					11	Yes	UK
UB					24	Yes	1

Band Combo	Band Number	Age in 1996	Year Banded	Age Banded	1996 Terr. No.	Mated in 1996?	No. HY in 1996
Non-territorial in 1996:							
GrSiYeRd	1960-03203	4Y	1994	SY			
WhSiOrRd	2060-20910	ASY	1996	ASY			
LaSiRdRd	2060-20601	ASY	1996	ASY			
BlSiOrRd	2060-20908	ASY	1996	ASY			
LaSiYeBk?	UK	UK					

1995

Band Combo	Band Number	Age in 1995	Year Banded	Age Banded	1995 Terr No.	Mated in 1995?	No. HY in 1995	Returned in 1996?
OrRdBlSi	1290-90847	4Y	1993	SY	1	Yes	2	No
LvSiMgPi	1960-03820	SY	1995	SY	2	Yes	2	No
BkSiMgYe	1960-03822	SY	1995	SY	3	Yes	2	No
LvRdPiSi	1960-03828	SY	1995	SY	4	Yes	2	No
GrSiBlBk	1960-03819	SY	1995	SY	5	Yes	2	No
BlSiPiRd	1960-03116	A3Y	1994	ASY	6	Yes	0	No
BkSi:Wh	1960-03833	SY	1995	SY	7	Yes	3	Yes
BkPi:Si	1960-03529	ASY	1995	ASY	8	Yes	3	No
BkWhMgSi	1960-03816	SY	1995	SY	9	Yes	2	Yes
GrLvWhSi	1960-03801	SY	1995	SY	10	Yes	2	No
GrRdOrSi	1290-90819	A4Y	1992	AHY	11	Yes	4	No
BlMgMgSi	1960-03111	3Y	1994	SY	12	Yes	1&2	No
YeSiYeGr	1960-03821	ASY	1995	ASY	13	Yes	1	Yes
OrSiGrMg	1960-03531	ASY	1995	ASY	14	Yes	1	No
OrSiRdGr	1960-03110	3Y	1994	SY	15	Yes	2	No
GrSiGrOr	1960-03108	3Y	1994	SY	16	Yes	3	No
MgSiBlBk	1960-03814	SY	1995	SY	17	Yes	2	No
BkSiOrPi	1960-03815	SY	1995	SY	18	Yes	2	Yes
WhSiYePi	1960-03410	SY	1995	SY	19	Yes	2	Yes
BkPiOrSi	1960-03534	ASY	1995	ASY	20	Yes	1	No
Rd:WhSi	1290-90836	4Y	1993	SY	21	Yes	2	No
RdBkWhSi	1960-03238	ASY	1994	AHY	22	Yes	3	No
YeBkYeSi	1960-03538	SY	1995	SY	23	Yes	2	No
MgGrMgSi	1960-03537	ASY	1995	ASY	24	Yes	2	No
WhRdMgSi	1960-03229	SY	1994	HY	26	Yes	2	No
Wh:YeSi	1710-25246	5Y	1992	SY	27	Yes	2	Yes
BkWhOrSi	1290-90834	4Y	1993	SY	28	Yes	2	No
YeSiLvBk	1960-03530	ASY	1995	ASY	29	Yes	2	No
YePiYeSi	1960-03675	SY	1994	HY	30	Yes	0	No
OrSiOrBk	1960-03798	SY	1995	SY	31	No	--	Yes
RdSi:Ye	1710-25464	4Y	1993	SY	32	Yes	2	Yes
Bk:PiSi	1960-03536	SY	1995	SY	33	Yes	2	No
OrSiYeLv	1960-03209	A3Y	1994	ASY	34	Yes	1	No
LvPiPiSi	1960-03208	3Y	1994	SY	35	Yes	1&2	No
BlSiYeMg	1960-03212	SY	1994	HY	36	No	--	No
RdYeBlSi	1710-25245	A5Y	1992	ASY	37	Yes	3	No
OrSiYeOr	1960-03115	3Y	1994	SY	38	Yes	2	No
Bl:WhSi	1290-90838	4Y	1993	SY	39	Yes	3	Yes
RdSiPiPi	1960-03548	SY	1995	SY	40	No	--	No
BlBlWhSi	1960-03709	ASY	1995	ASY	41	Yes	4	Yes
BlSiGrMg	1960-03708	ASY	1995	ASY	42	Yes	3	No
WhSiYeOr	1960-03207	3Y	1994	SY	43	Yes	2	No
Si:LvLv	1960-03710	ASY	1995	ASY	44	Yes	3	No
GrSiYeRd	1960-03203	3Y	1994	SY	45	Yes	3	Yes
YeBkMgSi	1960-03206	3Y	1994	SY	46	Yes	3	Yes
LvBkOrSi	1960-03533	ASY	1995	ASY	47	Yes	3	Yes
MgSiBkLv	1960-03553	ASY	1995	ASY	48	Yes	2	Yes
MgSiRdBl	1960-03408	SY	1995	SY	49	Yes	3	No

Band Combo	Band Number	Age in 1995	Year Banded	Age Banded	1995 Terr No.	Mated in 1995?	No. HY in 1995	Returned in 1996?
PiSiRdBl	1960-03829	SY	1995	SY	50	Yes	1&1	No
LvSi:Or	1960-03834	SY	1995	SY	51	No	--	No
GrPiMgSi	1960-03838	SY	1995	SY	52	Yes	1	Yes

Non-territorial in 1995:

YeSiYeWh	1960-03901	SY	1995	SY				No
PiSiBlBk	1960-03407	SY	1995	SY				No
OrSiRdBk	1960-03798	ASY	1995	ASY				No
GrMgBkSi	1960-03547	SY	1995	SY				No
BkSiBkBk	1960-03634	SY	1994	HY				Yes
Or:YeSi	1710-25265	A5Y	1992	ASY				No
Pi:RdSi	1960-03104	A3Y	1994	ASY				No
WhGrBlSi	1290-90833	4Y	1993	SY				No

1994

Band Combo	Band Number	Age 1994	Year Banded	Age Banded	1994 Terr. No.	Mated in 1994?	No. HY in 1994	Returned 1995?
OrRdBlSi	1290-90847	3Y	1993	SY	1	Yes	0	Yes
Pi:RdSi	1960-03104	ASY	1994	ASY	2	Yes	3	Possibly
BkBlOrSi	1290-90848	3Y	1993	SY	3	Yes	4	No
BlSiPiRd	1960-03116	ASY	1994	ASY	4	Yes	2	Yes
GrSiLvWh	1960-03132	SY	1994	SY	5	Yes	2	No
UB					6	Yes	4	
BlMgMgSi	1960-03111	SY	1994	SY	7	Yes	2	Yes
GrRdOrSi	1290-90819	A3Y	1992	AHY	8	Yes	3	Yes
GrSiGrOr	1960-03108	SY	1994	SY	9	Yes	0	Yes
Wh:BlSi	1710-25242	A4Y	1992	ASY	10	Yes	2	No
OrSiRdGr	1960-03110	SY	1994	SY	11	Yes	1	Yes
BkSiMgOr	1960-03109	SY	1994	SY	12	Yes	2	No
LvYeYeSi	1960-03117	SY	1994	SY	13	Yes	1	No
WhOrBlSi	1290-90833	3Y	1993	SY	14	Yes	2	No
BkRdMgSi	1960-03201	SY	1994	SY	15	Yes	1	Yes
RdSi:Ye	1710-25464	3Y	1993	SY	16	Yes	1	Yes
Wh:YeSi	1710-25246	4Y	1992	SY	17	Yes	3	Yes
BkWhOrSi	1290-90834	3Y	1993	SY	18	Yes	2	Yes
Rd:WhSi	1290-90836	3Y	1993	SY	19	Yes	2	Yes
UB					20	Yes	1	
UB					21	UK	0	
LvWhOrSi	1960-03202	SY	1994	SY	22	Yes	3	No
OrSiYeLv	1960-03209	ASY	1994	ASY	23	Yes	2	Yes
RdYeBlSi	1710-25245	A4Y	1992	ASY	24	Yes	2	Yes
LvPiPiSi	1960-03208	SY	1994	SY	24	No	--	Yes
MgBkBkSi	1960-03204	SY	1994	SY	25	Yes	3	No
YeBkMgSi	1960-03206	SY	1994	SY	26	No	--	Yes
Bl:WhSi	1290-90838	3Y	1993	SY	27	Yes	2	Yes
UB					28	Yes	3	
WhGrBlSi	1290-90837	3Y	1993	SY	29	Yes	3	No
WhSiYeOr	1960-03207	SY	1994	SY	30	No	--	Yes
GrOrBlSi	1290-90845	SY	1993	HY	31	Yes	2	No
Or:YeSi	1710-25265	A4Y	1992	ASY	32	UK	--	Yes
GrSiYeRd	1960-03203	SY	1994	SY	33	Yes	3	Yes
UB					35	Yes	2	
UB					36	UK	0	

Non-territorial in 1994:

OrSiYeOr	1960-03115	SY	1994	SY	NT	Yes??	--	Yes
RdBkWhSi	1960-03238	AHY	1994	AHY	NT	--	--	Yes

1993

Band Combo	Band Number	Age 1993	Year Banded	Age Banded	1993 Terr. No.	Mated in 1993?	No. HY in 1993	Returned in 1994?
BkBlOrSi	1290-90848	SY	1993	SY	1	Yes	4	Yes
RdOrGrSi	1710-25417	ASY	1993	ASY	2	Yes	1	No
GrRdOrSi	1290-90819	ASY	1992	AHY	3	Yes	2	Yes
UB					4	Yes	0	
YeYeGrSi	1710-25418	SY	1993	SY	5	No	--	No
Or:YeSi	1710-25265	A3Y	1992	ASY	6	Yes	1	Yes
Wh:BlSi	1710-25242	A3Y	1992	ASY	7	Yes	2	Yes
RdSi:Ye	1710-25464	SY	1993	SY	8	Yes	2	Yes
RdBkGrSi	1710-25419	SY	1993	SY	9	UK	--	No
UB					10	Yes	2	
Rd:WhSi	1290-90836	SY	1993	SY	11	Yes	2	Yes
Ye:YeSi	1710-25228	A3Y	1992	ASY	12	Yes	1	No
WhOrBlSi	1290-90833	SY	1993	SY	13	Yes	0	Yes
RdGrYeSi	1710-25268	A3Y	1992	ASY	14	Yes	2	No
BkWhOrSi	1290-90834	SY	1993	SY	15	Yes	3	Yes
Wh:YeSi	1710-25246	3Y	1992	SY	16	Yes	2	Yes
OrWhRdSi	1710-25380	3Y	1992	SY	17	Yes	3	No
WhWhOrSi	1290-90835	SY	1993	SY	18	Yes	4	No
RdYeBlSi	1710-25245	A3Y	1992	ASY	19	Yes	3	Yes
WhOrBlSi	1290-90833	A3Y	1992	ASY	20	Yes	2	No
BlGrRdSi	1710-25384	3Y	1992	SY	21	Yes	3	No
YeWhRdSi	1710-25381	A3Y	1992	ASY	22	Yes	2	No
WhGrBlSi	1290-90837	SY	1993	SY	23	Yes	2	Yes
Bl:WhSi	1290-90838	SY	1993	SY	24	No	--	Yes
UB					25	Yes	2	

Non-territorial in 1993:

OrRdBlSi	1290-90847	SY	1993	SY		--	--	Yes
WhRdBlSi	1290-90856	AHY	1993	AHY		--	--	No

1992

Band Combo	Band Number	Age 1992	Year Banded	Age Banded	1992 Terr. No.	Mated in 1992?	HY present in 1992?	Returned in 1993?
GrYeYeSi	1710-25230	SY	1992	SY	1	Yes	Yes	No
YeYeRdSi	1710-25378	ASY	1992	ASY	2	No	--	No
BlRdOrSi	1930-72772	AHY	1992	AHY	3	Yes	No	No
UB					4	Yes	Yes	
GrRdOrSi	1290-90819	AHY	1992	AHY	5	Yes	No	Yes
Or:YeSi	1710-25265	ASY	1992	ASY	6	Yes	Yes	Yes
UB					7	Yes	N	
RdBkBlSi	1710-25234	ASY	1992	ASY	8	Yes	Yes	No
Wh:BlSi	1710-25242	ASY	1992	ASY	9	No	--	Yes
GrWhYeSi	1710-25233	SY	1992	SY	10	No	--	No
UB					11	Yes	Yes	
Wh:Si	1880-64771	A3Y	1991	ASY	12	Yes	Yes	No
RdGrYeSi	1710-25268	ASY	1992	ASY	13	Yes	Yes	Yes
BlRdRdSi	1880-64770	A3Y	1991	ASY	14	Yes	Yes	No
UB					15	Yes	Yes	
RdYeBlSi	1710-25245	ASY	1992	ASY	16	Yes	No	Yes
WhBlRdSi	1710-25382	ASY	1992	ASY	17	Yes	Yes	Yes
Ye:YeSi	1710-25228	ASY	1992	ASY	18	Yes	Yes	Yes
OrWhRdSi	1710-25380	SY	1992	SY	19	Yes	Yes	Yes
Bk:BlSi	1710-25244	SY	1992	SY	20	Yes	Yes	No
Wh:YeSi	1710-25246	SY	1992	SY	21	Yes	Yes	Yes
YeWhRdSi	1710-25381	ASY	1992	ASY	22	Yes	Yes	Yes
BlGrRdSi	1710-25384	SY	1992	SY	23	Yes	Yes	Yes
WhBkRdSi	1710-25386	SY	1992	SY	24	No	--	No

Non-territorial in 1992:

Or:BkSi	1290-90820	AHY	1992	AHY				No
Rd:BkSi	1290-90821	AHY	1992	AHY				No

1991

Band Combo	Band Number	Age 1991	Year Banded	Age Banded	Returned in 1992?
Bk:Si	1880-64773	ASY	1991	ASY	No
BlRdRdSi	1880-64770	ASY	1991	ASY	Yes
Si:Bl	1880-64783	ASY	1991	ASY	No
Wh:Si	1880-64771	ASY	1991	ASY	Yes

Appendix D: List of all Adult Females Resighted on Fort Hood

This list is presented by band number and the number of times each was resighted.

Band number	No. times resighted	Banding Information				Resighting Information				Distance (m).
		Year	Age	East	North	Year	Age	East	North	
1480-34256	1	1991	ASY	UK	UK	1993	A4Y	305	486	UK
1960-03186	1	1994	AHY	319	563	1995	ASY	318	565	224
1960-03481	1	1995	ASY	320	500	1996	A3Y	320	498	200
1960-03532	1	1995	ASY	340	486	1996	A3Y	341	485	141
1960-03558	1	1995	AHY	314	542	1996	ASY	317	543	316
1960-03620	1	1994	ASY	310	537	1995	A3Y	310	538	100
1960-03620	2	1994	ASY	310	537	1996	A4Y	317	540	762
1960-03620	3	1994	ASY	310	537	1996	A4Y	320	538	1005
1960-03795	1	1995	ASY	157	704	1996	A3Y	156	704	100
1960-03862	1	1995	AHY	341	487	1996	ASY	342	487	100
1960-03862	1	1995	AHY	341	487	1996	ASY	339	485	283
1960-03864	1	1995	SY	345	484	1996	3Y	342	483	316

Appendix E: List of all HY Males' First Resightings on Fort Hood

This list is presented by resight type (ISA, incidental, searched for), in order by band number.

Band number	Search Type	Banding Information			Resighting Information				Distance (m)
		Year	East	North	Year	Age	East	North	
1290-90845	ISA	1993	346	471	1994	SY	336	473	1020
1290-90846	ISA	1993	346	471	1994	SY	314	487	3578
1930-72734	ISA	1992	342	478	1993	SY	319	502	3324
1960-03212	ISA	1994	342	473	1995	SY	341	477	412
1960-03229	ISA	1994	346	487	1995	SY	339	481	922
1960-03634	ISA	1994	294	454	1995	SY	341	477	5233
1960-03675	ISA	1994	306	487	1995	SY	345	478	4002
1960-03861	ISA	1995	338	490	1996	SY	345	479	1304
1960-03877	ISA	1995	345	487	1996	SY	342	488	316
1960-03883	ISA	1995	342	488	1996	SY	347	470	1868
3500-71111	ISA	1995	342	475	1996	SY	338	483	894
1290-90854	Incidental	1993	332	476	1994	SY	298	486	3544
1810-28984	Incidental	1991	303	562	1993	3Y	122	649	20082
1930-72731	Incidental	1992	345	564	1996	5Y	373	516	5557
1930-72753	Incidental	1992	243	482	1994	3Y	389	531	15400
1960-03618	Incidental	1994	316	541	1996	3Y	344	489	5906
1960-03642	Incidental	1994	364	524	1996	3Y	363	533	906
1960-03660	Incidental	1994	303	601	1996	3Y	333	587	3311
1960-03683	Incidental	1994	318	540	1996	4Y	327	485	5573
1960-03697	Incidental	1994	122	648	1995	SY	123	638	1005
1960-03888	Incidental	1995	342	470	1996	SY	332	484	1720
1960-03899	Incidental	1995	345	479	1996	SY	245	482	10004
1810-28979	Search	1991	312	562	1992	SY	UK	UK	60
1960-03552	Search	1995	341	477	1996	SY	315	500	3471

Appendix F: List of all HY Females Resighted on Fort Hood

This list is presented by band number. All females listed in this table were resighted once. * = Female was banded and recaptured by MAPS field crew. Exact location unknown

Band Number	Banding Information			Resighting Information				Distance (m)
	Year	East	North	Year	Age	East	North	
1960-03185	1994	308	485	1995	SY	341	475	3448
1960-03215	1994	341	477	1996	3Y	342	475	224
1960-03236	1994	343	483	1995	SY	339	478	640
1960-03581	1995	341	479	1996	SY	342	488	905
1960-03897	1995	339	482	1996	SY	363	462	3124
2060-20812	1995	310	497	1996	SY	314	504	806
2060-20816	1995	310	497	1996	SY	310	497	*0

Appendix G: Description of Palmer Drought Severity Index

Source: National Oceanic and Atmospheric Administration, National Climate Data Center, Asheville, NC.

Palmer Drought Severity Index (PDSI)

In 1965, Palmer developed an index to "measure the departure of the moisture supply" (Palmer 1965). Palmer based his index on the supply-and-demand concept of the water balance equation, taking into account more than only the precipitation deficit at specific locations. The objective of the Palmer Drought Severity Index (PDSI), as this index is now called, was to provide a measurement of moisture conditions that were "standardized" so that comparisons using the index could be made between locations and between months (Palmer 1965).

The PDSI is a "meteorological" drought index and responds to weather conditions that have been abnormally dry or abnormally wet. When conditions change from dry to normal or wet, for example, the drought measured by the PDSI ends without taking into account streamflow, lake and reservoir levels, and other longer-term hydrologic impacts (Karl and Knight 1985). The PDSI is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer. Human impacts on the water balance, such as irrigation, are not considered. Complete descriptions of the equations can be found in the original study by Palmer (1965) and in the more recent analysis by Alley (1984).

Palmer developed the PDSI to include the duration of a drought (or wet spell). His motivation was as follows: an abnormally wet month in the middle of a long-term drought should not have a major impact on the index, or a series of months with near normal precipitation following a serious drought does not mean that the drought is over. Therefore, Palmer developed criteria for determining when a drought or a wet spell begins and ends, which adjust the PDSI accordingly. Palmer (1965) described this effort and gave examples, and it is also described in detail by Alley (1984). In near-real time, Palmer's index is no longer a meteorological index but becomes a hydrological index referred to as the Palmer Hydrological Drought Index (PHDI) because it is based on moisture inflow (precipitation), outflow, and storage only, and does not take into account the long-term trend (Karl and Knight 1985). In 1989, a modified method to compute the PDSI was begun operationally (Heddinghaus and Sabol 1991). This modified PDSI differs from the PDSI during transition periods between dry and wet spells. Because of the similarities between these Palmer indices, the terms "Palmer Index" and "Palmer Drought Index" have been used to describe general characteristics of the indices.

The Palmer Index varies roughly between -6.0 and +6.0. Palmer arbitrarily selected the classification scale of moisture conditions (Table 23) based on his original study areas in central Iowa and western Kansas (Palmer 1965). Ideally, the Palmer Index is designed so that a -4.0 in South Carolina has the same meaning in terms of the moisture departure from a climatological normal as a -4.0 in Idaho (Alley 1984). The Palmer Index has typically been calculated on a monthly basis, and a long-term archive of the monthly PDSI values for every Climate Division in the United States exists with the National Climatic Data Center from 1895 through the present. In addition, weekly Palmer Index values (actually modified PDSI values) are calculated for the Climate Divisions during every growing season and are available in the Weekly Weather and Crop Bulletin. These weekly Palmer Index maps are also available on the World Wide Web from the Climate Prediction Center.

The Palmer Index is popular and has been widely used for a variety of applications across the United States. It is most effective measuring impacts sensitive to the soil moisture conditions, such as agriculture (Willeke et al. 1994). It has also been useful as a drought monitoring tool and has been used to start or end drought contingency plans (Willeke et al. 1994). Alley (1984) identified three positive characteristics of the Palmer Index that contribute to its popularity: (1) it provides decision makers with a measurement of the abnormality of recent weather for a region; (2) it provides an opportunity to place current conditions in an historical perspective; and (3) it provides spatial and temporal representations of historical droughts. Several states, including New York, Colorado, Idaho, and Utah use the Palmer Index as one part of drought monitoring systems.

There are considerable limitations when using the Palmer Index, and these are described in detail by Alley (1984) and Karl and Knight (1985). Drawbacks of the Palmer Index include:

- The values quantifying the intensity of the drought and signaling the beginning and end of a drought or wet spell were arbitrarily selected based on Palmer's study of central Iowa and western Kansas and have little scientific meaning.

- The Palmer Index is sensitive to AWC of a soil type. Thus, applying the index for a Climate Division may be too general.

- The two soil layers within the water balance computations are simplified and may not be accurately representative for a location.

- Snowfall, snow cover, and frozen ground are not included in the index. All precipitation is treated as rain, so that the timing of PDSI or PHDI values may be inaccurate in the winter and spring months in regions where snow occurs.

- The natural lag between when precipitation falls and the resulting runoff is not considered. In addition, no runoff is allowed to take place in the model until the water capacity of the surface and subsurface soil layers is full, leading to an underestimation of the runoff.

- Potential evapotranspiration is estimated using the Thornthwaite method. This technique has wide acceptance, but it is still only an approximation.

Several other researchers have presented additional limitations of the Palmer Index. McKee et al. (1995) suggested that the PDSI is designed for agriculture, but does not accurately represent the hydrological impacts resulting from droughts of longer time scales. The Palmer Index is also applied within the United States and has little acceptance elsewhere (Kogan 1995). One explanation for this is provided by Smith et al. (1993), who suggested that it does not do well in regions where there are extremes in the variability of rainfall or runoff. Examples in Australia and South Africa were given. Another weakness in the Palmer Index is that the "extreme" and "severe" classifications of drought occur with a greater frequency in some parts of the country than in others (Willeke et al. 1994). "Extreme" droughts in the Great Plains occur with a frequency greater than 10%. This limits the accuracy of comparing the intensity of droughts between two regions, as well as planning response actions based on a certain intensity more difficult.

Table 23: PDSI classifications for Dry and Wet Periods	
4.00 or more	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient dry spell
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
-4.00 or less	Extreme drought

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