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Local and Installation-wide Black-capped Vireo Dynamics on the Fort Hood, Texas Military Reservation

by
Howard J. Weinberg, Timothy J. Hayden, and John D. Cornelius

The Black-capped Vireo is a shrubland passerine that was federally listed as an endangered species in 1987. A substantial population nesting on Fort Hood, Texas, has been monitored since the year of its listing. This report presents results from that program, including extensive territory monitoring and bird banding. Results are presented in three forms; data collected on a regional basis, regional data combined for installation-wide totals, and data collected from study sites located within three primary regions. Regional and study site data collection protocols differed by the frequency and constancy of territory monitoring. These protocols provided installation-wide overviews as well as closer survey of local populations.

In 1987 and 1988, nesting success throughout the installation was exceedingly low and brood parasitism was severe. An effective cowbird mitigation program has resulted in a notable reduction in the incidence of parasitism and nesting dynamics have dramatically improved.

While vast improvement is clear, the viability of the installation-wide population is yet to be determined. Recent data suggested that vireos in some areas on the installation were producing young at levels indicative of self-maintaining populations, while others were not. The percentage of first-time breeders increased, which suggests improved population stability.

Foreword

This study was conducted for Headquarters, III Corps and Fort Hood under Military Interdepartmental Purchase Request (MIPR) No. 6FCER00439.

The work was performed by the Natural Resources Assessment and Management Division (LL-N) of the Land Management Laboratory (LL), U.S. Army Construction Engineering Research Laboratories (USACERL), in cooperation with the Fort Hood Natural Resources Branch. The USACERL principal investigator was Timothy J. Hayden.

This report was prepared by Howard J. Weinberg of Colorado State University, Center for Ecological Management of Military Lands, Department of Forest Sciences, Fort Collins, CO 80523; Timothy J. Hayden of USACERL, Natural Resources Assessment and Management Division, P.O. Box 9005, Champaign, IL 61826-9005; and John D. Cornelius of HQ III Corps and Fort Hood, Natural Resources Branch, Directorate of Public Works, Fort Hood, TX 76544-5057.

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1 Introduction

Background

The Black-capped Vireo (*Vireo atricapillus,* BCVI) is a migratory passerine whose breeding range in the contiguous United States has shrunk notably in recent decades. The bird was never widespread across the United States, but was reported to broadly occupy Kansas, Oklahoma, and Texas (Grzybowski 1995). Some sightings have occurred in southeastern Nebraska (one specimen collected), New Mexico, and Louisiana (Brunner 1896 in Graber 1961; Marshall, Clapp, and Grzybowski 1985). Today, however, the United States population breeds in a restricted range that includes only parts of Oklahoma and Texas. As of 1991, it occupied only three areas in Oklahoma and is probably extirpated from north-central Texas (Marshall, Clapp, and Grzybowski 1985; U.S. Fish and Wildlife Service [USFWS] 1991; Grzybowski, Tazik, and Schnell 1994; Grzybowski 1995).

Reed (1995) categorized neotropical migrants based on an estimated susceptibility to extinction. The BCVI was assigned to the class with the highest risk. Based on a "migrant vulnerability" classification, Rappole (1995) suggested that BCVI have a high probability of declining within the next decade. BCVI were listed as an endangered species in 1987 (Ratzlaff 1987).

Known populations occurring in Texas include reports of at least one male BCVI in 34 south-central and central Texas counties (USFWS 1996). These reports are derived from population counts and observations from 1990 through 1996. In many counties, thorough surveys have not been conducted. BCVI were observed in six additional counties that were last surveyed between 1985 and 1988. Large concentrations of the known population in central Texas are found in Bell, Coryell, and Kerr counties. Populations in Bell and Coryell counties are within the boundaries of the Fort Hood Military Reservation in Killeen, Texas. Approximately 300 males were documented there in 1995 and 1996. As stewards of this relatively large concentration of BCVI, second only to that reported in Kerr County (602 males, USFWS 1996), Fort Hood began monitoring the species in 1987 (Tazik 1991a; Tazik and Cornelius 1993).

This report provides demographic data to land managers and contributes to the understanding of BCVI nesting and population dynamics. It complements other reports regarding BCVI on Fort Hood that have addressed abundance and distribution from 1987 through 1989 (Tazik, Cornelius, and Abrahamson 1993), nesting and population dynamics from 1987 through 1989 (Tazik 1991a; Tazik and Cornelius 1993), habitat use (Tazik, Grzybowski, and Cornelius 1993), nest site location (Melton in prep.), effects of military activity (Tazik et. al. 1992), and cowbird parasitism and control (Hayden et. al., In press). Additionally, reports submitted annually to Fort Hood provided progress information (Hayden and Tazik 1991; Bolsinger and Hayden 1992; Bolsinger and Hayden 1994; Weinberg, Bolsinger, and Hayden 1995; and Weinberg, Jetté, and Cornelius 1996).

Objectives

The objectives of this report are (1) to present local and installation-wide nesting and population data, (2) to use such data to estimate local and installation-wide trends in nesting and population dynamics, and (3) to complement earlier accounts with additional data and insight regarding the nesting and population dynamics of BCVI breeding at Fort Hood.

Approach

BCVI and their nests were located and monitored in each year (1987 to 1996, excluding 1990) to document nesting dynamics and population dynamics. Birds were banded for individual identification, aging purposes, and evaluation of site fidelity.

Scope

This report describes the demographics for Black-capped Vireos on Fort Hood. Different comparisons and analyses target different subpopulations on the installation and during certain years. Primary topics reported are nesting dynamics and dynamics derived from banding studies (e.g., age structure). The data reported pertains to Fort Hood; the generality to other avian studies is unknown except where stated in this report.

Mode of Technology Transfer

This research can be used by biologists at Fort Hood, and elsewhere, as it contributes to the understanding of BCVI breeding ecology. The data in this report can be incorporated into population models (e.g., see USFWS 1996; Melton In prep.; Trame et. al. 1997) and may be used by land managers to develop and refine endangered species management policy.

2 Installation Description

Fort Hood, which encompasses 87,890 ha (U.S. Department of the Army 1987), is located in Region 2 of the BCVI Recovery Plan (USFWS 1991). The installation is located on the eastern edge of the Edward's Plateau and lies within the Lampasas Cut Plains physiographic region (Raisz 1952). The installation is comprised primarily of perennial grassland (65%) and woodland (31%, Tazik 1991a). The general topography consists of a number of mesas, ranging from a 40 to 80 m gain in elevation. Mesas in areas of high erosion are steep sloped, while those with less erosive substrate have gentler slopes (Tazik and Cornelius 1993). Several patches of BCVI habitat are found on the slopes and tops of these mesas. BCVI habitat is described as grassy or wooded areas intermixed with shrubby patches of various size and height (e.g., Graber 1961; Grzybowski, Tazik, and Schnell 1994; Tazik, Grzybowski, and Cornelius 1993). Some woody species relevant to BCVI nesting on Fort Hood include Texas oak (*Quercus buckleyi*), live oak (*Quercus fusiformis*), shin oak (*Quercus sinuata* var. *breviloba*), redbud (*Cerecis canadensis*), skunkbush sumac (*Rhus aromatica*), netleaf hackberry (*Celtis reticulata*), Mexican buckeye (*Ugnadia speciosa*), flame-leafed sumac (*Rhus lanceolata*), and Ashe juniper (*Juniperus ashei*).

Rainfall on Fort Hood can vary considerably from month to month and year to year, and periodically, drought conditions exist. Such conditions prevailed in 1996. The Palmer Drought Severity Index, which was developed by the National Drought Mitigation Center, Texas, determined that Texas was in a mild to extreme drought for most of 1996. Total rainfall at Fort Hood from January to July, 1994 to 1996 is depicted in Table 1.

Fort Hood is delineated into four areas. The delineations are based on land use and include the cantonment areas, the permanently "dudded" area, live fire area, and the non-live fire area (Figure 1). At the geographic center of the installation is the dudded area, which receives ordnance and munitions fire. Surrounding the dudded area is the live fire area. The live fire area is a buffer zone to the dudded area and the primary location of firing points. It receives little foot or vehicular traffic, except at the fringe where firing points are located. The non-live fire area surrounds the live fire area and is used primarily for troop activity (e.g., troop maneuvers, bivouacs). It can receive heavy foot and vehicular traffic (e.g., Tazik 1991b). Cantonment areas are in the non-live fire area and are generally located along the southern and northeastern borders of the installation.

Table 1. Rainfall (inches) in January to July at Fort Hood 1994 to 1996.

MONTH	1994	1995	1996
January	.86	.51	.19
February	3.41	1.52	.12
March	1.44	3.14	1.23
April	.91	4.27	2.37
May	6.58	3.24	1.95
June	1.98	4.81	2.99
July	.99	1.43	1.16
Monthly Average	2.31	2.70	1.43

Data supplied by Tim Buchanan of Fort Hood Natural Resources Branch, Fort Hood, Texas.

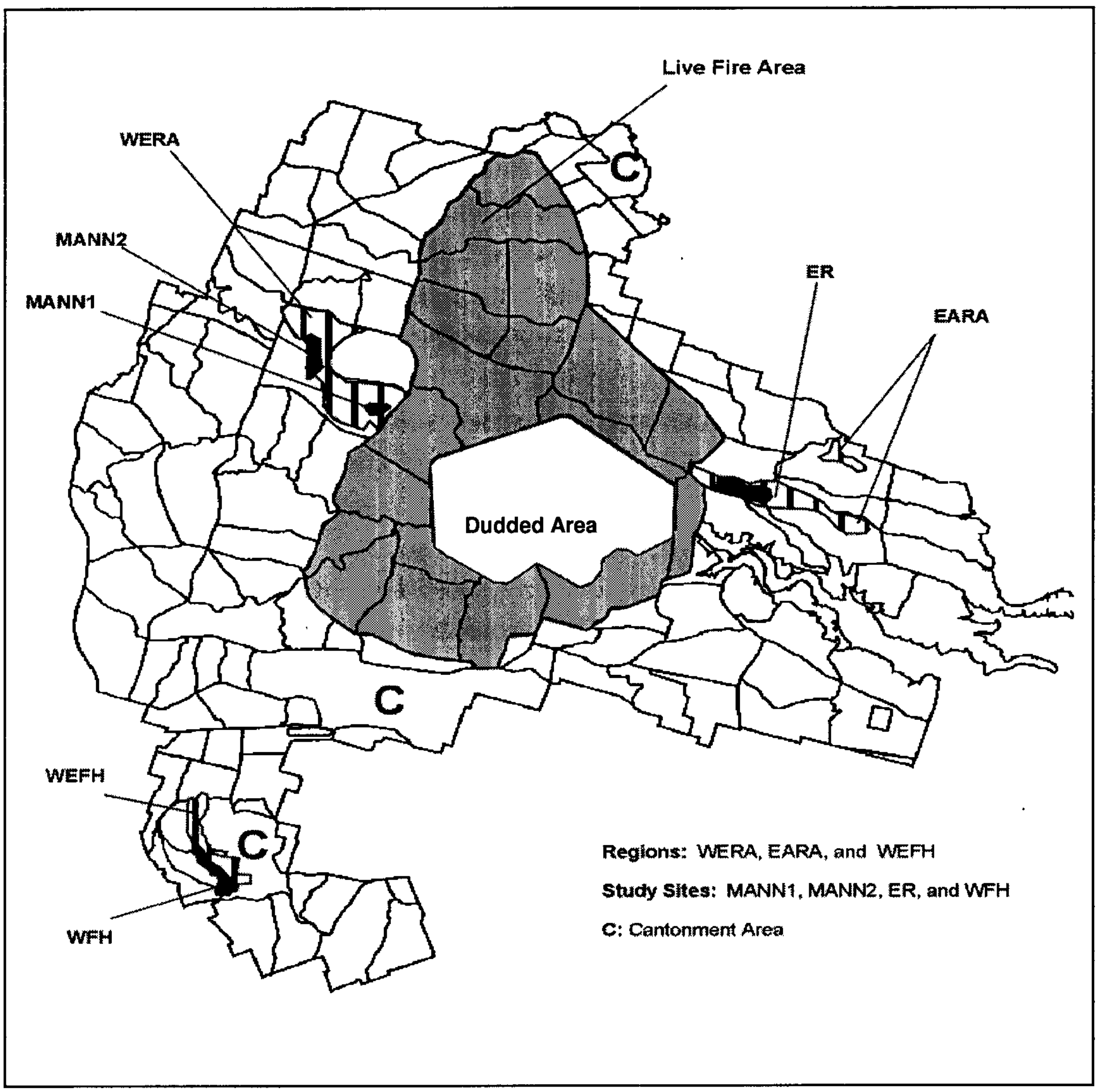


Figure 1. Map of Fort Hood.

The installation is further delineated into regions. Region classification follows that of Tazik and Cornelius (1993). The four major regions discussed in this report are: East Ranges (EARA), West Ranges (WERA), West Fort Hood (WEFH), and the six live fire areas (LF, Figure 1). Collectively, EARA, WERA, and WEFH are referred to as the non-live fire (NLF) area. In 1996, study sites were delineated based on historic BCVI occupation and the continuity of field work from 1994 to 1996 (Figure 1). These sites represent "core" areas within the regions. Study site East Range (ER) is located in region EARA. Study site West Fort Hood (WFH) encompasses the southern half of the WEFH region. Study sites Manning Mountain #1 (MANN1) and Manning Mountain #2 (MANN2) are two areas in the WERA region. Survey effort was not consistent across years at MANN2; therefore, it was not included in local population analyses. BCVI have been found throughout the installation. Figure 2 shows known areas that have been occupied by BCVI.

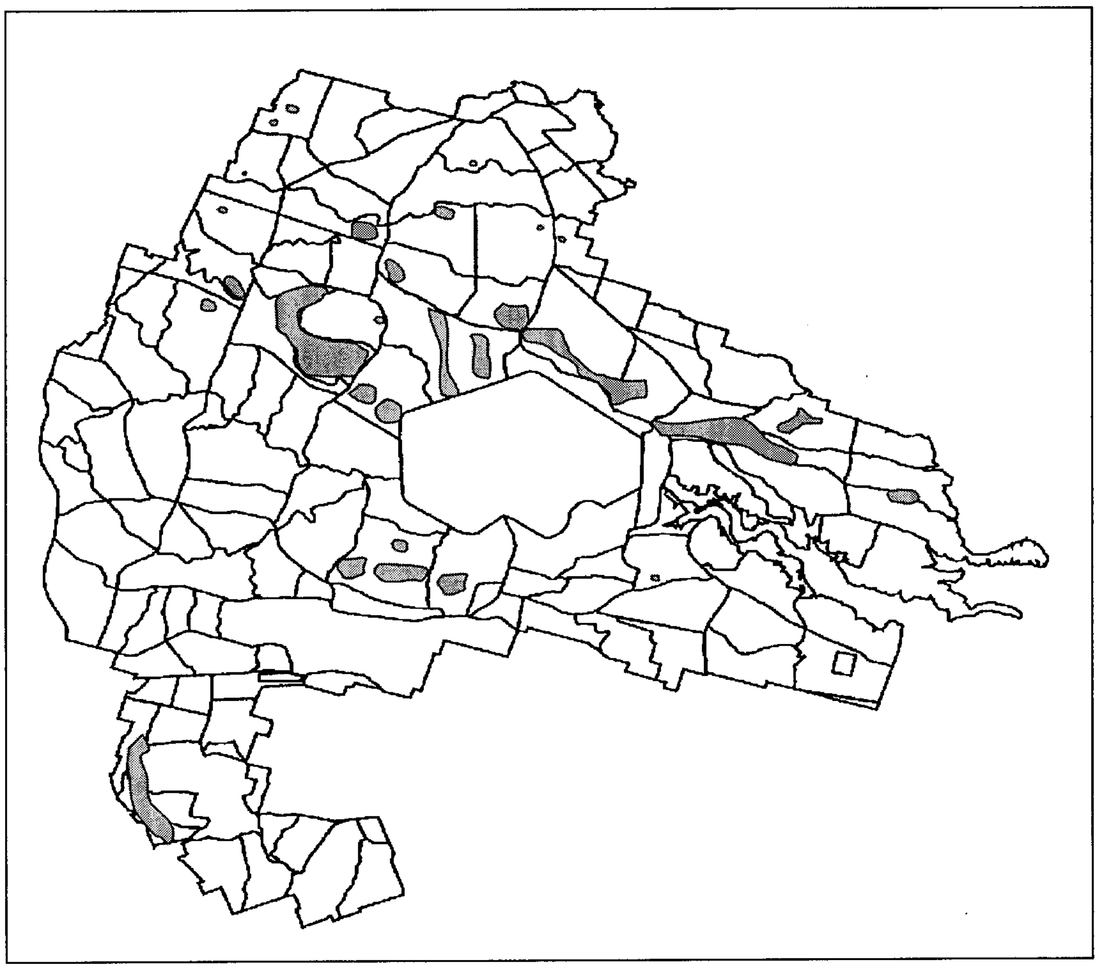


Figure 2. Map showing known areas (shaded) of BCVI occupation 1987 to 1996.

3 BCVI Biology and Pertinent Risk Factors

BCVI are open-cup nesting birds that typically nest in shrubby hardwoods. Nests are often placed at heights below 2 m (e.g., Graber 1961; Grzybowski 1995; Tazik and Cornelius 1989; Tazik 1991a; Melton in prep.). The breeding season in central Texas is from mid-March through early August (Tazik, Grzybowski, and Cornelius 1993; Grzybowski 1995). BCVI are subject to intense brood parasitism pressure from the Brown-headed Cowbird (*Molothrus ater*). It is commonplace for BCVI to renest after failed or successful nest attempts (e.g., Graber 1961; Tazik 1991; Tazik and Cornelius 1993). Adult male BCVI exhibit strong site fidelity (Grzybowski 1995; Tazik 1991a; Tazik and Cornelius 1993). Average territory sizes reported on Fort Hood have ranged from 2.92 to 4.08 ha (Tazik 1991a).

Several factors and life history traits can make BCVI susceptible to population decline. These factors are discussed in Ratzlaff (1987), Grzybowski (1995), and USFWS (1991, 1996). Five of these factors are addressed below.

1. The BCVI population is relatively small. The effects of perturbations and demographic stochasticity in small populations can be much more severe than in larger populations (see references in Soule 1986 and 1987). Certainly, management intervention with smaller populations can be successful, as demonstrated by the Kirtland's Warbler (*Dendroica kirtlandii*). This warbler nests in 15- to 20-year old Jack Pine (*Pinus banksiana*) stands. In Michigan, 1987 censuses resulted in 167 singing males. Aggressive public awareness, forest management, and cowbird control programs have benefited the species. During the breeding season of 1995, 765 singing males were documented (Endangered Species Update 1995).

2. BCVI nest in a specific habitat type (although there is local variation). On Fort Hood, BCVI typically can be found in shrubby habitat that is between 5 and 30 years old (e.g., Tazik 1991a). Scrub/shrub birds have received far less attention with regard to habitat fragmentation and landscape concerns compared to forest birds, but similar concerns regarding the potentially deleterious effects appear valid (e.g., Askins 1993, 1994; Dobkin 1994; Knick and Rotenberry 1995). For example, Askins (1994) briefly reviewed Breeding Bird Survey data that indicated 75% (12 of 16) of shrubland species had showed decline from 1966 to 1991. This compares to 84% (16 of 19) for grassland species and 27% (11 of 40)

for forest species. Six "shrubland specialists" were also compared (Askins 1993) from four monitoring programs (Breeding Bird Survey, Manomet Bird Observatory banding program, Powdermill Nature Reserve banding program, and daily counts at Long Point, Ontario). Data were available in 16 of a possible 24 cases (6 species in 4 reports). In 13 of the 16 cases there was a decline and in five it was significant. Martin (1992) reported that shrub-nesting birds had the lowest nest success rates compared to canopy and ground nesters. This was suspected to be partly the result of higher nest predation and cowbird parasitism pressure. Both of these pressures can increase with increasing habitat fragmentation (e.g., Whitcomb et. al. 1981; Robbins et. al. 1989; Brittingham and Temple 1983; Wilcove 1985; Gates and Gysel 1978; Robinson 1992; Askins 1995; Donovan et. al. 1995).

3. Some shrubland birds appear to have minimum area requirements, as do many forest birds (e.g., Askins 1994). The BCVI may be such a bird. It often nests in relatively large groups (e.g., Graber 1961). It does nest near developed areas, but only if there is available habitat. The White-eyed Vireo (*Vireo griseus* Boddaert), a congener of BCVI, and the Yellow-breasted Chat (*Icteria virens*), a shrubland bird often found nesting in close proximity to BCVI, have shown evidence of being area sensitive (see Askins 1993, 1994). Such sensitivity can restrict these birds to areas of habitat that are above a certain size threshold.

4. In central Texas, fire is the historic means by which BCVI habitat is created and maintained. Increasingly, fire suppression has become general practice and poses a threat to BCVI by allowing existing habitat to succeed beyond suitable stages (USFWS 1991; Grzybowski 1995). In addition to maintaining suitable habitat, fire can revert unsuitable habitat (e.g., old shrubland or forest) to an earlier successional stage that is (or can be) used by BCVI. Fire suppression precludes this possibility. The Florida Scrub Jay (*Aphelocoma coerulescens*), Red-cockaded Woodpecker (*Picoides borealis*), and Bachman's Warbler (*Vermivora bacmanii*) are some other species that have been adversely affected by fire suppression (Rotenberry et. al. 1995).

5. A vulnerability to cowbird parasitism is another key factor that can put BCVI at risk. Some reports indicate that over 90% of the observed BCVI nests in a given year were parasitized (e.g., Tazik and Cornelius 1993; Grzybowski 1985, 1986). An effective cowbird trapping program is a critical component of a BCVI management plan (Marshall, Clapp, and Grzybowski 1985; Grzybowski, 1985, 1988a). This has been born out in practice where high rates of parasitism for BCVI have been dramatically lowered (from ~90% to ~20%) at Fort Hood. BCVI at other locations (Kerr Wildlife Management Area in central Texas and areas in Oklahoma) have benefited from effective cowbird programs (Grzybowski 1989).

4 Methods

Nesting and population data are presented in this report in three ways: a study-site total, regional total, and regional totals combined for an installation-wide total. Regional and study site data were obtained using different criteria. Regional data were generally derived from a sampling protocol that addressed broader-scale dynamics, whereas study site data were obtained from protocol that addressed very site-specific dynamics. Monitored regional territories were visited at least three times during the season and often at least once per week. Study site delineations occurred in 1996, but data from 1994 and 1995 in these areas were collected with the same protocol. Monitored study site territories were visited approximately every 4 or 5 days. Thus, data from the 3 years (1994 to 1996) were comparable. Details of the field protocols used are described in Hayden, Jetté, and Weinberg (in prep.).

Installation-wide data are comprised of combined regional totals and are presented for 1987 to 1996, excluding 1990. Data from 1990 are not directly comparable and are not included in this report. Most regional data are presented for 1991 to 1996, and study-site data and some regional data are presented for 1994 to 1996. Data from 1987 to 1989 were obtained from publications by Tazik (1991a) and Tazik and Cornelius (1993). Data from 1991 to 1996 were obtained from the original field records. The use of the term "population" in this report refers to a collection of BCVI occupying a given area. Local concentrations (study sites and regions) are referred to as "local populations." The "installation-wide population" is referred to when describing broader-scale dynamics on Fort Hood. This use of the term "population" does not imply a genetically isolated population. In the same vain, the terms "habitat quality" and "habitat suitability" are used broadly in this report to represent features (floristic or otherwise) that can affect or be indicative of breeding success or reflect the general state of an area as it pertains to BCVI.

BCVI Abundance and Nesting Dynamics

Abundance of BCVI on Fort Hood was documented by surveying areas where BCVI were observed in previous years. Additional surveys were conducted in all known areas of apparently suitable habitat based on structure and species composition of the vegetation.

BCVI territories in the non-live fire (NLF) area were visited on a regular basis to document nest success, cowbird parasitism rates, pair success, and productivity. Territories in the live fire (LF) region were monitored as access permitted. Access to LF was greatly increased from 1994 to 1996 compared to earlier years, but military restrictions still limited access. Because of that, monitoring in LF was less consistent than in NLF.

Nest success was determined by monitoring nests to termination. Nest stage, nest contents, and presence and behavior of adults were recorded at each visit. Attempts were made to determine the fate of all monitored nests. Nest success was measured as the percent successful (fledged at least one young at discovered nests). Similarly, pair success estimates were reported as the percent of pairs that were successful (i.e., fledged at least one offspring). Nest success was also estimated based on days of exposure (Mayfield 1975). Nests that had already failed when discovered were included in calculations of observed nest success and excluded from exposure-based estimates of nest success.

Cowbird parasitism rates were reported as the percent of monitored nests with cowbird eggs or nestlings from the pool of nests that had known nest contents (Tazik and Cornelius 1993). Cowbird trapping was conducted throughout the NLF areas. Cowbird shooting occurred at selected locations. Cowbird control methods at Fort Hood are described in Hayden et. al. (in press). Brood parasitism rates were calculated from regional data.

Productivity was reported as young per pair per season. Regional productivity was calculated from monitored territories. Productivity from the study sites was calculated using territories from ER, WFH, and MANN1, and only at territories for which productivity was known with reasonable accuracy.

First nest initiation dates were calculated as described in Male, Roberts, and Weinberg (in prep.). Nests from study sites in the years of 1994 to 1996 were used in this analysis. The first recognized nest for each pair was included in the analysis. Nests initiated after May 25 were not included as there was a high probability that these may have been renesting attempts. Initiation dates were back-calculated using nest observations and following nesting chronology in Graber (1961). This includes 4 days assigned to nest construction, 1 day of rest, an average of 15 days of incubation, and an average of 11 days of the nestling stage. Shorter incubation periods (11 days) were used to backdate nests found with cowbird nestlings (Friedmann 1963; Kattan 1995).

In seasonal nest initiation and parasitism analyses, the period of April 1 to July 31 for the years 1994 to 1996 was divided into 12, 10- or 11-day intervals.

Estimated nest initiation dates were assigned to the corresponding interval. Parasitized nests were evaluated to estimate the date the cowbird egg was laid and were assigned to the appropriate interval. In many cases the date of egg laying was known. In others, backdating was necessary to estimate laying date. When backdating was necessary, the first day of laying was used as the day the cowbird egg was laid. When the laying stage was not evident, the day after the last day it was known that no cowbird egg existed in a nest was designated as the day the cowbird egg was laid. In some cases it was not possible to estimate the laying date and such nests were not included in the analysis.

Possible effects of cowbird control and reduced parasitism pressure on nesting frequency were evaluated by comparing the number of nesting attempts in a year of intense parasitism pressure (1989) to one of less intense pressure (1996). Completed nests and nestings at which fledglings were found on territories with season-long monitoring (or as long as adult birds were present) at the study sites were included in this analysis.

Banding: Age Structure and Return Rate

BCVI were captured in 6-m and 12-m mist nets with 24-mm mesh. BCVI were lured to nets by a taped vireo song. All captured adult BCVI were banded with a USFWS numbered aluminum band and a unique combination of colored plastic bands. Nestlings were banded with a numbered aluminum band and a single colored band on the opposite leg.

Sex was determined for captured BCVI by cap color and presence of a brood patch or cloacal protuberance. Adult BCVI were aged as second year (SY) or after second year (ASY) by the extent of black on the cap and by the color and wear of the primary covert feathers (Grzybowski 1988, 1989; Tazik 1991a). Sex for nestling and fledgling BCVI could not be determined.

The banding data (used to estimate age structure and return rate) presented in this report focuses on adult males due to the small number of banded females and the relative infrequency with which banded females were identifiable. Age structure estimates for 1987 to 1989 were obtained from Tazik (1991a). Age structure estimates for the years of 1991 to 1996 were calculated as in Bolsinger and Hayden (1992). The following equation was used to estimate the number of SY in the unbanded and banded population.

SYest = SYbdcy x (UB + AHYbdcy)/SYbdcy + ASYbdcy

where:

SYbdcy = second year birds banded in the current year.

UB = the number of unbanded birds.

AHYbdcy = the number of after hatch year (AHY) banded in the current year.

ASYbdcy = the number of after second year (ASY) birds banded in the current year.

The percent of all SYs in the population was estimated using:

%SY = [(SYest + SYbdcy + SYbdpy)/N] x 100

where:

SYbdpy = the number of SYs banded in the prior year (as hatch year birds).

N = the number of unbanded birds + the entire pool of SY, ASY, and AHY band identifiable birds.

Annual return rate was estimated as the percent of banded vireos captured or observed on Fort Hood in two consecutive years. Coverage and banding efforts varied from site to site and year to year. Results were interpreted in this report accordingly. Consequences are typically more moderate in more intensively monitored areas.

Chi-square, T-tests, and ANOVA tests were used to test for possible local and year effects in nesting and population dynamics. Chi-square tests with degrees of freedom of one were calculated using Yates' continuity correction (Sokal and Rohlf 1995). Linear regression was used to test for a relationship between nest success and age structure and between the nest initiation date and the number of nestings attempted. The probability value of 0.05 was used to determine statistical significance.

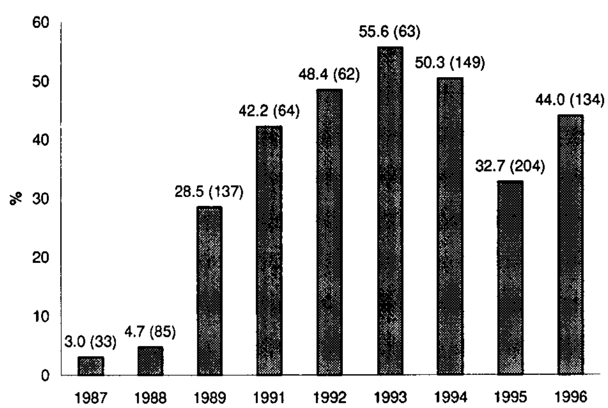
5 Results

Installation-wide Trends and Considerations

Comparison of Installation-wide Trends 1987 to 1996

The installation-wide trends derived from regional parameters for 1987 to 1996 for six nesting and population parameters are presented to help assess the BCVI population on Fort Hood. These parameters include nest success (observed and exposure-based), pair success, productivity, brood parasitism, abundance, and age structure.

Nest Success. Data suggest three general trends in nest success since monitoring began in 1987 (Figure 3): (1) very low success during the first years of monitoring (1987 to 1989), (2) dramatic increase as the cowbird control program evolved (1991 to 1994), and (3) lesser, but relatively moderate nest success (1995 to 1996). During the first 2 years of monitoring, average nest success was very low. Less than 5% of the nests fledged BCVI in 1987 and 1988. Nest success increased to 28.5% in 1989 and continued to increase, peaking at 55.6% in 1993. Since then it declined, but was still greater than 40% in 1994 and 1996. The total average success rate from 1987 to 1996 was 34.4%. From 1991 to 1996, the success rate was 42.9%.



Graph represents the percent of nests that were successful from the pool of nests included in the analysis. Numbers over the bar are percent of nests that were successful, and the sample size (in parentheses).

Figure 3. Annual installation-wide BCVI nest success in 1987 to 1996.

Annual estimates of nest success based on exposure ranged from a low of 2.4% in 1987 to a high of 56.0% in 1994 (Table 2). The total average for 1987 to 1996 was 29.4%. For 1991 to 1996, the rate was 38.5%.

Pair Success. Pair success generally followed the pattern documented for nest success (Figure 4). One exception to this was when nest success increased in 1996 from rates reported in 1995, while the pair success rates reported declined. Pair success was low in 1987 and 1988, then increased to a high of 79.2% in 1992. Installation-wide pair success has shown a decline in recent years, but from 1991 to 1995 still was above 50%. This reflects an improvement in pair success since 1987 to 1989 when an average of 40.8% of the pairs were successful (Tazik 1991a).

The reported data likely underrepresent actual regional and installation-wide pair success. Two factors could contribute to this possibility. First, monitoring in LF can be less consistent because of access limitations. Some territories satisfied monitoring criteria and were included in regional pair success calculations, but some nestings may not have been discovered on these territories. Field technicians suggested this may have occurred in 1996. For example, observed nest success was 52.1% in LF in 1996, yet pair success there was 35.8%. Comparison of study site and regional results support the likelihood. Second, to a lesser degree, differences in monitoring intensity at some territories in NLF could have contributed to lower regional estimates of pair success.

Table 2. Estimates of nest success based on exposure.

YEAR	NEST SUCCESS (EXPOSURE-BASED)*	DLR (INCUB., NESTLING)**	TOTAL DAYS OF EXPOSURE
1987	2.4%	.1031, .1569	196.5
1988	6.9%	.0763, .0920	554.5
1989	23.7%	.0447, .0438	1005.5
1991	36.2%	.0435, .0313	312
1992	27.1%	.0350, .0670	362
1993	40.6%	.0340, .0341	557.5
1994	56.0%	.0125, .0290	1384
1995	28.6%	.0412, .0511	2242.75
1996	42.7%	.0344, .0291	1366.25
TOTAL ANNUAL AVERAGE	29.4%	-	-

* Estimates for 1991 to 1996 are based on calculations derived from the incubation and nestling stages. Estimates for 1987 to 1989 also include calculations derived from the construction and laying stages.

** Daily Loss Rate (DLR) is given for the incubation and nestling stages.

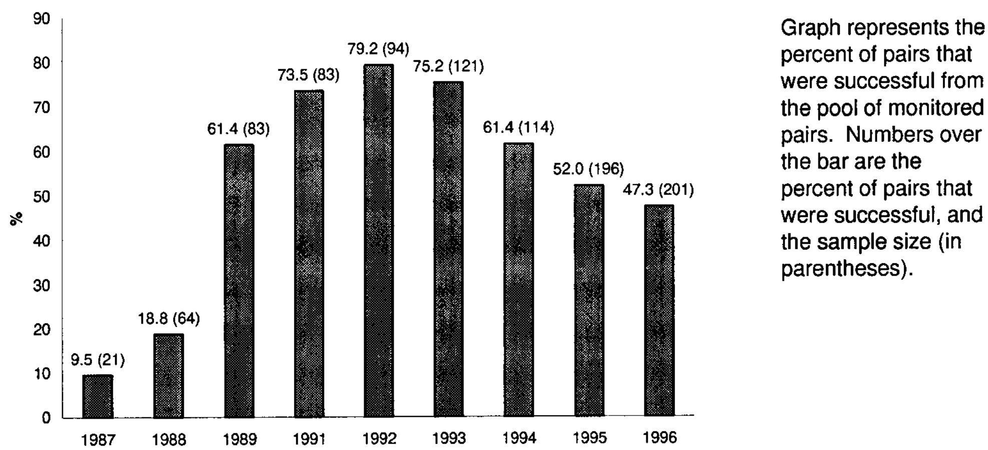


Figure 4. Annual installation-wide BCVI pair success 1987 to 1996.

Productivity. Between 1987 and 1996, installation-wide productivity ranged from 0.29 young per pair per season (1987) to 2.08 (1992) (Figure 5). Totals from 1987 to 1992 were averaged midpoints of maximum and minimum values while values from 1993 to 1996 were means. Prior to 1989, productivity was less than 0.5. There was a significant positive relationship between annual productivity and nest success ($r^2 = 0.67$, $p = 0.0073$). As with pair success, productivity estimates (particularly the decline reported in 1996) could have been affected in part by the monitoring regime.

Cowbird Parasitism. In 1987 and 1988, approximately 90% of BCVI nests were affected by parasitism (Figure 6). Less than 5% of the nests were successful during this time. Cowbird control began in 1988, and by 1991 was a proficient and effective program (Hayden et. al., in press). Parasitism rates have decreased since the program began. Parasitism rates were below 25% in 1994, 1995, and 1996, falling to a low of 12.8% in 1994. Trapping efficiency has increased from 0.035 female cowbirds removed or trapped per day in 1988 to 0.510 in 1994 (Hayden et. al., in press). Additionally, the shooting program has evolved into a very effective complement to the trapping program.

Abundance. The number of documented male BCVI has increased steadily on the installation from 85 in 1987 to 316 in 1996 (Table 3). Over time, all four regions have experienced increases that were 100% greater than numbers documented in 1987. The period of greatest annual change, on a percentage basis, in regional abundance of males occurred in 1987 to 1988 at LF (116% increase), in 1991 to 1992 in WERA and WEFH (100% and 61.1% increases, respectively), and between 1989 and 1991 in EARA (53.3% increase; data from

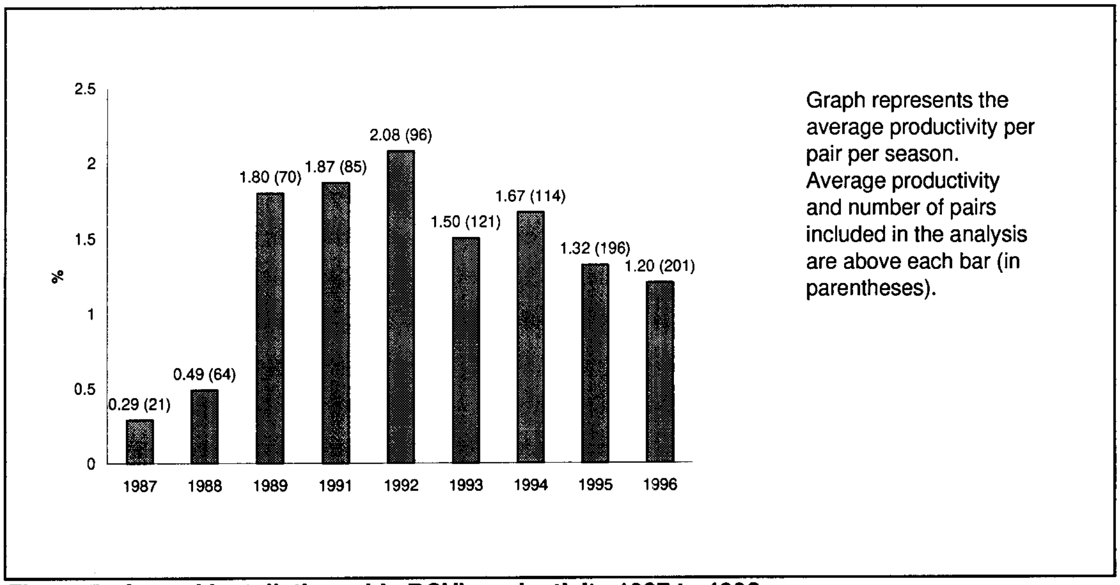


Figure 5. Annual installation-wide BCVI productivity 1987 to 1996.

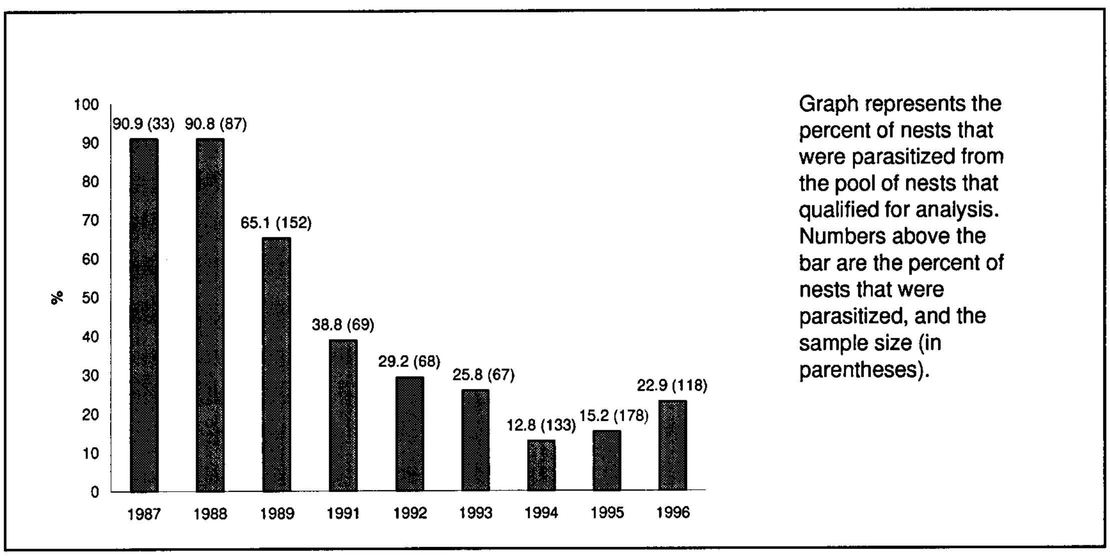


Figure 6. Annual installation-wide brood parasitism 1987 to 1996.

Table 3. BCVI regional abundance 1987 to 1996.

Site	1987	1988	1989	1991	1992	1993	1994	1995	1996
EARA	24*	30	30	46	63	65	72	73	54
WERA	15	13	12	17	34	44	42	62	58
WEFH	14	20	17	18	29	36	34	34	34
LF	32	69	84	71	64	75	131	121	170
Total	85	132	143	152	190	220	279	290	316

* Value represents the number of male BCVI documented.

1990 was not directly comparable). The period of greatest increase as measured by counts of observed males occurred in 1993 to 1994 in LF (increase of 56), in 1991 to 1992 in WEFH (increase of 11), in 1994 to 1995 at WERA (increase of 20), and in 1991 to 1992 in EARA (increase of 17).

Age Structure. Installation-wide the estimated annual percentage of SYs in the population of male BCVI has varied from a low of 10.0% in 1989 to a high of 49.7% in 1992 (Figure 7). The difference among years (1987 to 1996) was highly significant ($\chi^2 = 92.454$, df = 8, $p < 0.0001$). With the exclusion of 1992, the SY percentage has been somewhat constant from 1991 to 1996, ranging from 17.5% to 29.1% during those years, and between 25.2% and 29.1% in 1991, 1993, 1994, and 1995.

An association that approached statistical significance was present between nest success in year t and the age structure in year t + 1 (regression, $p = 0.0865$, $r^2 = 0.48$; Figure 8). In general, the percentage of SYs present in the current year on an installation-wide basis tended to loosely reflect nest success rates documented in the previous year.

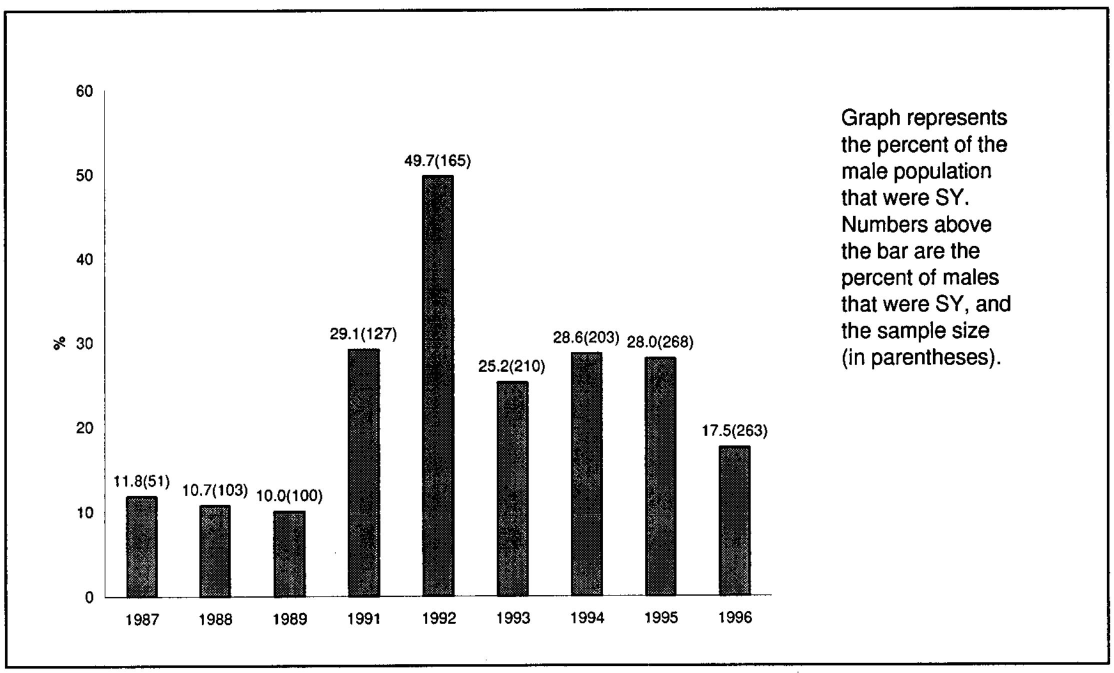


Figure 7. Annual installation-wide age structure 1987 to 1996.

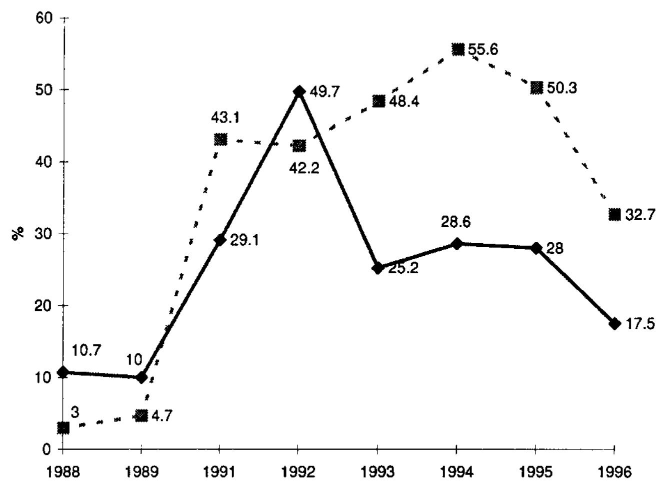


Figure 8. BCVI age structure and nest success comparison.

Comparison of NLF and LF

The NLF and LF areas receive different levels and types of military training. There is no direct cowbird control in LF, while direct (shooting) and indirect (trapping) control occurs in NLF. To assess the effects of these differences, selected parameters for the three NLF areas collectively and the LF were compared for 1991 through 1996. The parameters were: regional nest success, productivity, brood parasitism, and age structure. These data are depicted in Tables 4 through 8.

Nest Success. Nest success tended to be higher in the NLF areas, although it was significantly different in only 1 year, 1991 ($\chi^2 = 6.0358$, df = 1, p = 0.0140, Table 4). The observed rate was higher in NLF in 3 years (1991, 1992, 1994), and higher in LF in 3 years (1993, 1995, 1996). The 6-year total nest success rate was 44.5% in NLF and 39.8% in LF.

Table 4. BCVI regional nest success 1991 to 1996.

YEAR	EARA	WERA	WEFH	NLF TOTAL	LF	TOTAL
1991	65.0(20)*	50.0(2)	50.0(8)	60.0(30)	26.5(34)	42.2(64)
1992	69.6(23)	66.7(6)	33.3(21)	54.0(50)	25.0(12)	48.4(62)
1993	59.3(27)	78.6(14)	26.7(15)	55.4(56)	57.1(7)	55.6(63)
1994	53.0(49)	42.9(28)	57.1(35)	51.8(112)	45.9(37)	50.3(149)
1995	22.5(74)	41.2(31)	39.4(33)	32.6(138)	37.1(66)	32.7(204)
1996	31.6(38)	43.6(39)	53.1(32)	42.2(109)	52.1(25)	44.0(134)
Total	43.7(231)	49.2(120)	45.1(144)	45.5(495)	39.8(181)	42.9(676)

* Value represents the percent of nests that were successful. The total number of nests is in parentheses.

Pair Success. The percent of pairs that were successful was greater in NLF in five of the six years (Table 5). The differences however, were significant only in 1996 (χ^2 = 3.968, df = 1, p = .0464) and for the total 6-year average percent (χ^2 = 4.746, df = 1, p = .0294). The 6-year total percent of pairs that were successful was 66.5% in NLF and 49.6% in LF.

Productivity. Productivity was higher in NLF in 4 years (1991 to 1993 and 1996) and higher in LF in 2 years (1994 and 1995, Table 6). The 6-year average of annual productivity was significantly higher in NLF (t-test, p = 0.0385, n = 12). Average productivity in LF was less than 1.00 in 2 years and was never greater than 1.9 in any year. In NLF, average productivity was greater than 2.00 in 2 years (1991 and 1992) and was never below 1.29. Productivity may have been underestimated in LF in 1996 because of the difficulty monitoring some territories there. However, when data were reanalyzed without 1996 data, NLF still had a higher average (1.80 in NLF compared to 1.36 in LF), but it was not statistically significant (t-test, p = 0.1118, n = 10).

Table 5. BCVI regional pair success 1991 to 1996.

YEAR	EARA	WERA	WEFH	NLF TOTAL	LF	TOTAL
1991	66.7(27)*	100.0(11)	69.2(13)	74.5(51)	67.6(34)	71.8(85)
1992	84.6(39)	93.8(16)	66.7(12)	82.9(73)	69.6(23)	79.2(96)
1993	79.2(53)	96.2(26)	60.0(25)	78.8(104)	52.9(17)	75.2(121)
1994	63.4(41)	55.6(18)	72.0(25)	64.3(84)	53.3(30)	61.4(114)
1995	38.1(63)	64.1(39)	62.1(29)	51.1(131)	53.8(65)	52.0(196)
1996	42.9(28)	71.9(32)	65.6(32)	60.9(92)	35.8(109)	47.3(201)
Total	61.4(251)	76.8(142)	65.5(142)	66.5(535)	49.6(278)	60.9(813)

* Value represents the percent of pairs that were successful. The total number of pairs is in parentheses.

Table 6. BCVI regional productivity 1991 to 1996.

YEAR	EARA	WERA	WEFH	NLF AVERAGE	LF	TOTAL AVERAGE
1991	1.94(27)*	2.5(11)	2.11(13)	2.18(3)	1.52(34)	1.87(85)
1992	2.62(39)	2.62(16)	1.56(18)	2.27(3)	1.22(23)	2.08(96)
1993	1.62(53)	2.19(26)	0.92(25)	1.58(3)	0.88(17)	1.50(121)
1994	1.36(41)	1.56(18)	2.12(25)	1.68(3)	1.8(30)	1.67(114)
1995	0.85(63)	1.67(39)	1.76(29)	1.43(3)	1.37(65)	1.32(196)
1996	1.36(28)	2.00(32)	1.91(32)	1.76(3)	0.72(109)	1.2(201)
Total Annual Average	1.63(6)	2.09(6)	1.73(6)	1.82(6)	1.25(6)	1.61(6)

* The value represents the average fledglings per male per season. The number of males included in the analysis is in parentheses.

Cowbird Parasitism. The difference in parasitism in NLF versus LF was notable (Table 7). In 5 of 6 years, the percentages of nests affected by cowbirds were greater in LF and the difference was significant in 1991 ($\chi^2 = 18.8275$, df = 1, $p < 0.0001$). It was nearly significant in 1992 and 1994 ($\chi^2 < 3.5$, df = 1, $p < 0.063$). Rates have declined in LF throughout the period although they were still generally higher than in NLF.

Age Structure. The estimated age structure in NLF and LF areas was significantly different in 1994 ($\chi^2 = 3.9253$, df = 1, p = 0.0476, Table 8) and 1995 ($\chi^2 = 20.6250$, df = 1, $p < 0.0001$), and was nearly so for the 6-year totals ($\chi^2 = 3.6494$, df = 1, p = 0.0561). In each of these three cases, there was a greater percentage of SY males in the LF areas and such was the case in 4 of 6 years. A difference in the age-structure pattern was evident between the two areas. In NLF, the SY percentage increased from 30.3 in 1991 to 48.3% in 1992 and then steadily fell to 15.3% in 1996. In contrast, SY percentages in LF fluctuated from year to year with no clear trend.

Table 7. BCVI regional parasitism 1991 to 1996.

YEAR	EARA	WERA	WEFH	NLF TOTAL	LF	TOTAL
1991	13.6(22)*	50.0(2)	25.0(8)	18.8(32)	57.1(35)	38.8(69)
1992	4.2(24)	14.3(7)	42.9(21)	29.2(65)	61.5(13)	29.2(68)
1993	14.8(27)	13.3(15)	60.0(15)	26.3(57)	22.2(9)	25.8(67)
1994	11.1(45)	3.8(26)	11.8(34)	9.5(105)	25.0(28)	12.8(133)
1995	18.5(65)	0.0(22)	6.9(29)	12.1(116)	21.0(62)	15.2(178)
1996	34.8(23)	18.2(33)	14.8(27)	20.9(91)	29.6(27)	22.9(118)
Total	15.9(214)	10.5(105)	22.4(134)	16.6(453)	33.3(174)	21.0(633)

* Value represents the percent of nests that were parasitized. The number of nests that qualified for the analysis is in parentheses.

Table 8. BCVI regional age structure 1991 to 1996.

YEAR	EARA	WERA	WEFH	NLF TOTAL	LF	TOTAL
1991	37.5(32)*	47.1(17)	0.0(17)	30.3(66)	27.9(61)	29.1(127)
1992	58.3(60)	48.4(31)	20.0(25)	48.3(116)	53.1(49)	49.7(165)
1993	30.3(66)	26.7(35)	24.3(37)	27.7(148)	19.4(62)	25.2(210)
1994	39.1(69)	19.5(41)	17.6(34)	28.5(144)	44.1(59)	28.6(203)
1995	17.3(75)	23.8(63)	9.4(32)	18.2(170)	44.9(98)	28.0(268)
1996	17.1(35)	15.7(51)	12.5(32)	15.3(118)	19.3(145)	17.5(263)
Total	33.5(337)	26.6(248)	15.3(177)	27.0(762)	32.3(474)	29.0(1236)

* Value represents the estimated percentage of male population that was SY. The number of males involved in each estimation is in parentheses.

Local Trends

Comparison of Local Populations From 1994 to 1996

Several parameters and considerations derived from three specific study sites (Figure 1), (and regional data in some cases) were compared to assess current BCVI dynamics on a very local scale for 1994 to 1996. These parameters and considerations included nest success (and causes of failure), pair success, productivity, brood parasitism, first nest initiation, nest initiation and brood parasitism, number of nesting attempts per pair per season, nesting attempts and brood parasitism, age structure, and return rates.

Nest Success. Observed nest success varied among the three study sites (Table 9). The 3-year (1994 to 1996) average was 35.9% in ER, 58.1% in WFH, and 41.9% in MANN1. The difference among the sites was nearly statistically significant in 1995 ($\chi^2 = 5.7761$, df = 2, p = 0.0557) and was significant for all 3 years combined ($\chi^2 = 7.8683$, df = 2, p = 0.0196). Nest success was consistently higher at WFH and notably lower in ER in 1995 and 1996. The greatest contribution to the χ^2 was associated with the WFH values (58.9% of the χ^2). Three-year totals in WFH and MANN1 were not statistically different.

Differences in total nest success were also significant among years ($\chi^2 = 6.8938$, df = 2, p = 0.0318). Observed nest success was highest in 1994 (59.6%) and lowest in 1995 (36.5%). This was consistent with regional trends (Figure 3) documented during the same period (1994 to 1996).

Table 10 depicts the frequency of the two leading causes of nest failure in the study sites: nest abandonment and nest predation. These data should be interpreted as potential trend indicators only and might not represent actual depredation or abandonment rates. Field technicians categorized a nest as abandoned or depredated when there was evidence of such an event. A portion of the nests classified as abandoned may have been partially depredated first and then abandoned, and nests categorized as depredated could have been abandoned first and then depredated (see Pease and Grzybowski 1995).

In each year (1994 to 1996), ER had the greatest percentage of nests that were categorized as abandoned. The difference was significant in 1995 ($\chi^2 = 6.1039$, df = 2, p = 0.0473) and for all years combined ($\chi^2 = 8.3266$, df = 2, p = 0.0156). The abandonment rate in ER increased dramatically from 1994 (9.5%) to 1995 (28.6%). This corresponds to the documented increase in brood parasitism. The abandonment rate was below 10% in the other two sites in each year.

Table 9. BCVI pair and nest success in study sites 1994 to 1996.

	1994		1995		1996		TOTAL	
Site	Pair	Nest	Pair	Nest	Pair	Nest	Pair	Nest
ER	66.7(24)*	61.9(21)	31.8(22)	21.4(28)	42.9(21)	31.0(29)	47.8(67)	35.9(78)
WFH	76.2(21)	69.6(23)	77.8(18)	55.0(20)	75.0(24)	51.6(31)	76.2(65)	58.1(74)
MANN1	70.0(10)	38.5(13)	70.0(10)	40.0(15)	90.0(10)	46.7(15)	76.7(30)	41.9(43)
Total	70.9(55)	59.6(57)	56.0(50)	36.5(63)	65.5(55)	42.7(75)	64.4(160)	45.6(195)

* Value is percent of pairs that fledged young. The number of pairs included in the analyses is in parentheses.

Table 10. BCVI nest abandonment and predation at study sites 1994 to 1996.

SITE	1994		1995		1996		TOTAL	
	A*	P	A	P	A	P	A	P
ER	9.5(21)**	23.8(21)	28.6(28)	14.3(28)	17.2(29)	20.7(29)	19.2(78)	19.2(78)
WFH	4.3(23)	17.4(23)	5.0(20)	25.0(20)	9.6(31)	22.6(31)	6.8(74)	21.6(74)
MANN1	7.7(13)	30.8(13)	6.7(15)	20.0(15)	0.0(15)	40.0(15)	4.7(43)	30.2(43)
Total	8.8(57)	22.8(57)	15.9(63)	19.0(63)	10.7(75)	25.3(75)	11.2(195)	22.6(115)

*A = abandonment, P = predation.

** Value is percent of nests that were abandoned or depredated. The number of nests that were included in the analyses is in parentheses.

Depredation rates were not significantly different among sites or years ($0.35 < \chi^2 < 2.2$, $p > 0.30$), although differences may have been biologically important (see Chapter 6). MANN1 had the highest percentage of nests categorized as depredated in 2 of the 3 years (1994 and 1996) and for all years combined 19.2% in ER, 21.6% in WFH, and 30.2% in MANN1). In all but two cases (ER in 1995 and ER all years combined), the depredation rate exceeded the abandonment rate.

Pair Success. Pair success was similar in two study sites: MANN1 and WFH. It was lower at ER during 1994 to 1996. Average pair success in the study sites was 47.8% in ER, 76.2% in WFH, and 76.7% in MANN1 (Table 9). The difference among sites was significant in 1995 ($\chi^2 = 9.4812$, df = 2, $p = 0.0087$) and 1996 ($\chi^2 = 9.4812$, $p = 0.0087$), and for all years combined (χ^2=13.8753, df = 2, $p = 0.0010$). The greatest contribution to the χ^2 was associated with the values from ER. While WFH and MANN1 displayed similar pair success rates, a greater disparity existed in nest success at the two sites.

Unlike nest success, year effects in study-site pair success were not significant ($\chi^2 = 2.5811$, df = 2, $p = 0.2751$), although the general pattern was similar. The highest pair success occurred in 1994 (70.9%) and the lowest in 1995 (56.0%).

Productivity. Productivity per pair per season in the study sites averaged between 0.81 fledglings per season to 2.75 from 1994 to 1996 (Table 11). ER experienced the lowest 3-year average productivity of 1.28 fledglings per pair. WFH displayed the highest with 2.40 followed closely by MANN1 with 2.26. Total productivity estimates among sites were significant (ANOVA, $F_{2,8} = 6.5143$, $p = 0.0314$). There was no significant year effect. Average productivity per successful attempt was 3.14.

Productivity may have been affected by age (Table 12). Territories that were occupied by SY males averaged 0.81 fledglings per season compared to 2.4 for ASY males, a significant difference (t-test, $p = 0.0067$).

Cowbird Parasitism. Regional parasitism rates in 1994 to 1996 are depicted in Table 7. Regions in which the study sites were located had relatively low parasitism overall, but parasitism was increasing at EARA. EARA had the highest rate (18.4%) compared to WERA (8.6%) and WEFH (11.1%). The differences in cowbird parasitism rates were significant in 1995 ($\chi^2 = 6.2537$, df = 2, $p = 0.0439$) and approached significance overall ($\chi^2 = 4.9155$, df = 2, $p = 0.0856$).

Table 11. BCVI productivity in study sites 1994 to 1996.

YEAR	EF	WFH	MANN1	TOTAL
1994	1.75(20)*	2.18(17)	1.75(8)	1.91(45)
1995	0.81(21)	2.42(12)	2.29(7)	1.55(40)
1996	1.28(18)	2.59(22)	2.75(8)	2.13(48)
TOTAL AVG.	1.28(59)	2.40(51)	2.26(23)	1.86(133)

* Value represents the average fledglings per male per season.

The number of males included in the analysis is in parentheses.

Table 12. Age-related productivity from known-age males in study sites, 1994 to 1996.

Age class	Productivity
SY	0.63(8)
3Y	2.1(10)
4Y	1.0(11)
5Y	4.0(3)
7Y	0.0(1)
All ASY	2.18(103)

First Nest Initiation Dates. Mean initiation dates for first nests on the study sites were compared. In all, 96 nests were included in the analysis (Table 13). First nest initiation dates among study sites were significantly different in 1994 (ANOVA, $F_{2,33}$ = 3.3048, p = 0.0290) and 1995 (ANOVA, $F_{2,28}$, = 3.3690, p = 0.0091). The greatest disparity between sites occurred in 1994 when mean dates by site varied by 16.7 days. The shortest disparity occurred in 1996, when the mean dates varied by 7.3 days. In all years ER had later start dates and MANN1 had early dates (although MANN1 and WFH had similar average dates in 1995). There was not a significant year effect in the start dates (ANOVA, p > 0.20) for any of the sites.

Nest Initiation and Parasitism. Season-long nest initiation data showed that the earliest of the estimated initiation dates was April 7 (Julian date: 98) and the latest was June 27 (Julian date: 179). Nests were active in July, and at least one nest could have been initiated then, but the initiation date for that nest could not be estimated with reasonable accuracy. In the study sites from 1994 to 1996, 73 nests were initiated on or before April 30 (Table 14). This represents 48.7% of the nests in this analysis. Peak initiation was from April 11 through May 31 (80% of the nests). The observed success rate for nests initiated on or before April 30 was 65.8% (48 of 73) and the rate for nests initiated later was 50.6% (39 of 77, Table 15).

Table 13. BCVI "first nest" initiation dates in study sites, 1994 to 1996.

SITE	1994		1995		1996		TOTAL
	First Nest*	Mean(n)	First Nest	Mean(n)	First Nest	Mean(n)	Mean(n)
ER	99	121.8(17)	98	123.2(11)	105	118.2(11)	121.2(39)
WFH	105	114.1(10)	100	109.4(12)	103	116.6(14)	113.5(36)
MANN1	98	105.1(7)	101	109(6)	102	110.9(8)	108.4(21)
TOTAL		116.1(34)		114.6(29)		115.8(33)	115.5(96)

* First nest is the earliest nest initiation date recorded in that site. Julian dates are given.

Table 14. BCVI season-long nest initiation dates in study sites, 1994 to 1996.

	April			May			June			July		
	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
1994	7*	10	5	5	8	6	2	1	2	0	0	0
1995	4	10	9	5	5	5	4	4	0	0	0	0
1996	0	16	12	6	8	10	4	1	1	0	0	0
Total	11	36	26	16	21	21	10	6	3	0	0	0

* Values represent the number of nests initiated in that 10- or 11-day period in study sites.

Table 15. Nest success for nests with estimated initiation dates (season-long).

	April*			May			June			July		
	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
1994	5/7**	8/10	3/5	4/5	6/8	2/6	2/2	0/1	2/2	0	0	0
1995	4/4	6/10	6/9	2/5	1/5	2/5	1/4	0/4	0	0	0	0
1996	0/0	9/16	7/12	4/6	3/8	7/10	2/4	1/1	0/1	0	0	0
Total	9/11	23/36	16/26	10/16	10/21	11/21	5/10	1/6	2/3	0	0	0

* Nest success of April 1-30: 48/73 = 65.8%. Nest success after April 30: 39/77 = 50.6%

** Value represents the number of successful nests/number of nests with estimated initiation date in study sites 1994 to 1996.

Most nests initiated early in the season (i.e., April) were not affected by cowbirds (Table 16). In ER and MANN1, no nests initiated in April were parasitized and only two nests were parasitized during that period in WFH. By far, the majority of nests were parasitized during the three periods of May (May 1-10, 11-20, 21-31) and the first period of June (June 1-10). In ER, the estimated cowbird egg-laying date at all 21 parasitized nests occurred during these four periods. Six of the eight parasitized nests in WFH occurred during the three periods of May; four of the five in MANN1 occurred during the first two periods of May and first period of June. Overall, 28 of 34 parasitized nests occurred between May 1 and June 10.

Table 16. Parasitism seasonality.

PERIOD	ER	WFH	MANN1	TOTAL
April 1-10	0*	0	0	0
April 11-20	0	1**	0	1a
April 21-30	0	1	0	1
May 1-10	4	2	2	8
May 11-20	4	2	1	7
May 21-30	4	2	0	6
June 1-10	6	0	1	7
June 11-20	3	0	0	3
June 21-30	0	0	1	1
July 1-10	0	0	0	0
July 11-20	0	0	0	0
July 21-31	0	0	0	0
Total	21	8	5	34

* Value represents number of nests with estimated cowbird egg-laying date in EARA, WEFH, and WERA, 1994 to 1996.

** Could not be determined if laying had occurred in April 11-20 or April 21-30.

Nesting Attempts. The number of observed nesting attempts (or ones inferred by the presence of fledglings) per pair varied among the three study sites (Table 17). In 1994 to 1996 combined, pairs averaged 1.67 nesting attempts per season at MANN1, 1.33 at WEFH, and 1.23 at ER. Differences among all three sites were significant (ANOVA, $F_{2,157} = 4.9172$, $p = 0.0085$). Differences between ER and WFH were not. On average, pairs at MANN1 renested more often than pairs at the other regions. Only at MANN1 were third nesting attempts documented. The average number of attempts increased each year from 1994 to 1996, but not significantly so (ANOVA, $F_{2,157} = 3.0543$, $p = 0.1429$). There was a nearly significant association between nest date (for nests in study sites whose first nest initiation date could be estimated) and the number of nesting attempts. However, there was a low r^2 value associated with the statistic ($r^2 = 0.04$, $p = 0.0643$).

The number of nesting attempts generally was related to the fate of the first nesting. The data indicated that the likelihood of a second attempt was 25.0% when the first attempt was successful (and only 21.4% when the successful nest was not located, but fledglings were observed on the territory), 51.6% when the first nest was depredated, and 83.3% when the first nest was abandoned (Table 18).

Table 17. Number of nest attempts for BCVI in study sites, 1994 to 1996.

SITE	1994	1995	1996	TOTAL
ER	1.0(22)*	1.27(22)	1.42(21)	1.23(65)
WFH	1.29(21)	1.28(18)	1.42(24)	1.33(63)
MANN1	1.6(10)	1.7(10)	1.7(10)	1.67(30)
Total	1.23(53)	1.36(50)	1.47(55)	1.35(158)

* Value represents the average number of nesting attempts per male included in the analysis; the number in parentheses is the number of males.

Table 18. Fate of first nesting and corresponding percent of renestings at study sites, 1994 to 1996.

Fate of First Nesting	Renestings/Total First Nests (%)*
Depredated	16/31 (51.6%)
Abandoned	10/12(83.3%)
Fledged BCVI	15/60(25%)
Found Fledglings but Nest not located	3/14(21.4%)

* Includes nests that were not included in the first nest initiation analysis.

Nest Attempts and Parasitism. The number of observed nest attempts per pair per season decreased over time. In 1989, there was an average of 2.6 nesting attempts per monitored pair. This compares to an average of 1.47 in 1996. The difference between the years was significant (ANOVA, $F_{1,103} = 36.5811$, $p < 0.0001$). The reduction in nesting attempts could be a result of increased nest success due to a reduction in parasitism pressure. In 1989 the parasitism rate was 65.1% (after having averaged 90.8% the previous 2 years) and nest success was 28.5%. In contrast, in 1996 the installation-wide parasitism rate was 22.9% and nest success was 44.0%.

Age Structure. The lowest annual estimate of the age structure during 1994 to 1996 in two of the three regions occurred in 1996 (Table 8). WEFH had the lowest 3-year total for the estimated SY percentage (13.3%) and EARA had the highest (25.7%). The total SY percentage among the three areas for these 3 years was significantly different ($\chi^2 = 6.0372$, df = 2, p = 0.0489). While the totals were significantly different, only in 1994 did an annual estimate among the three regions differ significantly ($\chi^2 = 7.421$, df = 2, p = 0.0245). A significant year effect was present in 1994 at EARA when the SY percentage was approximately double that documented in 1995 or 1996 ($\chi^2 = 10.6100$, df = 2, p = 0.0050).

Return Rates. Regional return rates for male BCVI in the regions where the study sites are located fluctuated between a low of 27.5% (EARA in 1994) and a high of 64.7% (WERA in 1994; Table 19). There was high between-year variation. For example, the return rate was above 50% in one season in EARA, but below 32% in two others. In one season in WERA the return rate was 64.7%, but below 38% in two others. WEFH showed the greatest constancy, with return rates greater than 48.0% in three seasons. WEFH also had the highest 3-year total return rate. Annual rates within each region were significantly different during 1994 to 1996 at EARA ($\chi^2 = 7.2697$, df = 2, p = 0.0264) and were nearly so in WERA ($\chi^2 = 4.5026$, df = 2, p = 0.0567). The differences in return rates among these regions were significant only in 1994 ($\chi^2 = 8.3670$, df = 2, p = 0.0152). Calculated return rates could have been affected by the fact that unidentifiable banded birds were present. The specific band combination for these banded birds was not verified. Therefore, the identity of the birds was unknown. Nine such birds were present in EARA and LF in 1996 compared to four in WERA and two in WEFH. In 1995, one such bird was reported each in EARA and WEFH, seven in LF, and none in WERA. Four such unknown birds were present in EARA, one in WERA, three in LF, and two in WEFH in 1994. Return rates would be affected to the degree that some of these birds were "returnees" versus "birds banded in the current year."

Table 19. BCVI regional return rates, 1994 to 1996.

YEAR	EARA	WERA	WEFH	LF	TOTAL
1994	27.5, 27.3, (11)*	64.7, 54.5, (11)	55.0, 72.8, (11)	16.7, 75.0, (4)	36.6, 54.1, (37)
1995	53.5, 65.2, (23)	37.1, 92.3, (13)	53.8, 85.7, (14)	37.5, 75.0, (12)	45.6, 77.4, (62)
1996	31.5, 55.6, (18)	31.8, 84.6, (13)	48.0, 66.7, (12)	26.7, 60.0, (15)	32.4, 65.5, (58)
Total	37.1, 53.9, (52)	39.8, 78.4, (37)	52.1, 75.7, (37)	27.7, 67.7, (31)	37.7, 67.5, (157)

* Value represents the percent of band-identifiable males documented in the current year that were also documented in the prior year, followed by the percentage that returned $\leq$ 500 m from the prior year's location. Number of returnees is in parentheses.

Both WEFH and WERA had similar, 3-year total percentages of adults that returned within 500 m of the previous year's location and both were higher than EARA. This percentage was 78.4% in WERA, 75.7% in WEFH, and 53.9% in EARA. Differences in these overall percentages were statistically significant (χ^2 = 5.7839, df = 2, p = 0.0110). The difference in annual percentages in WERA during 1994 to 1996 approached statistical significance (χ^2 = 5.4737, df = 2, p = 0.0648).

Local areas that were monitored more regularly across years have often exhibited higher return rates than rates documented in entire regions. This includes central areas in Training Area (TA) 2 (in EARA), TA 44B (in WERA), and TA 24 (in WEFH) which often had male return rates equal to or greater than 50% (e.g., Tazik 1991; Bolsinger and Hayden 1992).

6 Discussion

Installation-wide Trends and Considerations

Nesting Dynamics

Nesting data from 1987 to 1996 indicate that nesting dynamics on Fort Hood have improved substantially for BCVI. The average, annual percentage of nests that have been successful during 1991 to 1996 at Fort Hood was 45.5% compared to less than 5% in 1987 and 1988. Observed nest success rates for small passerines are generally thought to be around 45% (e.g., Ricklefs 1969). Estimates based on exposure (i.e., Mayfield estimates) of success are reported to be around 35% (Martin 1992). Thus, nest success, whether based on observed success (42.9% on Fort Hood 1991 to 1996) or on exposure-based estimates (38.5% on Fort Hood 1991 to 1996) for BCVI during years of intensive cowbird control is consistent with observations for other passerine species.

Nesting success has improved since 1987 and so too has annual productivity. Installation-wide productivity averages were well below 1.00 young per pair in 1987 and have been between 1.3 and 2.08 since 1989. Seasonal productivity was a key component in population trends over time. Two population viability analyses of BCVI on Fort Hood, derived from study site estimates, suggested that BCVI were producing well enough to sustain the local population in some areas in recent years. Tazik and Cornelius (1993) estimated seasonal production necessary for population stability at Fort Hood to be 2.67 young per pair, based on 60% adult and 30% juvenile survivorship. MANN1 surpassed that level in 1996 and WFH approached that level in 1995 (2.42) and 1996 (2.59). In no case did a local sites' 3-year average meet the 2.67 level. WFH was closest with 2.41, followed by MANN1 with 2.26. Based on this estimate, much of the Fort Hood population was not producing well enough to maintain itself.

The second population estimate, derived from a population viability modeling workshop conducted in 1996 (USFWS 1996), incorporated predation and parasitism data and a model developed by Pease and Grzybowski (1995). The workshop attendants emphasized that the results were preliminary. The conclusion from the workshop suggested that seasonal productivity of 1.2 to 1.25 females per adult female (or 2.4 to 2.5 young per pair) would be needed to reduce the probability of extinction to less than 5%. This level of productivity was surpassed in WFH in 1995 and 1996, in MANN1 in 1996, and was nearly met in MANN1 in 1995. The 3-year total (1994 to 1996) for productivity in WFH (2.40) met that level and the level was nearly met in MANN1 (2.26). The level was not met at ER in any of the 3 years. Based on this model, between one- and two-thirds of the sites were producing well enough in any single year to keep the risk of extinction low. If each local population is viewed as a contributor of young to the installation-wide population, it would appear that WFH and to some degree MANN1 were functioning as population sources, particularly in 1995 and 1996, while ER was functioning as a population sink (sensu Lidicker 1975; Pulliam 1988; Pulliam and Danielson 1991). Birds at ER were not producing well enough to sustain themselves or to effectively lower the risk of extinction in either model. Productivity was higher in EARA prior to 1993, thus, it may be possible to identify and eliminate or minimize putative factors and increase productivity there.

Cowbird Parasitism. An important finding relevant to BCVI at Fort Hood was the vulnerability to and prevalence of parasitism by the Brown-headed Cowbird. Such findings were not new. For example, parasitism rates of greater than 90% were reported for BCVI in Texas and Oklahoma populations (Graber 1961; Grzybowski 1985, 1986, 1989). The awareness of the high incidence of parasitism at Fort Hood allowed biologists there to intervene and initiate the cowbird control program.

In all regions except EARA, cowbird parasitism rates have dropped from rates reported in the late 1980s and early 1990s. The increase in parasitism rates at EARA corresponded to the absence there of direct cowbird control in recent years. The drop in parasitism pressure is evident in LF where parasitism rates were above 50% in 1991 and 1992, but have been below 30% since, and in WEFH where rates were 25.0%, 42.9%, and 60% in 1991 through 1993, respectively, but have been below 16% since. Tazik and Cornelius (1993) estimated that parasitism rates would have to be reduced to less than 38% to foster conditions that allow for population stabilization, all things being equal. That reduction has been achieved by the ongoing cowbird mitigation effort (although population stability has not yet been determined). A revised shooting strategy, complementing the trapping program in WEFH and WERA, began in 1994 and has helped to reduce parasitism rates. Shooting has also proven to be an effective method for reducing parasitism for other species, the Hooded Warbler (*Wilsonia critrina*) for example. However, intense nest predation "swamped" the beneficial effects of cowbird control (Stutchbury 1997). Other successful control programs have dramatically reduced the incidence of parasitism for the

Kirtland's Warbler (Walkinshaw 1983), Least Bell's Vireo (*Vireo bellii pusillus*, Franzreb 1989), and BCVI at other locations (e.g., Grzybowski 1989).

It is interesting that parasitism rates in LF dropped, although they were generally higher than rates in the other regions. One reasonable conclusion could be that parasitism pressure has dropped at Fort Hood because there are fewer cowbirds. However, the increased number of cowbirds caught in the trapping effort does not suggest this (see Hayden et. al., in press). It is more likely that benefits of installation-wide trapping have indirectly affected areas in LF, reducing parasitism pressure there (Hayden et. al., in press).

Rothstein (1994) presented a sobering possibility. In his review of cowbird range expansion in the west, he suggested that brood parasitism is only part of the problem affecting host species. Habitat destruction is at least as problematic and can magnify the effects of cowbirds. Both the Least Bell's Vireo and Willow Flycatcher (*Empidonax traillii*) experienced the historic presence of cowbirds and parasitism pressure, but without notable host species population decline. Only when large areas of the host species habitat were destroyed did the species show decline. The implication is that when sufficient habitat is lacking, mechanisms like human intervention (cowbird trapping and shooting) might be necessary to reduce the incidence of cowbird parasitism. If this possibility applies to other habitat types (e.g., shrublands), it might be that long-term cowbird management for BCVI should include a substantial increase in suitable habitat.

Abundance

The number of BCVI reported on the installation has increased steadily. To what extent abundance data represent real installation-wide population change or are the result of increased coverage and access is unclear. The number of field technicians has increased since the project began. There were two field people each season through 1993, three in 1994, and four in 1995 and 1996. Additionally there was a notable increase in access to LF, beginning in 1994. It is clear that certain changes in population numbers are largely the result of increased coverage and greater access to the LF. For example, in 1994, the first year there was full-time access to LF, the number of documented territories there increased by 56. This accounted for the majority of the observed increase in the total number of male BCVI reported on the installation in 1993 (220) compared to 1994 (279), and represented the greatest increase in absolute numbers reported in LF. There are also cases that clearly are the result of true population change in a local area. For example, in habitat at TA 6 (in the southern section of EARA), 14 male BCVI were documented in 1987 (Tazik 1991a). This dwindled to only one by 1991 (Hayden and Tazik 1991). Habitat succession was suspected to be the reason BCVI no longer occupied that area. Some habitat patches in TA 6 were estimated at 28 to 29 years old in 1988, at least 6 years older than habitat age estimates at other BCVI sites (Tazik 1991a) and near the age when habitat is generally thought to have succeeded beyond stages used by BCVI.

In other cases it is less clear how much of the reported change in abundance can be attributed to true population change, greater access, or increased monitoring coverage. There appears to have been real increases in TA 44B (in WERA) where 39 males were documented in 1994. The same field technicians that were present in 1994, documented 57 in 1995 (Weinberg et. al. 1995, 1996). There are also thought to be real increases occurring in some sections of the LF where a large area (about 400 ha) that burned in 1991 is becoming heavily occupied.

Some data suggest that a period of the greatest rate of increase occurred in the early 1990s and there has been less overall change in the abundance of black-capped vireos on Fort Hood the past 3 years. The greatest increase in regional abundance on a percentage basis occurred in 1992 or earlier in all regions, although large increases in the absolute number of males were documented in 1994 and 1996 in LF and in 1995 in WERA. Increases in nest success since 1989 and the higher percentage of SYs in the 1992 population suggest that at least some of the increase in the number of documented males represented a true population increase. The lower percentage of SYs in the population in 1994 to 1996 and the fact there has been smaller annual percentage change in abundance in 1994 to 1996, suggests less installation-wide change in abundance during that period.

Abundance at WEFH has been constant since 1993. The number of male BCVI documented there has varied annually by two from 1993 to 1996. In contrast, EARA fluctuated by as many as 11 males, and WERA by as many as 18 annually during the same period. This suggests that monitored habitat at WEFH is consistently occupied and may be at or near capacity.

Abundance, when used as the only criteria to assess habitat quality, can lead to erroneous conclusions (Van Horne 1982, 1983). Simply put, more birds does not necessarily mean better habitat. The number of BCVI documented has increased in most regions on Fort Hood in recent years, but nesting dynamics have differed considerably. For example, it has been demonstrated that areas of low production (population sinks) can have high density. Van Horne (1982) reported such findings in her study of Deer Mice (*Peromyscus maniculatus*). High density in a sink area in one year was attributed to an "irruption" of juvenile immigrants. In their long-term (30-year) study of Hazel Grouse (*Bonasa* *bonasia*) and source/sink habitats, Beshkarev et. al. (1994) reported that densities were greater in sink habitats in 20% of the survey years. Thus, abundance (or density) alone, should not be used as the only index to assess an area. It is important to continue collecting BCVI nesting data in combination with installation-wide population assays.

Age Structure

The installation-wide trend appears to indicate constancy in the age structure in recent years. The annual SY percentage has been approximately 28% in 4 of the 6 years from 1991 to 1996. This constancy could be indicative of a population that has experienced rapid growth (as seen in the early 1990s when the annual nest success and the SY percentages peaked) and is now showing signs of slower growth (i.e., decline or stabilization). The fact that average nest success has been above 40% for 5 of the past 6 years indicates that a moderately high degree of successful nesting has occurred during this time. Installation-wide, the SY percentage has been between 17.5% and 49.7% since 1991, and was 29% for the past 6 years combined. A 10-year study of the American Redstart (*Setophaga ruticilla*) indicated that the percent of male SYs in the population ranged from 17% to 52%, but was generally around 20% annually (Sherry and Holmes 1992). This is similar to percentages documented for BCVI at Fort Hood. Sherry and Holmes estimated SY percentages of 30% to 50% were needed for a healthy population (based on 50% to 70% adult survival estimates), and therefore, concluded that the lower percentage of SYs seen in the population was indicative of population decline. If this is applicable to BCVI on Fort Hood, the recent trend in age structure represents the lower end of the healthy estimate. The total of 29% the past 6 years at Fort Hood is still much higher than the percent of males that were SY in 1987 to 1989 (below 12% in each year). Grzybowski (in USFWS 1991) estimated the percentage of SYs in a stable BCVI population would have to be at least 29%, based on adult male survivorship of 71%. Tazik (1991a) suggested a suitable working estimate for adult BCVI survival on Fort Hood to be 60%. If these estimates are representative of Fort Hood in recent years, then the percentage of SYs entering the Fort Hood population may be at, or slightly below the level needed for a stable population. This is concordant with the population stability estimates derived from the productivity data and viability models.

The association of the proportion of SYs present on the installation in a year and nest success the prior year was near, but not at the statistically significant level. Current percentage of SYs in the population being associated with prior year's nest success (or presence of HYs) has been reported for other species, for example, the American Redstart and Swainson's Thrush (*Cathrus ustulatus*) (Sherry and Holmes 1992; Johnson and Geupel 1996).

NLF and LF Comparison

The LF area receives different levels of military use and cowbird control than NLF. For the most part, there is far less military traffic in the LF area. It is used primarily for ordinance and artillery firing practice. A notable difference between NLF and LF is the absence of direct cowbird control in LF. It is not surprising that in 5 of the 6 years from 1991 to 1996, there was a smaller percentage of nests parasitized in NLF, as well as a greater percentage of successful pairs. The 6-year total parasitism rate in LF was double the rate documented in NLF (33.3% in LF versus 16.6% in NLF). The effects of this on nest success were not as clear as expected: nest success was not always higher in NLF compared to LF. The observed nest success was higher in NLF in three years and higher in LF in three others, although the overall mean success was slightly higher in NLF (45.5%) than LF (39.8%). One aspect of nesting, that of productivity, was significantly lower in LF than that documented in NLF.

The explanation that nest success might help explain the differences in age structure among the individual regions might also help account for age structures documented in NLF versus LF. There was a higher percentage of SYs in the LF population in 4 of the 6 years, but the totals were not very different (27.0% in NLF versus 32.3% in LF) and overall nest success was higher in NLF, but not dramatically so (45.5% in NLF versus 39.8% in LF). Total nest success was a little higher in NLF and the total percentage of SY a little lower than in LF.

It is interesting that a pattern in age structure was observed in NLF (of a declining percentage of SYs), while no clear pattern was detected in the LF population. Often the age structure can be used as an index to the suitability of a given area based on the availability of territories, competition for territories, and abundance of birds. It is commonly reported in the literature that SYs are relegated to what is thought to be lower quality habitat (e.g., Ficken and Ficken 1967; Curio 1983; Pärt and Gustafsson 1989; Sether 1990; Sherry and Holmes 1989, 1992; Moller 1991; Holmes, Marra, and Sherry 1996). The lack of a clear pattern in LF might be due, to some degree, to the continual habitat disturbance/regeneration there that is the result of a much greater frequency of artillery related fires in LF compared to NLF. If these areas of new growth were lesser-quality habitat, it would be expected that they were occupied by a higher proportion of SYs than ASYs. It may be that SYs, to some degree, show up wherever the disturbances have occurred (after some time for vegetation regrowth) in LF, relative to population and environmental pressure. In contrast, habitat in NLF may be more uniform successionally, resulting in a less sporadic BCVI age structure.

It appears that in some years NLF was a somewhat more productive area than LF and may be overall, but evidence is inconclusive. There were years, however, in which nesting dynamics in LF were high.

Local Trends

Comparison of Local Populations on Fort Hood 1994 to 1996

Nesting and Population Dynamics. Local nesting and population data can complement installation-wide data and improve habitat assessment on Fort Hood. Assessments of habitat can include two considerations. One is the likelihood of an area offering the collective suite of conditions that promote settlement and nesting. The second is the likelihood of success once nesting has begun. The latter can be affected by several factors, some may not be directly related to the bird or habitat, such as cowbird control. The former can be based on habitat-related features like size of the area, floristic characteristics, and possibly the presence or absence of other BCVI. First nest initiation dates documented in this report might reflect settlement dates for BCVI on Fort Hood, and thereby indicate which areas promote settlement. Field personnel did note that the first BCVI of the spring were seen in MANN1 and WFH, and lastly in ER in 1996 (Howard Weinberg, Ecologist, field observations), this is concordant with the average first nest initiation dates documented in those sites. Some other studies corroborate that early settlers have nested earlier than their later arriving counterparts. For example, Aebischer et. al. (1996) found that females on territories of early arriving male Savi's Warblers (Locustella lusciniodes) laid eggs earlier (and had greater overall success) than later arrivals. The authors found that the early arriving males secured territories with more favorable habitat characteristics (as measured by reed density and vegetation litter).

Nest initiation data support the possibility that MANN1 and WFH were more preferable than ER and, on average, were settled earlier from 1994 to 1996. Later settlement (or at least nest initiation) in ER could be the result of many factors. Fitness of individual birds and habitat quality certainly might be of influence. These are difficult to measure directly and typically are inferred from other measures, like breeding success and age structure. Based on those two criteria, because birds in WFH and MANN1 exhibited greater nesting success and at times consisted of older populations than birds in ER, it could be inferred that the former two locations had higher habitat quality and/or more fit birds.

Site fidelity (which can be related to fitness and habitat quality) also can affect nest initiation. Male, Roberts, and Weinberg. (in prep.) found that immigrant BCVI had later first nest initiation dates than established returnees. Thus, a lower percentage of established returnees (or conversely, a greater percentage of new birds) could offer some explanation for later first nest initiation dates. There is some indication that birds in the EARA region exhibited low return rates and had fewer birds return within 500 m of the previous year's location. This occurred at EARA even in years that followed relatively high nest success when high site fidelity would be expected, because high nest success has been reported to result in high site fidelity (e.g., Greenwood and Harvey 1982; Payne and Payne, 1993; Roth and Johnson 1993). These results support the possibility that factors and cues in ER that result in early nest initiation were less favorable than ones in WFH and MANN1 from 1994 to 1996. But the relationship between site fidelity and nest initiation is less than clear for two reasons: there were several band-unidentifiable birds in EARA, and WERA had documented low return rates, but still had early nest initiation dates. While the underlying factors are not clear, BCVI on Fort Hood might have selected territories using cues that revealed potential for nesting success (e.g., selecting areas that reduce the risk of predation, sensu Martin 1993), and occupied the less suitable areas last (e.g., Fretwell 1972).

Once settlement has occurred and nesting begun, the next consideration is the likelihood of success. Over the 3-year period, ER clearly displayed less productive, less consistent dynamics than WFH or MANN1. Observed nest success was greater than 50% in all 3 years at WFH, equal to or greater than 40% in MANN1 in 2 years, and less than 35% in ER in 2 years. Pair success varied by only 2.8 percentage points in WFH, ranging from 75% to 77.8% over the 3 years. It was greater than 70% in all 3 years (and 90% in 1 year) in MANN1, while less than 45% in ER in 2 years. Productivity was never above 1.75 in ER, below 2.1 in WFH, or below 1.70 in MANN1 in each of the 3 years. Differences between the nesting dynamics in WFH and MANN1 from 1994 to 1996 were less distinct than those between ER and other sites.

One interpretation of the nesting data is as follows. Nest predation was conspicuous in MANN1 and to a lesser extent in ER. The presence of direct cowbird control benefited BCVI in MANN1 and WFH, but the absence of control negatively affected BCVI in ER. Thus, both WFH and MANN1 from 1994 to 1996 offered better potential for nest success than ER, but for different reasons. WFH had relatively early start dates and little nest predation or parasitism pressure. MANN1 also had early start dates and little parasitism pressure, but relatively high nest predation pressure. It is possible that both sites were settled early (or at least first nests were initiated earlier), but events or processes in MANN1 (e.g., higher nest predation) caused more nests there to fail compared to WFH. Despite these failed nests, pairs were able to fledge young because they attempted more nestings. This may have been related to the early first nest initiation dates documented there (which could have allowed more time for renestings). Thus, pairs in MANN1 averaged more nesting attempts than pairs in WFH (who experienced a higher success rate). It is likely that in each area there is a mix of suitable and less suitable patches. Although ER may have some suitable patches, it may have fewer, or less suitable ones than MANN1 or WFH.

The explanation for the relatively lower number of nesting attempts observed in ER is not clear. If high nest success resulted in fewer nest attempts in WFH, then the reverse should have been true for ER, as was the case for some pairs in MANN1 whose first nesting attempt failed. ER had the greatest percentage of nests that were abandoned compared to MANN1. As mentioned earlier, pairs with abandoned first nests renested 83.3% of the time. ER, however, did not have a high average number of nest attempts per pair. The average later first nest start date in ER may have been a relevant factor, perhaps resulting in a shorter season, allowing birds there less time to renest on a season-long basis. The nearly significant association of early nest starts with the number of nest attempts per pair lends some credence to this possibility. Another possibility stems from the commonly reported trend that increased nest failure can increase the likelihood of emigration (e.g., Greenwood and Harvey 1982; Payne and Payne 1993; Roth and Johnson 1993). An interesting possibility is that, because of poor nesting success in ER, birds emigrated from there at a greater frequency than birds in areas of higher nesting success. This could have been occurring within the framework of the shorter season described above. However, the number of attempts per pair has increased in ER from 1.0 in 1994 to 1.27 in 1995 and 1.43 in 1996, although a non-significant increase was present on an installation-wide basis in 1996. The annual increase in nesting attempts, coupled with strong site fidelity reported for BCVI, casts some doubt on this possibility.

Lastly, age structures documented on Fort Hood support the possibility of different levels of suitable habitat among the three sites. As mentioned earlier in this report, it is commonly thought that SY males can be relegated to "lesser" quality habitats under certain scenarios. One example of this is the Black-throated Blue Warbler (*Dendroica caerulescens*), which also nests in shrubs, although in forest settings, demonstrated age-related habitat use. ASYs were disproportionately more abundant in denser shrub patches (Holmes, Marra, and Sherry 1996). With regard to BCVI, Grzybowski, Tazik, and Schnell (1994) found that floristic characteristics of SY territories, on average, differed from those of ASY territories. SY territories resembled unoccupied, "non-vireo" areas more than ASY territories. At Fort Hood, WEFH had the lowest regional SY percentage (13.3%) compared to 20.0% in WERA and 25.7% in EARA from 1994 to 1996. Although the differences in age structure were not exceptional, the data were consistent with the possibility that general habitat quality was higher in WEFH than in EARA from 1994 to 1996. The 3-year mean SY percentage in WERA was lower than in EARA, however, interpretation of that was less clear because in one year the age structures were not very different at those two areas and in another the percentage was higher in WERA.

Potential Factors Affecting Local Populations. Nest predation, cowbird parasitism and control, fire effects, origin of habitat, habitat age, military use, and drought are factors that have the potential to affect BCVI nesting and population dynamics. Their relevance to Fort Hood is discussed in the following paragraphs.

Nest Predation. Approximately 23% of the nests in the study sites from 1994 to 1996 were categorized as depredated. As the incidence of cowbird parasitism was reduced through control measures, nest predation became increasingly influential. The three sites exhibited different levels of nest predation pressure. MANN1 experienced relatively high predation and WFH less severe pressure (see also the "Fire Effects" section below in which locally high depredation pressure in some sections of ER is discussed). It is not uncommon that different nest predation pressure be reported in different localities within a landscape (e.g., Karr 1982; Loiselle and Hoppes 1983; Zimmerman 1984; Ratti and Reese 1988; Patnode and White 1992). Such appears to be the case on Fort Hood. Tazik (1991a) suggested different predator groups may exist on Fort Hood based on nest destruction patterns. Depredation rates reported in this paper support that likelihood. For example, of the NLF sites, scrub jays (*Aphleocoma coerulescens)* were regularly observed at WEFH, but far less frequently than at other sites. Imported fire ants (*Solenopsis invicta*) were prevalent throughout the installation, but appeared to be most abundant (or at least more conspicuous) in EARA (Howard J. Weinberg, Ecologist, field observations). Potential predators at Fort Hood include snakes (e.g., rat snake [*Elaphe obsoleta lindheimeri],* coachwhip [*Masticophis flagellum testaceus*], rough green snake [*Opheodrys aestivus*], and broad-banded copperhead [*Agkistrodon contortrix*]), mammals (e.g., raccoon [*Procyon lotor*]), fire ants, and birds (e.g., scrub jays, wrens). Predator identification research would be a significant step in gaining a better understanding of this dynamic.

Cowbird Parasitism. Brood parasitism has greatly affected BCVI on Fort Hood. In 1987 and 1988, when there was little cowbird control, the incidence of parasitism was very high (about 90%) and nest success was low (less than 5%). Parasitism rates dropped and nest success rates increased as the cowbird control program grew. Results are evident in areas that receive different levels of cowbird control and examples have been discussed earlier in this report.

Analysis of nest initiation and cowbird egg-laying dates revealed within-season trends in parasitism. There was a window of minimal cowbird parasitism pressure on BCVI during April, and later in the season as well. Such a dynamic is discussed by Robinson et. al. (1995) and may be an attempt by cowbirds to match their egglaying to the peak of host availability. That matching may provide windows of minimal pressure for some host species. Cowbirds certainly can target more than one host. From 1994 to 1996 the vast majority of BCVI nests in the study sites on Fort Hood were initiated between April 11 and May 31 (80%). The majority of nests that were parasitized occurred from May 1 to June 10 (82.4%). Thus, cowbird parasitism pressure was most intense during the period of high BCVI nest initiation. But, only two (5.9% of those parasitized) nests out of 73 (48.7%) nests initiated were parasitized in April compared to 32 out of 77 (51.3%) nests initiated (94.1% of those parasitized) during the rest of the season. There may have been a benefit to early nesting with respect to parasitism. Nests initiated in April (i.e., those with estimated initiation dates) had a higher observed success rate (65.8%) compared to later initiated nests (50.6%).

Intense brood parasitism, as documented in 1989, apparently affected the nesting season in that nesting pairs attempted more nestings compared to periods of reduced parasitism pressure in 1996. This could have been the case because of the dramatically high rates of nest failure (and high parasitism rates) in 1989. Reduced parasitism pressure in 1996 resulted in greater success and a lower number of average nest attempts.

Fire Effects. A large fire (6,232 ha) affected Fort Hood during the winter of 1996. This fire destroyed approximately 4,290 ha of habitat used by another endangered passerine on Fort Hood, the Golden-cheeked Warbler (*Dendroica chrysoparia*), and 223 ha of BCVI habitat. It is hoped that much of these areas will grow into BCVI habitat. In this portion of BCVI range, fire is the historic means by which BCVI habitat is created (Graber 1961; Marshall, Clapp, and Grzybowski 1985). This section addresses the productivity potential of burned areas for BCVI in the years immediately following a fire. Of the BCVI study sites, approximately 1/3 of the vireo habitat in ER was affected by the fire. The area was left in varying degrees of burn, often with areas of severe burn intermixed with less burned or unaffected patches. Additionally, large fire breaks were created to help fight the fire. O'Neal et. al. (1996) found that prescribed burns, even ones of high intensity, did not negatively impact BCVI productivity at the Kerr Wildlife Management Area in central Texas. In the first post-burn season, documented productivity in burned and non-burned areas in the O'Neal et. al. study was not statistically different and productivity averaged 2.9 young per active nest. At Fort Hood in 1996, nine male BCVI were documented in this mixed burn/non-burn area, although two were not observed later in the season and may have left the area. None of the males were known to have a successful nesting attempt (11 total attempts) nor were any fledglings found on any of the territories there. In contrast, 9 of 12 monitored pairs in the eastern, non-burned portion of the study site fledged young. It is possible that affects of the 1996 fire and 1996 drought combined to heighten negative impacts on nesting (e.g., Rotenberry et. al. 1995 discusses drought-related lower reproductive success in birds).

Fire effects on reproductive success could not be assessed because BCVI in this same area of ER had very low nesting success (and productivity) in 1995. There may have been existing conditions in this area that were already negatively impacting nest success prior to 1996. In 1995, young were found on only one of ten monitored territories in the area that became the burn area. One possible explanation was that the burn area of ER (or what was to become the burn area) was subject to heavier parasitism or nest predation pressure than the remainder of ER. Parasitism, however, did not differ much between those two areas (for example, parasitism in 1996 was 33.3% in the burn area of ER, compared to 35.7% for the rest of ER). The number of nests categorized as depredated in 1996 was 45.5% in the burn area of ER and 5.3% in the remainder of ER. The combined effect of parasitism and nest predation likely accounted for the low nesting success in the burn area in 1996. In 1995, the percentage of nests categorized as depredated was still greater in what was to become the burn area (17.6% versus 8.3% in the remainder of ER), however it was less severe than in 1996. Brood parasitism did not differ greatly between the two sections of ER in 1995 (18.8% in what was to become the burn area versus 18.2% in the remainder of ER), and may not have accounted for much of the difference in nest success. But 35.3% of the nests in the future burn area were abandoned versus 16.7% in the remainder of ER. The cause of the difference in abandonment rates is not known.

Habitat Origins. Another potentially relevant consideration with respect to nesting and population dynamics is the means by which habitat patches at each locale were created. A large portion of BCVI habitat in ER was created by mechanical clearing. In some areas, much of the topsoil was removed and ground cover there was slow to grow back. In contrast, much of the BCVI habitat in WFH and MANN1 originated from fire. It may be that the way habitat was created or manipulated is relevant to nesting BCVI.

Habitat Age. Habitat age also can be important with regard to nesting and population dynamics. Regional habitat age estimates were conducted in 1988 (Tazik 1991a). Habitat tends to be comprised of a mosaic of vegetation patches of different ages and sizes, so these estimates represent only broad appraisals. Vegetation in WEFH was estimated to be between 0 to 19 years old in 1988, making it 6 to 24 years old in 1994. This compares to estimates in EARA of 4 to 11 years of age in 1988, making it 10 to 17 in 1994, and estimates in WERA of 5 to 11 in 1998, making it 11 to 17 years old in 1994. All appear to be generally similar in age, with some habitat in WEFH being a few years older. All are considered to be within the age range of occupiable habitat. Marshall, Clapp, and Grzybowski (1985) reported the best BCVI habitat was 10 to 15 year post-fire (from burns hot enough to kill junipers), while Tazik, Grzybowski, and Cornelius (1993) reported that BCVI habitat on Fort Hood was between 5 and 30 years post disturbance. General estimates of habitat age do not appear to differ and may not account for differences observed in nest initiation or other nesting dynamics. The range of age estimates varied notably in each region. The effect of this, if any, might depend on the actual age of each habitat patch, the number of patches within each age class, and distribution of the patches.

Military Activity. The frequency of military use differed among regions. Military activity conducted in 1989 relevant to BCVI were evaluated in Tazik (1991b) and Tazik et. al. (1992). WEFH received only limited use (1 to 10 dry track vehicle equivalents per day per square mile (dtve/day/sq mi) while WERA (21 to 30 dtve/day/sq mi) and EARA (11 to 30 dtve/day/sq mi) experienced heavier and different types of use (often company and platoon training in EARA and task force battalion operations in WERA). Of nine cases of documented Army activities that affected BCVI in 1989, only one occurred in WEFH (Tazik and Cornelius 1993). Areas in WERA can receive heavy bivouac and vehicular traffic use, and roads in EARA can receive heavy vehicular use (Tazik 1991b). Not much of the activity in WERA, however, occurred where MANN1 is located. Tazik (1991a) concluded that based on 1989 data, only 1% of all nests can be expected to be negatively impacted by military activity, and the benefit that certain activities can result in the creation of habitat outweighs these impacts. There was then, and is now, the potential for substantial negative impact. Not only are vegetation trampling, bivouacking, obscurant smokes, and road maintenance activities factors that could directly affect BCVI (Tazik 1991b), but less direct factors associated with habitat fragmentation might also be involved. It is important to keep in mind that these estimates of military use and their effects and relevance, were based on data from the late 1980s. Trends in activity appear to be consistent to the present day, but new data should be collected and tested.

Drought. Drought conditions of 1996 certainly may have been biologically important and may have had an effect on BCVI. As mentioned earlier, Texas was categorized by the Palmer Drought Severity Index to be in drought conditions for much of 1996. Drought can adversely affect abundance (e.g., Blake, Niemi, and Hanowski 1992; Rotenberry et. al. 1995). This did not appear to occur on Fort Hood, as the number of males documented on the installation continued to increase. Drought could have negatively impacted the available food supply. Insectivores are particularly sensitive to drought-related food shortages (see Rotenberry et. al. 1995). Food supplement studies have shown that ample food availability can result in an earlier egg laying date, while food deprivation can delay laying (see Meijer and Langer 1995). In addition to nest initiation effects, drought-related effects can reduce reproductive success (e.g., Rotenberry et. al. 1995).

There was no significant decrease, however, in nest success, pair success, productivity, or number of nest attempts in 1996. In fact, some of those parameters showed increases in 1996. Additionally, there was no statistically significant delay in nest initiation in 1996 compared to 1994 or 1995. There may have been an effect involving initiation, even though not statistically significant. Eleven nests were initiated during the first period of April in 1994 and 1995. No known nests, however, were initiated during the same period in 1996. There is the possibility that nesting was delayed slightly in 1996. Interpretation of this is somewhat complicated by the fact that the field team started 1 week later in 1996. There was, however, one experienced field worker present beginning in late March, so field work was being conducted during late March and early April.

7 Conclusion

There is always caution and concern when hands-on intervention is the management tool used, particularly when animals of conservation concern are involved. There are examples of well-intentioned recovery programs that did not meet their objective, at least initially (see Clarke, Reading, and Clarke 1994). Yet intervention is often necessary to improve the conditions for endangered species. In many cases the intervention has been beneficial. Cade and Temple (1994) reviewed 30 accounts that addressed the management of threatened birds. In 66% of the cases, the population in question benefited from the intervening management practices. At Fort Hood, proactive management practices clearly have benefited BCVI. Nesting parameters have dramatically improved since monitoring began in 1987, mostly the result of the aggressive cowbird control program which has been documented by the monitoring effort.

The extent of improvement in the nesting and population parameters is not yet known. Based on population models or estimates (Tazik and Cornelius 1993; USFWS 1996), some areas of the installation appear to have nest success, cowbird parasitism, and productivity levels that are necessary for population stability. Other areas are not meeting those parameters, nor do the total values for Fort Hood. The overall age structure suggests the installation-wide population is at, or slightly below the level expected for a stable population.

The data indicate the complexity of local and regional dynamics, as local BCVI populations often contributed differently to the Fort Hood total, relative to a given parameter. Local and installation-wide monitoring should continue on Fort Hood and data utilized to address trends, concerns, and recommendations discussed in this report.

8 Recommendations

1. Continue monitoring the Ford Hood population. This includes banding and nesting monitoring on the local (study sites) and regional scale.
2. Continue installation-wide census (include banding to get representative sample of the age structure).
3. Continue surveys of the installation for potential habitat. This includes revisiting recently burned areas and revisiting historically unoccupied areas to determine occupation.
4. Initiate research to examine potential habitat associations with BCVI occupancy and nesting success. This includes vegetation surveys to evaluate differences among study sites and regions.
5. Monitor study sites early in the season as BCVI arrive to:
   - Determine if early arrivals have earlier first nests
   - Determine if early arriving males do occupy superior-quality territories.
   - Based on b, evaluate habitat quality in each region.
6. Initiate nest predation research to:
   - Identify local predators.
   - Determine if predator management is warranted and feasible.
7. Monitor effects of military activities, if any, on BCVI.
8. Continue monitoring ongoing BCVI vegetation manipulation and habitat restoration activities.
9. Continue cowbird research to seek long-term solutions to the brood parasitism issue.
10. Continue cowbird mitigation efforts.
11. Continue to refine population viability models to determine critical parameters for the BCVI population on Fort Hood. Work on the initial models has identified data needs. Address these needs, and incorporate appropriate protocol when possible into the BCVI monitoring program. Key data needed include survivorship and between-site movements.

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