USACERL Special Report EN-93/01
December 1992

US Army Corps
of Engineers
Construction Engineering
Research Laboratory

Biological Assessment of the Effects of Military Associated Activities on Endangered Species at Fort Hood, Texas

by
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Specific mitigation actions that will minimize or offset incidental wildlife losses include changes in existing cattle grazing regime, active cowbird control, regulation of troop activities and recreational vehicle use near endangered species areas, habitat development outside of heavily used training areas, and continuing research. Annual inventory and monitoring of Fort Hood endangered species populations will be needed to document status and trends in population size, habitat, area occupied, and demographic parameters. Although some incidental loss may occur, a balance can be found that provides for protection and recovery of endangered species with minimum impact on the training mission.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1992	Final

4. TITLE AND SUBTITLE
Biological Assessment of the Effects of Military Associated Activities on Endangered Species at Fort Hood, Texas

5. FUNDING NUMBERS
Project IAOs
348-87
66-88
268-88
FAD 89-080046
MIPR JE26-91

6. AUTHOR(S)
David J. Tazik, John D. Cornelius, Dennis M. Herbert, Timothy J. Hayden, and Billy R. Jones

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Construction Engineering Research Laboratories (USACERL)
PO Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
SR EN-93/01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
HQ III Corps and Fort Hood
ATTN: AFZF-DE-EMO
Fort Hood, TX 76544-5057

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Fort Hood, TX contributes importantly to the Army's mission by providing resources and training facilities for the Active and Reserve Component units that train on the installation each year. Current military activities at Fort Hood include maneuver, live fire, aviation training, and operational testing. Other land uses include controlled burning, juniper cutting, cattle grazing, recreation, and scientific studies. These activities may affect five federally endangered species known to occur on Fort Hood. Of these, the black-capped vireo and the golden-cheeked warbler reside on the installation during the summer breeding season and are of primary concern in this biological assessment.

Specific mitigation actions that will minimize or offset incidental wildlife losses include changes in existing cattle grazing regime, active cowbird control, regulation of troop activities and recreational vehicle use near endangered species areas, habitat development outside of heavily used training areas, and continuing research. Annual inventory and monitoring of Fort Hood endangered species populations will be needed to document status and trends in population size, habitat, area occupied, and demographic parameters. Although some incidental loss may occur, a balance can be found that provides for protection and recovery of endangered species with minimum impact on the training mission.

14. SUBJECT TERMS
Fort Hood, TX
black-capped vireo
cowbird parasitism
endangered species
golden-cheeked warbler

15. NUMBER OF PAGES
142

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

EXECUTIVE SUMMARY

Fort Hood is an 87,890 ha area located in the Lampasas Cutplains physiographic region of central Texas between Waco and Austin. The history of the Fort dates to 1942 when the Army established a camp to prepare soldiers for tank destroyer combat during World War II. Between 1971 and 1990, it was the only installation assigned two divisions, the 2d Armored and the 1st Cavalry. Although the Fort presently supports only one division, a second division, the 5th Mechanized Infantry, is proposed for restationing from Fort Polk, LA to Fort Hood.

The Army's mission is to maintain a trained and ready force in peacetime to deter war, to fight and control wars that start, and to terminate wars on terms favorable to U.S. and allied interests. Fort Hood contributes importantly to this mission by providing resources and training facilities for the Active and Reserve Component units that train on the installation each year. Presently, 34,171 military personnel are authorized for assignment to Fort Hood. Current military activities include maneuver, live fire, and aviation training, and operational testing. Other land uses and activities include controlled burning, juniper cutting, cattle grazing, recreation, and scientific studies.

Five federally endangered species are known to occur on Fort Hood. Two of these, the peregrine falcon and the whooping crane, occur rarely and then only as migrants or transients. The bald eagle occurs at Belton Lake during winter on areas adjacent to the Fort, but does not nest in the area. The two remaining species, the black-capped vireo and the golden-cheeked warbler, reside on the installation during the summer breeding season and are of primary concern in this biological assessment. A plant species, *Croton alabamensis*, was recently discovered on Fort Hood that is being proposed as a category 2 candidate for federal listing. Several rare and endangered cave invertebrates have a reasonable likelihood of occurrence on the Fort as well.

The *Croton alabamensis* on Fort Hood is a new variety that is also known from Travis County. It is currently under taxonomic review. This species is not likely to be affected by military or other activities on Fort Hood.

Approximately 300 adult black-capped vireos are known to occupy early successional hardwood scrub habitat on Fort Hood each year from late March into August. Although individual vireos and their habitat may occasionally be adversely affected incidentally by military activity on Fort Hood, this same military activity has had a net positive impact on the population as a whole. Most of the Fort is protected from urban development and rangeland improvement, which threaten vireo habitat elsewhere, and much of the existing vireo habitat on the installation is the result of military-related fires. Also, the vireo population on Fort Hood has remained stable since 1987.

The greatest threat to the vireo on Fort Hood is cowbird parasitism. Cowbirds lay their eggs in nests of a variety of songbirds. In the case of the black-cap, this results in a substantial reduction in reproductive success. Cowbird abundance is related to the number of cattle that graze on the installation. As such, modification of the existing cattle grazing regime on Fort Hood in conjunction with trapping and shooting of cowbirds will enhance vireo reproductive success. Success in this endeavor will contribute to recovery of this species, thereby mitigating incidental losses due to military activity.

The golden-cheeked warbler is present on Fort Hood from early March into July. It resides in mature juniper-oak woodland habitat that happens to be abundant on the installation. A status survey initiated during 1991 documented presence of 515 adult male golden-cheeks throughout suitable habitat on the Fort. This is a conservative estimate, and more birds are likely to be found. As in the case of the vireo, Fort Hood has inadvertently protected a substantial acreage of warbler habitat from urban

development and rangeland improvement. Unlike the case of vireo habitat, however, fire is detrimental to warbler habitat. As such, inadvertent fires, whether or not related to military activity, and fires from natural causes may adversely affect the warbler and its habitat.

The impact of cowbird parasitism on the golden-cheek has not yet been documented. Future studies will attempt to address this issue.

Impact of maneuver training on both the vireo and the warbler can be minimized by regulating troop activities in the vicinity of their respective habitats. Other activities on Fort Hood as currently conducted—controlled burning, juniper cutting, recreation, and scientific studies—are not expected to adversely affect either the vireo or the warbler population provided these activities are properly coordinated through the Environmental Management Office.

Neither the peregrine falcon nor the whooping crane are adversely affected by Fort Hood activities. Wintering bald eagles are protected by restricting aircraft overflights in the vicinity of eagle roosting sites.

Cave invertebrate surveys have been initiated in order to document the presence/absence of any rare and endangered taxa on Fort Hood. Known cave sites can and should be protected in a manner that conflicts little with on-going military activity.

Fort Hood has managed to support two mechanized divisions for 20 years while also managing to support significant populations of two federally endangered bird species. With proper leadership and discipline, there is no reason to assume that the Army cannot continue to support these and other species that may be identified in the future. Although some incidental loss may occur, a balance can be found that provides for protection and recovery of endangered species with minimum impact on the training mission.

Specific mitigation actions that can be taken to minimize or offset incidental losses include modification of the existing cattle grazing regime, active cowbird control, regulation of troop activities and recreational ORV use in the vicinity of endangered species areas, habitat development outside of heavily used training areas, and continuing research. Annual inventory and monitoring of Fort Hood endangered species populations will be needed to document status and trends in population size, habitat, area occupied, and demographic parameters.

FOREWORD

This Biological Assessment (BA) was prepared based on field studies conducted on Fort Hood from 1987 through 1991. These studies were carried out for Headquarters (HQ) III Corps and Fort Hood under Project IAOs 348-87, 66-88, and 268-88, for the Engineering and Housing Support Center of the U.S. Army Corps of Engineers (USACE) under Funding Authorization Document (FAD) 89-080046, and for HQ, Forces Command under Military Interdepartmental Purchase Request (MIPR) JE26-91.

The work was performed by the Environmental Natural Resources Division (EN) of the Environmental Sustainment Laboratory (EL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Dr. David Tazik. Several individuals participated in field work that made this Biological Assessment possible. These include Daniel Salzer and Geralyn Larkin (1988-1989); David and Elizabeth St. George and Grant Critchfield (1989), Douglas Short, Carolyn Bachler, and Arlo Raim (1990); Jeffrey Bolsinger, Drew Adams, Kris Bruner, Amy Knight, Gilbert and Wanda Ekrich, and Hugh Baker (1991). Important contributions were also made by Dr. Joseph Grzybowski (Central State College, OK) and Dr. Gary Schnell (Oklahoma Biological Survey). Dr. Robert Shaw (Colorado State University) graciously contributed unpublished data on the status of *Croton alabamensis* on Fort Hood. The Historical and Current Military Activity subsections of the "Background" section in Chapter I were provided by Fort Hood through the office of the Assistant Chief of Staff, G3, with the assistance of MAJ H.M. Davis. Dr. James Reddell of the Texas Memorial Museum, Austin, provided the information included in Appendix H. Thanks are also due to the experts cited in this report who generously provided their views on the status of the species addressed in this Biological Assessment. Robert E. Riggins is Acting Chief, CECER-EN. Dr. Edward W. Novak is Acting Chief, CECER-EL. The USACERL technical editor was William J. Wolfe, Information Management Office.

COL Daniel Waldo, Jr., is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

BIOLOGICAL ASSESSMENT OF THE EFFECTS OF MILITARY ASSOCIATED ACTIVITIES ON ENDANGERED SPECIES AT FORT HOOD, TEXAS

I. INTRODUCTION

A. Background

The Army's mission is to maintain a trained and ready force in peacetime to deter war, to fight and control wars that do start, and to terminate wars on terms favorable to U.S. and allied interests. Fort Hood contributes to this mission by providing resources and training facilities for the Active and Reserve Component units that train on the installation each year.

To maintain well trained forces, the Army must provide its troops with the necessary training opportunities. The three types of major training activities that potentially impact Fort Hood's natural resources include maneuver exercises, weapons live fire, and aviation training.

These types of training sometimes unavoidably damage soil and vegetation. The extent of damage depends largely on weather conditions, visibility, and inherent land capability. Training exercises conducted at night and under conditions of limited visibility (fog and obscurants), while representing optimum training conditions, have the greatest potential for inadvertent damage to vegetation and wildlife. Tracked vehicle and engineering operations involving bulldozers and demolition charges potentially cause the greatest soil damage by displacing and compacting soil. Ground and woody vegetation is also at risk of being damaged or displaced by these operations. Even so, such damage is not indiscriminate—environmentally protected areas (archaeological, habitat, and conservation areas) are known and are not knowingly violated.

The U.S. Army implemented the Land Condition-Trend Analysis (LCTA) program at Fort Hood in 1988. This Army-wide program, developed at the U.S. Army Construction Engineering Research Laboratories (USACERL), is based on the principles of sustained yield and multiple use (Tazik et al. 1991; Diersing et al. 1992). It is a multiresource inventory, monitoring, and analysis program designed to evaluate current conditions and trends occurring on Army lands, and the capability of those lands to support long-term multiple use, including military training and testing. Data are collected in a standardized manner each year from permanent field plots located on the installation in a stratified random fashion. (Stratification is by major soil and land cover type.) Data collected include soil, vegetation, wildlife, and land use. Major efforts currently underway will more fully address the many unique natural features that occur on Army lands, including threatened and endangered species and wetlands.

Biological assessments are part of this long-term program that will permit military land and wildlife managers and land use planners to evaluate the impacts of military activities on threatened and endangered species. The intent is to develop mechanisms to effectively integrate endangered species protection and conservation with the military mission.

B. Objectives

The objectives of this study were to determine the effects that military-associated activities have on endangered plant and animal species at Fort Hood, TX, and to recommend actions to lessen possible damage to those endangered species.

C. Approach

A literature review was conducted of endangered plants and animals known to occur at Fort Hood, TX. Recognized experts were interviewed by telephone to discuss the current state of knowledge regarding the species under consideration. A summary of each interview was returned to the interviewee to ensure that expressed views and opinions were accurately represented. Researchers from Colorado State University visited Fort Hood in March 1991 to study populations of *C. alabamensis*. USACERL researchers made site visits to Fort hood from 1987-91 to collect data on animal distribution and abundance, habitat preferences, and population and nesting ecology. Based on these data and on expert opinion, the effects of Fort Hood's military-associated activities on endangered species were assessed, and alternatives were reviewed.

D. Scope

Actions of concern to this Biological Assessment include continuation of the maneuver, live fire, and aviation training missions, operational testing, controlled burning, juniper cutting, grazing, recreational activities, and on-going scientific studies on Fort Hood.

E. Mode of Technology Transfer

The information developed as a result of this study should be transferred to installations and MACOMs as part of a handbook of threatened and endangered species on Army lands. The information also should be incorporated into the Army's Land Condition Trend Analysis (LCTA) Program database management system for Army-wide data summarization and dissemination. Also, a mechanism must be developed to update installation and species assessments through (1) direct input from installations and (2) expansion of and integration of data gathered in conjunction with the LCTA program.

II. SITE DESCRIPTION

A. Historical

Fort Hood dates to 1942 when the Army established a camp to prepare soldiers for tank destroyer combat for World War II. Known then as Camp Hood, it became a permanent installation in 1950 and was renamed Fort Hood. Various armored divisions have been housed here since 1946. From 1971 until late 1990, Fort Hood was the only installation assigned two divisions. The installation retains the infrastructure to support two divisions, a Corps headquarters, and its combat aviation assets, combat support, and combat service support units. With increased emphasis on force structure changes and unit re-stationing initiatives, Fort Hood will likely again become the largest active U.S. installation.

B. Terrain

Fort Hood covers an 87,890 ha area (U.S. Department of the Army 1987) located in central Texas in Bell and Coryell Counties adjacent to the city of Killeen. Fort Hood lies on the eastern fringe of the Edward's Plateau between the cities of Waco, 40 mi to the northeast (1 mi = 1.61 km), and Austin, 60 mi to the south (Figure 1). (All figures are included in Chapter X, p 89.) The installation 1987 Master Plan Report (Nakata 1987) contains details on Fort Hood's environment, organization, and activities. Much of the following is summarized from that report.

Central Texas' climate is characterized by long, hot summers and short, mild winters. Average monthly temperatures for the Fort Hood area range from a low of about 8 °C in January to a high of 29 °C in July (U.S. Department of Army 1990). Average annual precipitation is 81 cm. A climate diagram for Temple, TX, located to the east of Fort Hood, illustrates the patterns of temperature and precipitation for the area (Figure 2). (Diagrams for Gatesville to the north and Lampasas to the west show similar patterns.) In this diagram, 1 °C temperature on the left *y* axis is equated to 2 mm precipitation on the right. Plotting temperature and precipitation together in this manner indicates the relative aridity and humidity of an area (Walter 1985). The temperature line shows a steady increase from a low in January to a high in July and a steady decline thereafter. Precipitation has 2 major peaks, the largest during April and May and a smaller one in September. Precipitation exceeds temperature throughout the year except during a mid-summer low in precipitation. The annual growing season is defined by that portion of the temperature line above 10 °C.

The Fort lies entirely within the Lampasas Cutplains physiographic region and is within the Grand Prairies Land Resource Zone. The forces creating the Balcones Fault Zone, just east of the installation, have displaced underlying rock formations as much as 500 ft. Weathering and erosion over the past 70 million years has produced the present "cutplains" landscape. The exposed stratigraphy includes alluvium and river terrace deposit (unconsolidated); undivided Kiamichi Clay and Edward's Limestone (dense limestone); undivided Denton Clay, Fort Worth Limestone, and Duck Creek Limestone (dense limestone); Comanche Peak Limestone (loose limestone); Walnut Clay (chalky shale); Paluxy Sands (chalky limestone); and Glen Rose Formation (sandy limestone) (Figure 3). These formations are generally composed of massive, structurally sound limestone or a mix of limestone and shale known as marl, which crumbles and weathers. Soil cover generally is shallow to moderately deep and clayey and underlain by limestone bedrock. Major soil associations are illustrated in Figure 4. Descriptions follow (McCaleb 1985):

> *Eckrant-Real-Rock outcrop*: Very shallow to shallow, gently sloping, cobbly and gravelly, clayey and loamy and rock outcrop; on uplands. Primary use is

rangeland. Typical vegetation is tall grass in a live oak savannah with juniper encroachment on rugged areas.

Nuff-Cho: Deep and shallow, gently sloping to sloping, very stony and loamy soils; on uplands. Primary use is rangeland and pasture. Vegetation ranges from tall grasses in a live oak savannah to prairie of medium to tall grasses.

Slidell-Topsey-Brackett: Deep, gently sloping and undulating, clayey and loamy and gravelly soils; on uplands. Used mainly as rangeland and pasture. Natural vegetation is tall grass prairie.

Doss-Real-Krum: Shallow and deep, gently sloping, loamy and gravelly and clayey soils; on uplands. Primary use is rangeland. The vegetation is medium and tall grass prairie.

Bosque-Frio-Lewisville: Deep, nearly level to gently sloping, loamy and clayey soils; on bottomlands and terraces. Main uses are for crop and pasture land. Vegetation is medium and tall grasses with a tree canopy of pecan, elm, hackberry, oaks, and cottonwood.

Bastil-Minwells: Deep, gently sloping, loamy soils; on terraces. Used mainly as pasture land. Typical vegetation is tall grass in a post oak savannah.

Elevation ranges from 180 m to 375 m above sea level with 90 percent of the area below 260 meters and about 5 percent in bottomlands (Figure 5). The landscape exhibits a stair-step topography consisting of a gently rolling to rolling dissected remnant plateau. Numerous steep sloped hills and ridgelines 40 to 80 m in width rise above the flat to gently rolling plains. This benching is a result of the erosionally resistant limestone cap rocks of the plateau and mesa-hill structures. While the upheld areas exhibit steep slopes, the underlying less resistant shales and marl show more gradual slopes. Higher elevations occur on the western portions of the Fort and the lowest at the Belton Lake shoreline adjoining the Fort on the east. Surface water drains mostly in an easterly direction. Most slopes are in the 2 to 5 percent range. Lesser slopes occur along the floodplains, while slopes in excess of 45 percent occur as bluffs along the floodplains and as the side slopes of the mesa-hills.

Fort Hood lies in the Cross Timbers and Prairies vegetation area, which normally is composed of oak woodlands with a grass undergrowth. Woody vegetation on the installation is derived mostly from the Edward's Plateau vegetational area to the southwest and is dominated by ashe juniper, live oak, and Texas oak. The grasses are derived from the Blackland Prairie area to the east. Under climax condition, these would consist of little bluestem and indiangrass. Scientific names of species referred to in the text and tables are presented in Appendix A.

Data obtained from the Army's LCTA program at Fort Hood clearly show that the Fort is divided mainly into perennial grassland (65 percent) and woodland (31 percent) community types (Figure 6; Appendix B). Most of the grasslands exhibit a dense or closed vegetative cover (83 percent). As a result of a long history of grazing and military activity, the Fort's grasslands are dominated by Texas wintergrass (29 percent) and prairie dropseed (18 percent), with little bluestem grasslands comprising only 9 percent of the grassland area (U.S. Department of the Army 1990). Broadleaf woodlands comprise about 39 percent of LCTA woodland sites and typically are dominated by oaks. Coniferous and mixed woodlands comprise 61 percent and are dominated by ashe juniper or a mixture of juniper and various oaks.

C. Current Military Activity

As of 31 March 1991, 34,171 military personnel were authorized for assignment to Fort Hood, with 37,196 actually assigned. The total post population is just over 62,000, and approximately 10,000 civilian personnel are employed by the post. A detailed listing of the installations physical plant, military equipment, units, and personnel is presented in Appendix C.

1. Mission

Fort Hood contributes to the Army's training mission by providing resources and facilities for the Active and Reserve Component units that train on the installation each year. A detailed list of III Corps and Fort Hood organizations and units is presented in Appendix D. Detailed documentation of the official organizational alignment and functional distribution of responsibilities for performing the mission assigned to Headquarters, III Corps and Fort Hood is found in Fort Hood Regulation 10-5, dated 28 October 1987.

2. Training

Military units train using the Army's standardized training doctrine outlined in FM 25-100, *Training the Force* (15 November 1988), and FM 25-101, *Battle Focused Training* (30 September 1990), which provide a "road map" for attaining and sustaining unit readiness to support the Army's basic mission. Fort Hood's support of Operation Desert Shield/Storm emphasize the importance of achieving this goal. Following Iraq's invasion of Kuwait on 2 August 1990, III Corps was directed to prepare combat, combat support, and combat service support units for deployment. III Corps units were deployed from 9 August 1990 through 1 February 1991. The training time available to prepare the 25,181 soldiers during this period varied from weeks to days. This short notice reaction to a crisis situation emphasizes the need to maintain well trained forces—the transition from peace to war is oftentimes instantaneous. The three types of major training activities that potentially impact Fort Hood's natural resources include maneuver exercises, weapons live fire, and aviation training.

3. Maneuver Training

Maneuver training exercises are conducted at all levels to ensure a combat ready fighting force. Training programs focus on units attaining and maintaining proficiency in collective tasks that support mission essential tasks. Units involved in the collective training process span the entire spectrum from section to division. III Corps' training focus at Fort Hood is brigade and below.

Unit training has evolved from the practice of infrequent "peaking" to achieve the appropriate level of combat readiness to a program of sustained combat proficiency. Units train repetitively on critical tasks during allocated training periods to maintain a constant high state of training readiness. The skills necessary to perform these critical tasks are perishable and must be trained at intervals throughout the year to sustain proficiency. The process of sustaining training readiness places great demands on all resources, including time, money, land use, and natural resources.

Units train as they will fight; training exercises replicate combat conditions as closely as possible. Combat effects such as smoke, noise, and simulated nuclear, biological, and chemical (NBC) conditions are integrated into every training event to condition units for operations in a confused, stressful battlefield environment. Trainers are careful not to "simulate" or "assume away" any facet of a training mission, no matter how small. For example, units conducting defensive operations "dig-in" vehicle fighting positions and actually emplace the barrier and obstacle plan in those areas cleared for sub-surface excavation by environmental and archaeological managers. Such necessary training realism helps ensure a high level of combat readiness.

Units fight (and train for combat) in a task-organized mannner. Trainers integrate combat, combat support (including Electronic Warfare Operations), and combat service support elements to conduct multi-echelon, combined arms training. The trend is away from training exercises conducted in an uncoordinated "pure" configuration. Combined arms training involves formations that include members of the entire fighting force. Commanders synchronize the activities of these forces within a battlefield framework that includes maneuver and operations within the deep, the close-in, and rear battle areas. Such exercises involve greater depth and rapidity of movement dimensions and, therefore, also incur greater demands for concurrent land use.

Such training can unavoidably damage some soil and vegetation, to an extent depending largely on weather conditions, visibility, and the inherent land capability. Ground and woody vegetation may be damaged or displaced by these operations. Such damage is not indiscriminate—environmentally protected areas (archaeological, habitat, and conservation areas) are known and are not knowingly violated.

4. Live Fire Training

Weapons proficiency is a critical component of combat power. Fort Hood units train with some of the most modern and sophisticated weapon systems available. These weapons are constantly evolving to stay ahead of advancements in armament technology by threat forces. Fort Hood has some of the most modern live fire training ranges in the world. These ranges provide realistic combat conditions and scenarios to train crews to exacting standards of gunnery proficiency as well as test the capabilities of the weapons system. Live fire training facilities must be continuously upgraded to keep pace with evolving technology and changes in warfighting doctrine. Fort Hood uses a 5-Year Range Modernization Program to manage the upgrade and expansion of existing facilities and new construction projects to meet future training and evaluation requirements.

Ranges are modernized to take advantage of increasingly sophisticated scoring systems that provide quicker, more accurate scoring of crew and unit performance. Upgrades include emplacing sensors for computerized scoring systems and upgrading target arrays with more precise feedback mechanisms.

Modernized live fire training facilities require continuous maintenance to maximize range design capability. Sensor devices must be serviced and cleared of concealing vegetation to ensure unimpaired operation. Target arrays must be visible at maximum engagement ranges. A program of range maintenance whereby vegetation is routinely cleared away from target arrays and sensor devices is a critical component of range operation.

5. Aviation Training

Fort Hood has one of the largest aviation communities in the United States. The aircraft are some of the most modern and sophisticated in the World. Aviation units on Fort Hood train at various levels. They include a train-up period, sustainment training, evaluations, and gunnery. The train-up period can be individual, section, company, or battalion level. It includes flight progressions, tactical and doctrinal training, and evaluations. Sustainment training is an ongoing program to keep proficiency in aviation and combat skills honed. Gunnery is an annual event for each attack battalion/squadron.

The airspace for training is scheduled by units 60 days in advance. All airspace is scheduled for sole use, although the first unit may grant joint use to other users on a non-interfering basis. Training space is scheduled at 200 ft above the ground level (AGL) and below, and is defined by training areas on-post and the grid matrix system off-post in the tract known as the western training area. Air space is scheduled in 2-hour blocks, not to exceed two blocks continuously. The training tasks accomplished in the training areas include

all tactical maneuvers in accordance with each aircraft's aircrew training manual and the unit's standard operating procedures. This includes nap-of-earth, contour, and low level flight.

Aircraft gunnery for AH-64 units can be conducted on all multipurpose training ranges and the Artillery Impact Area. The Dalton-Henson Range Complex (training areas [TAs] 61-62), however, is used most often for this training. Hellfire Missile Shots are conducted into Blackwell Gap Multi-Use Range's Impact Area (TA 91). Helicopter Door Gunnery is conducted at Dalton Mountain Range or Crittenburger Range (TA 74-75). National Guard and Army Reserve units use the Dalton-Henson Range Complex for aviation training.

6. Operational Testing

Fort Hood's large maneuver and live fire training area, coupled with III Corps' modernized force, combine to provide excellent conditions for operational testing of various weapons, equipment, and doctrine. The U.S. Army Test and Experimentation Command (TEXCOM) is a tenant activity located at West Fort Hood. TEXCOM consists of nine test directorates, four of which are located at other Army installations; the TEXCOM Experimentation Center at Fort Hunter Liggett, CA; and six administrative and support directorates at West Fort Hood. TEXCOM is directly involved in training, doctrine, and combat developments of the products that the soldiers use on a daily basis and will use on the future battlefield. Today's mission is to plan and conduct operational tests of the systems the Army intends to buy; to plan and conduct force development tests dealing with tactics, doctrine, and organizational concepts; and to develop instrumentation to support tests, field exercises, and training.

Most TEXCOM tests employ "user testing," or allowing the front-line soldier to try out new equipment or concepts. The tests generally encompass activities similar to those described in the sections on maneuver, live-fire, and aviation training, so operational testing will not be treated separately.

D. Training Grounds

1. Maneuver Training Areas

Maneuver training areas are located west, east, southwest, and north of the live fire training area. They constitute 53,300 ha or 60 percent of the entire installation. Appendix E includes a detail inventory of maneuver training. The West Range Training Area provides excellent training opportunities for large armored and mechanized infantry forces. The training area averages 7 to 10 km in width and 30 km from north to south. The area features a wide variety of terrain and vegetation characteristics that greatly enhances cross country, combined arms maneuver. Because of its large, continuous size, this is the only parcel of maneuver area capable of supporting brigade level operations.

The East Range Training Area is divided into a northeast and southeast sector by the Belton Lake Reservoir. The northeast sector is heavily vegetated and cross-compartmentalized, providing limited value as a mechanized maneuver area. The southeast sector provides more favorable terrain attributes for maneuver units, but is only 4 to 7 km north to south and 15 km from east to west. Because of their limited size, the East Range training areas are best suited for unit assembly and logistical areas, artillery firing points, and company and platoon level mounted and dismounted training. Additionally, the training area supports engineer, combat support, and combat service support training, and provides the only location where amphibious operations and river crossing exercises can be conducted on the installation.

The Southwest and North Maneuver training areas do not support a high density of training activity due mostly to their small size and isolated locations. The Southwest Maneuver Training Area ("West Fort Hood") is separated from the main cantonment area by U.S. Highway 190 and the Santa Fe Railway. This training

area includes many restricted maneuver areas, the largest of which is Robert Gray Army Airfield. The North Maneuver Training Area is also isolated from the main cantonment area by the artillery impact area. Both maneuver training areas are used primarily for small mechanized unit and dismounted infantry training and as logistical sites. Training use intensity in dry track vehicle equivalents per day is shown in Figure 7. These data were provided by the Fort Hood Environmental Management Office.

2. Live Fire Training Areas

The live fire training area covers about 33,800 ha, including the central portion of the installation, bounded by East and West Range roads. Firing generally occurs inside these roads, and is directed towards the Artillery Impact Area. Numerous artillery firing points are located within the surrounding maneuver areas. Appendix F details these firing points and types of ordnance fired.

The Range Area serves for training and evaluation in all individual, crew-served, and major weapons systems, up to and including battalion live fire, of active units assigned or attached to III Corps and Fort Hood, and of Army National Guard and Army Reserve units supported by the installation. A range modernization Program (5-Year Plan) continues to manage the upgrade of existing facilities to meet training and evaluation requirements.

3. Air Operations

Two major airfields are located on Fort Hood—the Robert Gray Army Airfield (RGAAF) and the Hood Army Airfield (HAAF). HAAF is a 293 ha area located at the eastern end of the cantonment area (Figure 8). Presently, this airfield is used by the 6th Cavalry Brigade (Air Combat) and the Apache Training Brigade. Fixed winged aircraft can use the 4712-ft runway only for maintenance activities.

RGAAF is a 867 ha area located at West Fort Hood with a 10,000 ft runway (Figure 8). Major Army aviation units using RGAAF include: The 1st Cavalry Division Combat Aviation Brigade, the Fort Hood and III Corps Flight Detachment, the 507th Medical Company, the 15th Military Intelligence Battalion, and the 16th Air Traffic Control Battalion. RGAAF also supports a large number of U.S. Air Force aircraft used in conjunction with training and operational exercises directed towards meeting III Corps' world-wide contingency missions. Appendix G lists authorized aircraft and traffic counts and describes the landing strips. Several other landing strips are located around the installation (Figure 8).

Aircraft flying on post use the Corps Airspace Route Structure (CARS). The CARS consist of aerial transition routes, by use of corridors, over the entire reservation. This system is used to deconflict traffic for safety and prevents low flight of aircraft below 200 ft AGL that would disrupt training. Fort Hood also has four designated drop zones—Antelope, Fort Hood, Rapido, and West Fort Hood (Figure 8). These drop zones are used by XVIII Airborne Corps, 12th Special Forces Group, and the Navy Seals for airborne operations and training.

4. Explosives Storage and Handling

The installation's main supply and storage area for ammunition needed for training activities and for initial operational requirements is located in the Ammunition Supply Point (ASP) at West Fort Hood. The Ammunition Holding Area (AHA) is located northwest of the main cantonment area west of Clear Creek Road and north of Turkey Run Road. Ammunition to be utilized during training is transported from the ASP and held at AHA until picked up by individual units. Ordnance demolition by the 47th EOD Detachment takes place at Range 57 (Explosive Ordnance Disposal Range).

E. Force Structure

Fort Hood is the only U.S. Army post that has accommodated two mechanized divisions. Since 1971, both the 1st Cavalry Division (1CD) and the 2d Armored Division (2AD) have been stationed at Fort Hood. Other commands/activities stationed at Fort Hood are listed at Appendix D. In 1989, troop and civilian personnel authorizations were almost 42,500.

In 1990, the 2AD was designated for inactivation. One of the two combat brigades was inactivated during 1990. Following Operation Desert Shield/Storm, the remaining combat brigade was assigned to the 1CD to form a three-brigade division. The remainder of 2AD will be inactivated by 1 October 1991. Under this structure, troop and civilian personnel authorizations will number approximately 34,250. In February 1991, DOD announced its intent to restation the 5th Mechanized Infantry Division (5ID[M]) to Fort Hood from Fort Polk in 1993/1994. The 5ID(M) is almost identical in structure and size to the original pre-1990 2AD.

Additional unit moves from Conventional Forces, Europe (CFE) agreements may locate select company-size units at Fort Hood. These are combat support and combat service support units. No additional combat maneuver units are expected with the exception of the 5ID(M) from Fort Polk. With all known proposals, troop and civilian personnel authorizations could number approximately 47,250.

F. Other Current Activities

1. Controlled Burning

According to the 1985 Fort Hood Natural Resource Management Plan, a total of 4050 ha were targeted for controlled burning during 1986 through 1990 to eradicate large areas of ashe juniper and to improve wildlife habitat. During 1986 to 1989, 13,760 ha of grassland were actually treated by controlled burning. No burning was performed in 1990 in reaction to a fire at Lone Mountain that destroyed black-capped vireo habitat. Controlled burning is targeted to open grasslands where juniper is encroaching or, rarely, to open areas that have been chained or flat-cut where very little vegetation other than juniper is present. Primary control is through the Environmental Management Office, and most areas are chosen to benefit grazing.

2. Juniper Cutting

An extensive program for the removal of ashe juniper from maneuver training areas is conducted to allow for more effective training utilizing laser simulators. This has involved juniper removal primarily from the tops of the mesa-hills in the West Range training areas (TAs 34, 35, 36, 41, 42, 43, 44, 45, 48, 51, and 53). However, in many cases, contractors also have removed juniper and other brush from side slopes. There has been limited cutting on East Range training areas (TA 12, 13, 15, and 16).

The 1985 Natural Resource Management Plan called for brush cutting for habitat improvement on approximately 3840 ha for the period 1986 to 1990. Of this, 2225 ha were to be clearcut, and 1615 ha were to be hand cleared. During 1986 to 1989, a contract for juniper clearing on the west side of the reservation involved 8700 ha. Smaller contracts on the east side totaled about 1200 ha. Hand clearing by grounds crews totaled 400 ha. Areas selected were chosen primarily based on marketability of juniper. Areas where pure stands of juniper were present received top priority for cutting. Other areas cut were preferred training sites that had become too thick for training due to juniper encroachment. Grounds crews selected areas where large hardwoods were being choked out by junipers. The Environmental Management Office coordinated the effort and wrote contract specifications.

3. Grazing

Cattle grazing is permitted on Fort Hood by virtue of several lease agreements. The most significant of these involves approximately 65,560 ha leased by the Central Texas Cattlemen's Association from 13 March 1989 to 12 March 1994 at rent of $154,000 (Figure 9). Grazing limits are to be based on current range surveys and recommendations of range specialists from the Soil Conservation Service. For the first year of the lease, the limit was set at 1 animal unit per 45.7 acres of land or no more than 3500 animal units. Actual numbers were substantially less than this (1500 to 2000) during 1989 and 1990 as many cattle were removed due to a brucellosis epidemic. While the lease agreement specifically requires the lessee to not impact historical, archeological, architectural, or other cultural features on the installation, and also requires compliance with local, state, and federal water pollution regulations, it does not specify that lessees should avoid negatively impacting threatened or endangered species.

4. Recreation

The post is open to public hunting and fishing. Access is regulated by the Range Control office with the cooperation of Morale Support Activities and the Fish and Wildlife Branch. Over 80,500 ha are managed for fish and wildlife, including 100 surface ha of lakes and ponds, 88 km of rivers and permanent streams, and 85 km of shoreline access to Belton Lake. In recent years, the Fort has provided 90,000 fisherman-days and 45,000 hunter-days annually. Deer, turkey, migratory waterfowl, quail, and dove are hunted only in restricted seasons. Deer and turkey hunts are carefully controlled. Small game hunting with shotgun is always available.

Outdoor recreational vehicle use has major impacts on relatively small areas. An annual motocross race is sponsored by the Fort Hood Dirt Riders Club. Site selection for recreational off-road vehicle (ORV) use during any time of year must be coordinated with the Environmental Management Office. Trails must be located to minimize (1) damage to soil, watershed, vegetation, and other public land resources, and (2) harassment of wildlife or significant disruption of wildlife habitat. Training area ORV use is rotated on the following schedule as per FH Reg 420-2 (p 3-3):

1. March through July: TA 31-34
2. August through September: TA 24-27
3. October through November: TA 42-53
4. December through February: TA 11-17.

Various low-impact outdoor recreation activities take place at the Belton Lake Outdoor Recreation Area located in Training Area 17—beach and sun bathing, boating, and cottage use (see map attachment). Boy Scout Camps are located in TA 17 and 23. There are also 2 golf courses and various pavilions and picnic areas.

5. On-Going Scientific Studies

The LCTA program at Fort Hood is a long-term program that will permit military land and wildlife managers and land use planners to detect major changes in land condition and to consider these factors in mission training plans and amend other land management plans accordingly.

III. LITERATURE REVIEW

A. Plants

No federally endangered plant species are known to occur on the Fort. In early 1990, an undescribed variety of *Croton alabamensis* was discovered on the installation by (Fort Hood wildlife biologist) Mr. John Cornelius. This species, formerly known only from two counties in Alabama, is a category 2 candidate for federal listing. The taxonomy of the Texas populations is currently under review (Steve Ginzbarg, personal communication).

1. Croton alabamensis

a. Nomenclature and Classification

Scientific Name: *Croton alabamensis*. Variety designation is pending taxonomic review.
Family: Euphorbiacae
Original Description: pending
Type Specimen: pending
Current Federal Status: Proposed as category 2 (Clayton, personal communication)
Past Federal Status: None

b. History of the Taxon

C. alabamensis was first noticed by E.A. Smith in 1877 (McDaniel 1981), and has since been described as one of the rarest shrubs in the United States (Farmer and Thomas 1969). Habitat information and the original description were published in Mohr (1889). The Alabama variety of this taxon presently is listed as a category 2 candidate species for federal listing. A listing proposal probably will be submitted within the year subsequent to completion of field work (Norquist, personal communication). Having been just recently discovered in Texas (Poole, personal communication), little information is available on the Texas populations. These appear to be a distinct variety, differing from the Alabama populations primarily in the coloration of scales on the underside of the leaves and stems (Ginzbarg, personal communication). A taxonomic review is now being completed by Mr. Steven Ginzbarg of the University of Texas at Austin, who is monographing the genus *Croton*. Dr. Joe Allen Farmer published a dissertation on the species in 1962. Studies on the Fort Hood population have begun under the direction of Dr. Robert Shaw of Colorado State University.

c. Description

A technical description of the Texas variety of *C. alabamensis* is not yet available. According to Mr. Ginzbarg, the Texas and Alabama specimens are similar except for distinct differences in coloration of scales on the underside of the leaves and stems. Thus a description of *C. alabamensis* is in most respects applicable to the Texas variety (Kral 1983).

C. alabamensis is a broad-crowned, clonal shrub 2 to 3 m tall with overwintering leaves (Kral 1983). It is usually found in small, localized groves comprising dense thickets (Farmer 1962). Bark of older wood is thin, gray-brown, with irregular cracking. The main stem has an irregularly forking branch habit, usually branching at the base of old inflorescences. Branches are slender but stiffish and spreading, and leafy on toward the tips. The dense coat of scales on new shoot growth is silvery on Alabama specimens, coppery on Texas specimens (Ginzbarg, personal communication). Leaves are spirally arranged, spreading on stiff, slender petioles 0.5 to 2.0 m long. The blades are narrowly ovate, elliptic or oblong, and 5 to 10 cm long with a rounded-emarginate tip and acute base. Upper surface of the leaf is dark green. Dense scales on the lower

leaf surface are silvery in Alabama specimens, coppery in Texas specimens (Ginzbarg, personal communication). Main veins of the leaf are strongly raised and the margin is entire. The inflorescence forms terminal racemes of one sex or with male above female. The racemes are erect, slender, stiffish, and mostly 5 cm long or less. Flowers are symmetrical. Male flowers are broadly cupshaped or rotate and about 5 cm across. The five calyx lobes are narrowly triangular 2.5 to 3.0 mm long, and greenish with silvery scales. Petals are pale green, oblong, and 2.5 cm long. Ten to 25 stamens arise from inside of a low, lobed, orangish disc on 4 mm long filaments with 1 mm long anthers. Female flowers are 4 mm high with petals and sepals similar in shape to those of the male but more erect. The ovary is ringed at the base with an orangish, lobed disc and tipped by 3 style branches. Female flowers often predominate toward the base of the plant (Farmer 1962). The fruit is 3-lobed and pale green, lengthening to 1.5 to 2.0 cm. The broadly ovoid seeds are about 7 cm long and reddish-brown with irregular white streaks and mottling.

d. Geographic Distribution

Prior to its discovery in Texas, *C. alabamensis* was known only from Tuscaloosa and Bibb Counties in Alabama. There it is associated with calcareous rocky bluffs, rocky, wooded, ravine slopes and terraces where the Cahaba and Warrior River systems come near the Appalachian and Coastal Plain provinces (Kral 1983). The Texas variety has been observed only in Coryell and Travis Counties. In combination with habitat specificity, inherently poor dispersal abilities and fire contribute to the restricted distribution of the taxon (Farmer 1962).

e. Habitat

C. alabamensis is usually found on shallow soil on moderately to steeply sloping terrain (Farmer 1962), usually on hard limestones or dolomitic limestone or calcareous shales (Kral 1983). Although it appears to favor areas of full sunlight, the species may be found in woodland understory. According to Farmer (1962), occupied habitats are usually shrub dominated, and characterized by few or no live trees and a relative abundance of herbs.

f. Known Population

In Alabama, the species is restricted to two major population centers. Individual populations consist of a few to many individuals covering several acres (Kral 1983). At the time of Farmer's work (1962), the species covered no more than about 40 ha. Texas populations have not been fully enumerated.

g. Reproductive Biology

The reproductive biology of *C. alabamensis* was evaluated by Farmer (1962). As he observed no evidence of asexual reproduction, Dr. Farmer reported that the clonal nature of the species is not related to vegetative growth. That is, each stem within each colony site represents a different individual. Nonetheless, the species can be propagated by stem cuttings.

In nature, plants require 5 to 7 years growth prior to onset of sexual reproduction. Flower buds are produced in May or June and overwinter before flowering in mid-March. Plants are self-fertile, with pistillate flowers often most numerous toward the bottom of the plant. Wind is the primary pollenization agent. Fruits develop by mid-May. Seeds are dispersed up to about 7 m from the parent by a catapulting mechanism. A heavy seed crop is produced each year, much of it lost to rodents, birds, and possibly ants. Partial shade can reduce seed production by 10 to 50 percent. Forest cover can reduce it by 75 to 95 percent. Seeds, which require cold stratification, are dormant until germination takes place in February or March.

h. Survival and Growth

Seed survival is probably very low, perhaps 1 percent of seed production (Farmer 1962). Seedling mortality may be quite high as well. For experimental populations, Farmer (1962) reported 20 percent survival to 2 years. Clonal stands are all-aged and consist of individuals as old as 21 years (Farmer 1962).

Following germination, seedlings grow until dormancy begins in June (Farmer 1962). Most consistent plant growth occurs during March and April. More erratic growth occurs during periods of high moisture. Leaves turn yellow by mid-June. Growth of primary roots is restricted largely to the first 2 cm, with the remainder of root growth within 15 cm even on deeper soils.

The taxon appears to be well adapted to summer drought conditions and high temperatures (Farmer 1962). Flowering, fruit production, and seedling establishment all take place in early spring. Also, there is a general summer dormancy in seeds, seedlings and older plants.

i. Interactions With Other Species

Other plant species characteristically found in association with Alabama populations include *Cheilanthes lanosa*, *Hypericum frondosum*, *Rhus aromatica*, and *Juniperus virginiana*, with *Rhus* usually most abundant (Farmer 1962).

Seeds are thought to be utilized by various rodents, birds, and perhaps ants (Farmer 1962).

B. Animals

Five federally endangered wildlife species have been observed on or adjacent to Fort Hood: black-capped vireo (*Vireo atricapillus*), golden-cheeked warbler (*Dendroica chrysoparia*), bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), and whooping crane (*Grus americana*) (Diersing et al. 1985). Several endangered cave invertebrates have a reasonable expectation of occurrence on the installation (Appendix H). An extensive range of literature was reviewed in the course of endangered species studies on Fort Hood. A complete bibliography is presented at the end of this assessment (Chapter XII), which includes the specific literature cited here.

1. Black-capped Vireo

a. Nomenclature and Classification

Scientific Name: *Vireo atricapillus* Woodhouse
Family: Vireonidae
Original Description: Woodhouse 1852
Type Specimen: San Pedro River 10 mi from its source-Devil's River, near Sonora, Sutton County, Texas (Deignan 1961).
Current Federal Status: Endangered (52 FR 37420-37423 [6 October 1987]).
Past Federal Status: Category 2 (47 FR 58454 [30 December 1982]); Category 1 (50 FR 37958 [18 September 1985]).

b. History of the Taxon

A review of the history of the taxon can be found in Marshall et al. (1985). The species was first described by Woodhouse (1852). The name has remained unchanged since his original description. Until

recently, there were only two major studies of the black-capped vireo. The first was conducted by Bunker (1910). He studied nesting, stomach contents, and plumages of the vireo in Blaine County, Oklahoma. In the second study, Dr. Jean Graber (1957, 1961) examined the distribution, ecology, and population biology of the species, and made it one of the most well studied of American songbirds. More recently, Dr. Joseph Grzybowski has been studying the species in parts of Texas and Oklahoma, and Army-sponsored studies are on-going at Fort Hood, TX, the Camp Bullis Training Site of Fort Sam Houston, TX, and Fort Sill, OK.

c. Description

The black-capped vireo is a small, greenish songbird approximately 11 cm in length and 10 grams in weight. The sexes are dimorphic. On the adult male, the crown and upper half of the head is black and sharply demarcated. Black extends farther posteriorly on males more than 1 year old as compared to first-year males. The adult female is similar in color except for a slate gray crown and under parts washed with greenish yellow. Immature birds are browner above, and buffy below. (Marshall et al. 1985).

d. Geographic Distribution

The breeding range of the black-capped vireo formerly stretched from south-central Kansas through central Oklahoma and central Texas into central Coahuila, Mexico, and possibly Nuevo Leon and Tamaulipas (Graber 1961, American Ornithologists Union 1983). The northern extent of the range has contracted significantly over the past half-century (Marshall et al. 1985, Grzybowski et al. 1986). The species has not been observed in Kansas since the late 1950s (Tordoff 1956, Graber 1961) and reaches its northern limit in Blaine County, south-central Oklahoma (Grzybowski et al. 1986) (Figure 10). Furthermore, the vireo appears to be gravely endangered in Oklahoma (Grzybowski et al. 1986, Grzybowski 1987, Ratzlaff 1987) and populations are disappearing in a seemingly random pattern in Texas (Marshall et al. 1985). The vireo is migratory and winters along the western coast of Mexico from Sonora to Oxaca with most of the population in Sinaloa and Nayarit. More detailed distributional information is summarized in Marshall et al. 1985. Sexton and co-workers (1989; personal communication) are compiling additional data on the distribution and status of the species in Texas. In addition to Fort Hood, the vireo is known to breed on the lands of Fort Sill, OK (Grzybowski and Tazik 1992) and the Camp Bullis Training Site of Fort Sam Houston, TX (Shaw et al. 1989, Rust and Tazik 1990).

e. Migration

The black-capped vireo arrives on its breeding grounds about 1 week following the average date of the last frost (Graber 1961). Thus, vireos first arrive on Texas breeding areas during mid- to late March, and in Oklahoma during mid- to late April. Males usually arrive 1 to 2 weeks earlier than the females. Fall migration back to the wintering grounds takes place during August and September. Young birds disappear first, followed by adult females, and then adult males (Graber 1961).

f. Habitat

General: The black-capped vireo is found in hardwood scrub habitat that typically exhibits a patchy or clumped distribution of shrubs and thickets and a scattering of live and dead trees. Graber (1961) described it as being "wooly." Characteristic is the presence of hardwood foliage to ground level. Scrubby oaks often dominate or are a major feature of the habitat—blackjack oak in Oklahoma, shin oak, Texas oak, and live oak in Texas (Graber 1961, Grzybowski 1986). Dense juniper stands typically are avoided. In the eastern half of the range, preferred habitat often results from fire within stands of mature oak-juniper and remains suitable for 5 to 25 years after fire. The best vireo habitats found by Marshall et al. (1985) were in 10- to 15-year-old burns that were hot enough to kill junipers. Steep rocky slopes where erosion and boulders hold back succession can maintain habitat for long periods. In the arid western portions of the range, shrub habitats

occupied by the vireo represent climax conditions rather than successional habitats (Diamond, personal communication).

Nest Sites: The nest is open-cupped and pendulent, about 15 cm in diameter, and typically is located 0.5 to 1.5 meters above ground (Graber 1961, Grzybowski 1986). In areas of oak-juniper habitat, nests consist largely of cedar bark and oak leaves bound with spider web (Graber 1961). Other materials may include dead leaves, dried grasses, plant fibers, cottony plant substances, paper, wool, and caterpillar silk. A variety of woody species common to the general habitat are used as nest substrates. As with the species composition of the general habitat, nest substrates used vary geographically. Blackjack oak is the most frequently used species in Oklahoma while shin oak and Texas oak are frequently used in Texas (Graber 1961, Grzybowski 1986). Juniper and live oak are used but less than in proportion to availability (Grzybowski 1986).

Foraging Sites: The vireo is a foliage gleaning insectivore that forages among the trees and shrubs in its habitat. It does not feed on the ground (Graber 1961). Foraging substrate preferences have not been quantified.

g. Food Resources

Graber (1961) quantified the stomach contents of 11 black-capped vireos. Larvae constitute the bulk of the diet. Lepidopteran larvae predominate followed by Coleopteran larvae. Other animal matter included spiders, centipedes, Neuroptera, Odonata, Hemiptera, and Homoptera. The young are fed small larvae, with food items increasing in size as the young grow. Grasshoppers and other Orthopterans may contribute as much as one-third of their diet.

h. Known Population

A review by Marshall et al. (1985) put the adult breeding population at 592 to 1130: 120 in Oklahoma, 376-748 in Texas, and 96 to 262 in Mexico. More recent observations have increased the total documented population to between 1313 and 1844: Oklahoma: 133-146 (Grzybowski 1988a, 1989a), Texas: 1084-1436 (Marshall et al. 1985, Grzybowski 1990, Tazik et al. 1992a, Bryan and Stuart 1990), Mexico: 96-262 (Marshall et al. 1985). The actual population may be much larger (Wahl, personal communication, Grzybowski, personal communication). Additional surveys are needed away from well known vireo sites.

i. Territory Requirements and Density

Graber (1961) reported an average territory size of 1.5 ha. Mr. Jim O'Donnell reported an average territory size of about 3 ha in Travis County, Texas (in Marshall et al. 1985). Graber (1961) also reported that the smallest breeding population she ever found consisted of 5 males and 3 females. Three pairs at 1.5 to 3 ha suggests a minimum area requirement of 4.5 to 9 ha.

j. Survival

Graber (1961) found that 69 percent of the males that she banded returned the following year, but that only 41 percent of females returned. Grzybowski (1990) reported a similar discrepancy among the sexes—65 percent for males vs. 41 percent for females in main colony sites. One-year returns in the Wichita Mountains of Oklahoma were 62 percent for males and 44 percent for females (Grzybowski 1989a). The discrepancy between sexes may be due to several factors: greater inconspicuousness of females compared to males, less site tenacity on the part of females, or a real difference in survivorship between the sexes. Lower survivorship among female songbirds has been reported by others (Nice 1937, Stewart and Aldrich 1951, Nolan 1978). Preliminary analysis indicates that juvenile survivorship may be in the range of 35 to 55 percent (Grzybowski and Pease, personal communication).

Grzybowski (1990) also documented that return frequency in small satellite populations (48 and 23 percent for males and females) was significantly less than in larger main colony sites (65 and 41 percent). He indicated that the difference might be due to differences in site tenacity rather than to differences in survivorship between the two groups.

k. Reproductive Biology

The black-capped vireo is a sexually monogamous species. Individual pairs establish exclusive breeding territories within which they nest and forage. The nest cycle includes: construction (4-5 days), inactive construction (1 day), laying (4 days), incubation (14-17 days beginning after the second or third egg laid), brooding of nestlings (11 days), and fledging (40+ days) (Graber 1961). Pairs frequently renest after an unsuccessful nest. Pairs that successfully fledge a brood sometimes will attempt a second brood.

The male is involved in all portions of the nesting cycle. Both sexes participate in nest building although the female performs more of the construction as the male often pauses to sing and defend the territory (Graber 1961). The male accomplishes about one-third of the incubation. Upon hatching, the chicks are brooded by the female. The male participates by furnishing about 75 percent of the food for the young. Unless mated to a new male, a female caring for a second brood will be unaided by her mate who continues to care for the first set of fledglings. The parents actively defend their young.

Reproductive success reportedly has been poor throughout the range of the vireo due largely to the impact of brown-headed cowbird brood parasitism (Graber 1961, Marshall et al. 1985, Grzybowski et al. 1986, Grzybowski 1988a, 1989b, 1990). Pair success and production appears to be below that necessary to maintain the population except in areas with successful cowbird control efforts. See further discussion below (m. Threats to Survival).

In Graber's (1961) sample of 243 eggs, only 17.6 percent produced fledglings. Of the 134 eggs lost prior to hatching, 72.3 percent were lost to cowbird activity. Only 9 percent of eggs were lost to predators. Among the 95 eggs that hatched young, 26.3 percent were lost due to the presence of cowbird young in the nest, while 16.8 percent were lost to predators. In all, 19.7 percent (15 of 76) of nests laid in and 59.7 percent of mated pairs (46 of 77) were successful in fledging at least one vireo. A total of 43 young were fledged for an average production of 0.56 young per pair per year.

Grzybowski (1990) reported production of 0.92 to 2.58 young per pair in areas with cowbird removal and 0.00 to 0.38 young per pair in areas without cowbird removal during 1988. During 1989, production was 2.00 to 3.78 in removal areas compared to 1.27 to 1.44 in nonremoval areas. In Oklahoma, production was 1.37 with cowbird removal, 0.36 without removal (Grzybowski 1990). Bryan and Stuart (1990) report a range in production of 0.82 to 1.76 on three areas managed by the Texas Parks and Wildlife Department. On Fort Sill, OK during the period 1988 through 1990, production, assisted by cowbird egg removal, averaged 1.0 to 1.4 young per pair per year.

Evidence suggests that successful reproduction is enhanced where vireos cluster together in "colony" sites (Grzybowski 1985a).

l. Interactions with Other Species

Habitat Associates: The black-capped vireo co-exists with a wide variety of other species within its habitat. The particular composition of associated species differs somewhat geographically (Graber 1961). Some characteristic associates include northern cardinal, tufted titmouse, blue-gray gnatcatcher, northern mockingbird, yellow-breasted chat, brown-headed cowbird, painted bunting, rufous-crowned sparrow, field sparrow, and Bewick's wren.

Competition: Territories of the black-capped vireo sometimes overlap with that of the white-eyed vireo or Bell's vireo. Although, direct competition was not observed by Graber (1961), Mr. John Cornelius reports having observed a black-cap chase after a white-eye (personal communication).

Predation: Direct predation on adult birds has rarely been observed.

Parasites: The species is unusually free of ectoparasites and disease (Graber 1961).

m. Threats to Survival

Major threats to the continued existence of the black-capped vireo include (1) loss of habitat due to urban development, excessive rangeland improvement, grazing by sheep, goats, and exotic herbivores, and natural succession including juniper invasion; and (2) cowbird brood parasitism (Marshall et al. 1985, Shull 1986, Ratzlaff 1987).

A juniper eradication program started in 1948 in Texas was directed at pasture development and urbanization. It resulted in the loss of about 50 percent of the juniper acreage between 1950 and 1970 (Pulich 1976). Widespread loss of oak-juniper woodland continues. For example, rapid urbanization in the Austin and San Antonio areas and in the corridor between these two cities is resulting in the loss of much existing and potential vireo habitat. Although the vireo does not typically occupy mature oak-juniper woodlands, this habitat represents potential vireo habitat that can be created after a fire or similar disturbance. Loss of this habitat to pasture and urbanization is a loss of future vireo habitat potential.

Because vireo habitat is successional, at least in the eastern portion of the range, in most cases a given habitat patch eventually will become unsuitable without actions that set back succession. This emphasizes the need to maintain a stock of potential habitat that can develop or be developed into vireo habitat, replacing those areas lost to natural succession or destruction.

Grazing by goats has been particularly destructive to vireo habitat. Angora goats are particularly common within the Edward's Plateau (Oberholser 1974). The goats consume woody vegetation as high as they can reach, effectively eliminating foliage in the zone required by the vireo for nesting (0.5 to 2.0 meters). Browsing by deer, on the other hand, does not appear to harm the bird (Graber 1961), unless deer populations are excessive (Diamond, personal communication).

The cowbird is a brood parasite. It does not construct its own nest, but lays its eggs in the nests of other species. Over 200 bird species are known to be host to cowbird eggs (Friedmann and Kiff 1985). The black-capped vireo appears to be particularly susceptible to cowbird parasitism and is affected in several ways. First, cowbird eggs laid in a vireo's nest may displace vireo eggs. Second, cowbird eggs hatch sooner than vireo eggs—12 days incubation for the cowbird compared to 14 to 17 days for the vireo (Graber 1961). Third, the young cowbird develops in size more rapidly than vireo young and quickly outcompetes for food any young vireo that does hatch. Vireo young are not known to fledge from nests in which a cowbird has hatched. The only apparent defense available to the vireo is to abandon a parasitized nest.

During 1986 through 1989, the incidence of cowbird parasitism among black-capped vireo nests in areas of Texas and Oklahoma without cowbird removal averaged 71 percent and 68 percent respectively (Grzybowski 1990). With cowbird removal, parasitism was significantly reduced to averages of 29 percent and 33 percent.

Cowbird densities are in part related to the presence of livestock (Friedmann 1929, Rothstein et al. 1987, Grzybowski 1988b). Cowbirds typically forage in areas frequented by livestock. Cattle and horses are particularly attractive to cowbirds. In Texas, in the absence of cattle, cowbird parasitism is in the range of

35 to 40 percent, even where sheep and goats are present (Grzybowski, personal communication). This compares with parasitism of 60 percent and higher on areas with cattle.

2. *Golden-cheeked Warbler*

a. Nomenclature and Classification

Scientific Name: *Dendroica chrysoparia*
Original Description: Sclater and Salvin 1860
Family: Emberizidae
Type Specimen: Adult female collected by Osbert near Tactic, Vera Paz, Guatemala on 4 November 1859. Specimen in the British Museum 1885-3-8-262.
Current Federal Status: Endangered (55 FR 53153-53160 [27 December 1990]).
Past Federal Status: Emergency listing as Endangered (55 FR 18844-18845 [4 May 1990]); Category 2 (47 FR 58454 [30 December 1982], 50 FR 37958 [18 September 1985], 54 FR 554 [6 January 1989]).

b. History of the Taxon

The name of this species has not changed since the original description of a specimen collected in Guatemala (Sclater and Salvin 1860). The first U.S. specimen was collected in Bexar County, TX (Dresser 1865). The species may have originated as part of a superspecies complex including the black-throated green warbler, the Townsend's warbler, and the hermit warbler (Mengal 1964). The definitive and only major bioecological study of the golden-cheeked warbler was completed by Pulich (1976). Stein (1962) compared the song to other warbler species. There is considerable interest in the status of the species in the Austin-San Antonio corridor. The Army has initiated studies of the species on Fort Hood, TX and the Camp Bullis Training Site of Fort Sam Houston, TX.

c. Description

The golden-cheeked warbler is a small, strikingly colored songbird approximately 13 cm in length, and 9 to 10 grams in weight. Detailed descriptions can be found in Pulich (1976) and Oberholser (1974). The male of the species exhibits bright yellow cheeks outlined in black, with a black line through the eye. The upper parts, throat, neck, and upper breast are black with additional black streaking along the flanks. The wings are black except for two distinct white bars. The black tail is interrupted with white on the three outermost feathers. The female is duller than the male with a black-streaked olive back, a yellowish throat, and blackish upper breast. The cheeks of the female and immature birds are not as bright as that of the male. The back of the immature male also is streaked with green.

d. Geographic Distribution

The golden-cheeked warbler is the only North American bird species whose breeding range is restricted to one state (Texas), where it has been recorded in 41 of the 254 counties. It is a species characteristic of the Hill Country of central Texas, inhabiting mature juniper-oak woodlands of the Edward's Plateau. The range of the golden-cheek corresponds closely with that of ashe juniper (Pulich 1976).

At the time of Pulich's publication, only 31 counties were thought to be occupied. Pulich (1976) provides the following description of its recent range (see Figure 11):

> The warbler is a summer resident from the Austin area southwest along the Balcones Escarpment nearly to San Antonio, then west across the Edward's Plateau to the West Nueces River drainage

> in Kinney County. From here it ranges northeast to Junction in Kimble County, and skipping Mason County, eastward to Llano County, then northward to the Possum Kingdom area in Palo Pinto and Stephens Counties. In the vicinity of Glen Rose in Somervell County, the bird ranges across the Brazos River into very small portions of Hood and Johnson Counties. Through the Hill Country of the Brazos River and Colorado River drainages, the eastern boundary extends southward from Sommervell County, including portions of Bosgue, Bell, Coryell and Williamson Counties (p 13).

There has been no further evaluation of the extent of the range since this description was published. A recent status survey did not examine the extremes of the range (Wahl et al. 1990).

Pulich went on to provide a county by county description of the warbler's range. In Bell County, "All specimens and observations of this species are from the vicinity of the Belton Reservoir on the Leon River" (p 15). And he goes on to write,

> The Fort Hood Military Reservation retains considerable native vegetation including much cedar, portions of which contain excellent golden-cheeked warbler habitat. In the late spring of 1970 military personnel and the author saw several male golden-cheeks at a spring area within range 23 (military designation) just north of Belton Reservoir. Since this is federal land and military operations are compatible with the interests of the golden-cheek, the Commanding General of Fort Hood agreed to recommendations to set aside certain suitable acreages of cedar habitat on the military reservation for this unique warbler. These areas, consisting of approximately 4,446 acres in the area of Owl Mountain, are designated as Range 20N, Range 20S, Range 23 and Range 27 (p 15-16).

As to Coryell County, Pulich writes,

> After visiting the Fort Hood Military Reservation on April 10, 1970, the author recommended to the Commanding General that about 2,600 acres of the Henson Mountain region, Ranges 30N and 31N (military designations) be left undisturbed for golden-cheeks. Military personnel subsequently agreed to this proposal although in the final agreement the acreage had not been established definitely (p 23).

Outside of Fort Hood, only small scattered cedar breaks were still in existence within Coryell County according to Pulich (1976).

Based on an extensive review of existing records, Pulich (1976) concluded that the warblers winter in the mountainous areas of east-central Guatemala through Honduras to Nicaragua, but that the exact winter range was not yet well defined. The presence of wintering birds in Mexico was considered questionable. However, more recent evidence suggests that the golden-cheek may overwinter in the state of Chiapas in extreme southern Mexico (Braun et al. 1986, Lyons, personal communication).

e. Migration

The golden-cheeked warbler is a migratory species and it arrives early on its breeding grounds in Texas. The earliest spring arrival known to Pulich (1976) was a 2 March arrival in Austin during 1956. It is not certain whether the males arrive earlier than the females. The mean spring arrival date for Bexar, Dallas, Kerr, and Travis Counties was between 12 and 16 March.

The species begins post-breeding migration rather early, with some birds headed toward their wintering grounds as early as mid June (Pulich 1976). The main portion of the population disappears by the end of July.

f. Habitat

General: Golden-cheeked warbler habitat includes ashe juniper and a variety of oak species. Several other hardwood species may occur as well (Pulich 1976). Fifteen stands sampled by Wahl et al. (1990) were dominated by ashe juniper and Texas oak. Other important tree species included live oak, cedar elm, Lacey oak, Arizona walnut, post oak, and bigtooth maple. Studies by Johnston et al. (1952) and Huss (1954) reported juniper-oak stands occupied by the golden-cheek with juniper composition of 14 to 50 percent and hardwood composition of 20 to 70 percent. For good warbler habitat at Meridian State Recreation Area, Kroll (1980) reported 52 percent ashe juniper, 33 percent shin oak, and 5 percent Texas oak. Similarly, the most important species in warbler habitat at Kerr Wildlife Management Area were ashe juniper, Texas oak, and shin oak (Ladd 1985).

While ashe juniper is the dominant woody species throughout the warblers range, the composition of oak species varies geographically (Ladd 1985). Texas oak occurs frequently, especially in the central part of the range. To the north, shin oak occurs more frequently (e.g., Fort Hood). To the south and west, Lacey oak occurs more frequently.

Pulich (1976) suggested that the golden-cheek requires woodland habitat with junipers averaging 50 years of age, and 20 feet in height with some deciduous cover. He stated that, "Only older cedar brakes with some variation in age provide the necessary requisites of warbler habitat" (p 65). Kroll (1980) quantified habitat of the species at the Meridian State Recreation Area. He found that 86 percent of the junipers within the study area were less than 50 years old (average 40.8 ± 29.4 years). Good habitat that was consistently occupied from year to year differed significantly from unoccupied areas. Good habitat was characterized by older ashe juniper (mean of 47.4 vs. 25.6 years of age in good vs. poor habitat) but a greater variability in age, greater distance between trees, and a smaller juniper:oak density ratio (1.35 vs. 2.77). The warbler appears to be attracted to more mesic areas within the juniper-oak complex, such as canyons and seepy hillsides, where deciduous hardwood vegetation is more abundant (Diamond, personal communication).

Pulich (1976) concluded further that second-growth woodlands did not provide suitable habitat for the warbler. Kroll's (1980) data suggest otherwise. Also, recent observations suggest that the warbler will reoccupy second growth areas (Ladd, personal communication, Diamond, personal communication) presumably in areas that have the right mixture of juniper and deciduous oaks.

Wahl et al. (1990) report that warbler density increases with canopy cover above 5.5 m, the cover of deciduous oaks, and the mean stand height and variation in height; and decreases with amount of juniper cover at 3 m.

Kroll (1980) also suggested that, historically, the geographic area occupied by this species was a fire disclimax dominated by expanses of grassland maintained by fire. The juniper-oak communities probably were maintained only in refugia along streams and on rocky, limestone outcrops. He suggested that this warbler may have evolved as an edge species inhabiting the juncture between grassland and juniper-oak woodland. And (State of Texas field biologist) Ms. Susan Rust (personal communication) has indicated that the warbler may be more tolerant of edge than is evident in the literature. Although the warbler can be found in woodland edge, it does not appear to be an edge dependent species as it frequently is found in dense woodland vegetation away from natural or man-made edge (Wahl, personal communication).

Nest Sites: Chapman (1968) reported that the favorite nesting haunts of the golden-cheek were "isolated patches or clumps of scrubby cedar, with scant foliage on the summits of the scarped canon slopes and in the thick cedar 'brakes' (p 166). Nests typically are placed in juniper trees (Chapman 1968, Pulich 1976). Nest height above ground varies from about 1.8 to 6.5 m, averaging 4.6 m (Brewster 1879, Chapman 1968, Pulich 1976). "Nests are usually placed along the main trunk of the tree and supported by secondary branches.

Occasionally, they may be placed on lateral branches and supported by the smaller forks of the branch" (Pulich 1976, p 88). Nests average 8 cm in external width and 5 cm in external depth. They are composed mostly of bark collected from nearby juniper trees. The bark is obtained in strips from older cedar trees. Kroll (1980) estimated that juniper bark does not start to peel until about 20 years of age.

Foraging Sites: The golden-cheeked warbler forages for insects in tree canopies (Smith 1916, Simmons 1924, Pulich 1976). Essential foraging habitat is provided by oak species within the habitats occupied (Kroll 1980, Ladd 1985, Wahl et al. 1990). Based on data provided by Beardmore, Wahl et al. (1990) reported that oaks were used out of proportion to availability during April, but in proportion to availability during May and June. Fifty-seven percent of the foraging observations made by Kroll (1980) found warblers in oaks.

g. Food Resources

The golden-cheek consumes a wide variety of insects including Lepidopterans, Coleopterans, Hemipterans, Homopterans, Hymenopterans, Dipterans, and Arachnids (Pulich 1976). Kroll (1980) observed that most prey items used by the warbler were of Lepidopteran larvae (54 percent) and Orthopterans (13 percent).

h. Known Population

Pulich (1976) estimated that the breeding population of the warbler in 1962 and 1974 was between 15,000 and 17,000 birds. Wahl et al. (1990) estimated a range of 4822 to 16,016 in 1989. The two estimates are not directly comparable, however, since they were derived in very different ways (Wahl et al. 1990). Also, Wahl et al.'s estimate may be inflated since not all males are mated, and all available habitat may not be fully occupied at the assumed average density of 15 pair per 100 ha.

For Bell and Coryell Counties combined, Pulich (1976) estimated 160 adult golden-cheeks in 1962 and 250 in 1974. Data presented in Wahl et al. (1990) put the total 1989 golden-cheeked warbler population in these two counties at 465 to 1859 at a median density of 0.15 pair per ha. Applying Pulich's (1976) estimated density in average habitat of 0.05 pair per ha (see next section) yields 155 to 620 warblers.

i. Territory Requirements and Density

Most studies report one pair of warblers per 1.9 to 4.3 ha (Ladd 1985). Kroll (1980) reported a range of 4.5 to 8.5 ha per pair. A 15.1 ha area in the Austin area maintained a population of 5 to 6.5 territorial males during several years yielding 2.3 to 3.0 ha per pair (Johnston et al. 1952, 1953; Webster et al. 1954; Demoll et al. 1984).

Wahl et al. (1990) reported density estimates of 0 to 62.5 males per 100 ha with a median of 15 per 100 ha. Pulich (1976) classified warbler habitat into excellent, average, and marginal corresponding to 1 pair per 8.1, 20.2, and 34.4 ha respectively. Corresponding density estimates are 12.3, 5.0, and 2.9 pair per 100 ha.

j. Survival

One-year banding returns reported by Pulich (1976) were 44.8 percent for males and 22.2 percent for females.

k. Reproductive Biology

As with the black-capped vireo, the golden-cheeked warbler is a sexually monogamous species. Individual pairs establish exclusive breeding territories within which they nest and forage. The nesting cycle

is as follows: construction (4-5 days), inactive construction (3-4 days), laying (4 days), incubation (11-12 days), nestling (9 days), fledgling (28-45 days). Some nest construction may be initiated during late March, but most occurs during early April (Pulich 1976). Clutches typically consist of 4 eggs, sometimes 3, but rarely 5. The species does not appear to be double-brooded although pairs will renest after a failed nesting attempt.

In contrast to the vireo, the female golden-cheek performs most of the nesting duties (Pulich 1976). Males take a somewhat more active role during the nestling stage when they assist in feeding. Males do not brood the young.

Of the 33 nests observed by Pulich (1976), 58 percent were parasitized by cowbirds. Out of 55 eggs laid, 60 percent were lost to or deserted due to cowbirds. Only 4 percent were lost to predators, while 27.3 percent fledged young.

l. Interactions With Other Species

Habitat Associates: Other breeding birds found in association with the golden-cheek throughout most of its range include: mourning dove, yellow-billed cuckoo, greater roadrunner, eastern screech owl, chuck-will's widow, Carolina chickadee, Bewick's wren, Carolina wren, blue-gray gnatcatcher, white-eyed vireo, brown-headed cowbird, summer tanager, northern cardinal, painted bunting, and lark sparrow (Pulich 1976).

Competition: There probably is little competition from others of the same family as the golden-cheek occupies such a narrow ecological range (Pulich 1976).

Predation: Direct predation on adults apparently has not been observed frequently. However, nests may be depredated by snakes, grackles, jays, and possibly squirrels (Pulich 1976, Pease and Gingrich 1989). Fire ants are a potential problem (Pulich, personal communication).

Parasites: Pulich (1976) observed no mites or ectoparasites in golden-cheeked warbler nests.

m. Threats to Survival

Major threats to the golden-cheeked warbler include habitat loss and fragmentation, both of which result from urbanization and widespread clearing of juniper for rangeland improvement (Jahrsdoerfer 1990a 1990b). Cowbird brood parasitism may be a significant threat as well, particularly in fragmented habitats.

As noted earlier, a juniper eradication program reduced juniper acreage in Texas by 50 percent between 1950 and 1970 (Pulich 1976). Junipers have also been removed in some areas to benefit various game species. In addition to the loss of habitat acreage, these activities also have led to the fragmentation of the habitat, which can reduce the suitability of the remaining habitat for the warbler. Fragmentation exposes resident species to higher levels of predation and parasitism (Gates and Gysel 1978, Brittingham and Temple 1983, Wilcove 1985, Andren and Angelstrom 1988, Pease and Gingrich 1989), and in urban areas, closer proximity to human activities. Diamond (personal communication) believes that blue jays are a more serious predation threat to warblers in urban areas than in rural areas.

In many areas of the Edward's Plateau, secondary succession is leading towards woodlands dominated by junipers with poor deciduous hardwood regeneration. These areas are not suitable as warbler breeding habitat. Poor deciduous hardwood regeneration may be caused by over-browsing by deer and feral and domestic ungulates, and by oak wilt fungus (*Ceratocystis* spp.) (Wahl et al. 1990).

Wahl et al. (1990) reported warbler breeding habitat loss of approximately 4 percent per year over a 10-year period in urbanizing areas, and about 2 to 3 percent per year in rural areas over the past 20 years. At

this rate, the present population of the golden-cheeked warbler will be reduced by at least 50 percent by the year 2000 due to habitat loss alone. Although this work was based on satellite imagery from 1974 through 1981, knowledgeable individuals agree that the use of more recent imagery to delineate the habitat likely would show the situation to be worse than concluded by Wahl et al. (1990) (Grzybowski et al. 1990a).

In general, warbler species are sensitive to fragmentation of their breeding habitat (Moore and Hooper 1975, Galli et al. 1976, Blake and Karr 1984, Robbins et al. 1989). Wahl et al. (1990) reported extensive fragmentation throughout the range of the golden-cheek except the southern and eastern portions where extensive habitat loss was being documented. Although there was no information available on the minimum habitat patch size suitable for the golden-cheek, Wahl et al. (1990) assumed a minimum patch size of 50 ha. On this basis, they reported a 53 to 84 percent reduction in suitable habitat (>50 ha) around urban areas, and a 56 to 89 percent reduction in rural areas.

More recently, Benson (1990) concluded that the probability of finding golden-cheeked warblers was not related to breeding habitat patch size, amount of edge available, or patch shape. Unfortunately, the data presented do not fully support his conclusions. Further analysis of Benson's data is needed to clarify the situation (Grzybowski et al. 1990a, Short 1991). With respect to fragmentation, the data are consistent with that of several other studies demonstrating a relationship between habitat patch size and probability of habitat occupancy (Grzybowski et al. 1990a). He also reported that the species is 40 percent less likely to be found in habitat within urban areas.

Unfortunately, the wintering habitat of the golden-cheek in Central America is declining at a rate similar to that of the breeding habitat (2 to 4 percent) (Jahrsdoerfer 1990b; see also Lyons 1990).

As noted above, Pulich reported that 58 percent of golden-cheek nests that he found were parasitized by the cowbird. Unlike the vireo, the golden-cheek can fledge young from nests parasitized by cowbirds (Pulich 1976). And the early nesting habits of the golden-cheek may help it to avoid cowbirds, which begin breeding later (Grzybowski, personal communication). Thus, the warbler may not be impacted to the same extent as the vireo by cowbird parasitism. Nonetheless, Pulich reported that cowbird parasitism resulted in a 60 percent reduction in warbler production.

The incidence of cowbird parasitism can be expected to increase with habitat fragmentation. Brittingham and Temple (1983), for example, found that the incidence of parasitism decreases as the distance to an opening in the habitat increases. Furthermore, parasitism in areas near disturbances was higher than in undisturbed areas. Cowbird parasitism may be one of the reasons that area-sensitive species can not use small forest fragments (Robbins et al. 1989). The problem for the golden-cheek is that, ". . . as the population of warblers continues to decline and habitat fragmentation increases resulting in smaller, more isolated habitat patches surrounded by lands with livestock and associated cowbirds, the relative threat of cowbird parasitism becomes greater" (Wahl et al. 1990, p 37).

3. Cave Invertebrates

Several rare and endangered cave invertebrates have a reasonable likelihood of occurrence on Fort Hood (Appendix H). Five species known from northern Williamson County likely will be listed as endangered after a taxonomic review is complete and submitted to the U.S. Fish and Wildlife Service (USFWS) (Reddell, personal communication). Two species presently considered endangered are known from northern Williamson County—Bone Cave harvestman (*Texella* new species) and Coffin Cave mold beetle (*Excavodes* new species). Three others from this area are likely to be petitioned for listing in the near future—the ground beetle *Rhadine noctivaga* Barr, and the spiders *Cicurina* (*Cicurella*) new species and *Neoleptoneta anopica* (Gertsch).

According to Dr. James Reddell, "It would be highly surprising not to find species occurring in northern Williamson County to occur in this area . . ." (see Appendix H). If, on the other hand, there has been some limiting barrier to the occurrence of these species on Fort Hood, then Fort Hood may harbour a unique and endemic species complex of its own. Such endemic species would be good candidates for listing as threatened or endangered.

Cave invertebrates typically are found in moist caves with constant humidity and temperature (Reddell, personal communication). Caves occupied by several endangered invertebrates in Travis and Williamson Counties, TX are small and as shallow as 3 m. The largest has only 60 m of passage (Chambers and Jahrsdoerfer 1988). The cave fauna depends on ground water infiltration. If caves become dry during certain periods of the year, the resident fauna may retreat to deeper parts of the system.

In general, cave invertebrate populations are threatened by: (1) placement of impermeable ground cover, such as parking lots or buildings, in the vicinity of caves, (2) general pollutants including herbicides and pesticides, and (3) any drastic, permanent alteration of vegetation in the vicinity of caves (Reddell, personal communication). These factors affect cave invertebrates by increasing sedimentation, reducing food availability, and altering environmental conditions within the cave.

The major threats to endangered cave invertebrates in the Austin area are related to urbanization—road, industrial, commercial, and residential development (Chambers and Jahrsdoerfer 1988). These activities may result in filling or collapsing of caves and alteration of drainage patterns resulting in a disruption in groundwater infiltration or flooding. Urbanization may also result in: (1) increased inflow of sediment, pesticides, fertilizers, and general urban runoff, (2) increased human visitation and vandalism, and (3) increased populations of exotic invertebrates (e.g., sowbugs, cockroaches, and fire ants) that may compete with or depredate the native fauna.

4. Bald Eagle

The bald eagle has been recorded during winters at Belton Lake on or adjacent to Fort Hood (Cornelius, personal communication). Aircraft overflights are restricted during winter to avoid bald eagle roosting sites. The bald eagle does not nest on the Fort.

5. Peregrine Falcon

The peregrine falcon is a rare migrant occasionally observed on the installation (Diersing et al. 1985).

6. Whooping Crane

The whooping crane also is a rare migrant. Five whoopers were sighted in TA 15 during December 1986. They may fly over or near Fort Hood during spring (1 to 20 April) and fall (1 to 20 October) migration (Diersing et al. 1985). They probably stop over on Belton Lake during their annual migrations.

IV. VIEWS OF EXPERTS

Recognized experts were contacted by telephone to discuss the current state of knowledge with respect to the species under consideration in this biological assessment. Extensive notes were taken during each conversation and a summary prepared within 24 hours. The appropriate summary was sent to each of the experts for their review to ensure that their views were properly represented. Individual summaries are presented in the following pages. General topic areas intended to be covered in each conversation were:

1. Views on the Species
    a. Status
    b. Threats to survival/existence
    c. Adequacy of current information

2. Views on the Impact of Fort Hood
    a. Basis of knowledge or opinion
    b. Direct or indirect impacts

3. Impacts of cowbirds on golden-cheeked warblers and black-capped vireos

4. Effect of the presence of cattle on cowbird density

5. Possible management actions to protect/enhance/mitigate

Other recent contacts were:

- 18 March 1991—Mr. William Russell, U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, MD. To discuss noise impacts on wildlife.

- 27 March 1991—Ms. Alisa Shull, USFWS, Arlington, TX. To discuss availability of any recent reports on the black-capped vireo or golden-cheeked warbler; draft recovery plan for the black-cap; the Benson report; black-cap and golden-cheek experts; and the Alternative Actions section of the biological assessment.

- 27 March, 1991—Dr. Joseph Grzybowski, Central State University, Edmond, OK. Preliminary inquiry regarding a future telephone interview.

- 27 March, 1991—Mr. Clifton Ladd, Espey, Huston, and Associates, Austin, TX. To identify additional information available on the golden-cheeked warbler.

- 27 March, 1991—Ms. Jane Lyons, National Audubon Society, Austin, TX. To inquire regarding her work on the winter range of the golden-cheeked warbler.

- 27 March, 1991—Dr. Joseph Marshall, Smithsonian Institution, Washington, DC. To inquire as to any recent work that he might be involved in with the black-cap or golden-cheek, and the availability of any additional information on these species that he has.

- 28 March, 1991—Mr. Rex Wahl, National Audubon Society, Corpus Christi, TX. Preliminary inquiry regarding his work on the golden-cheeked warbler status survey.

- 28 March, 1991—Ms. Carol Beardmore, USFWS, Corpus Christi, TX. To inquire as to the availability of information from her thesis on the golden-cheek.

- 3 April 1991—Mr. Clifton Ladd, Espey, Huston, and Associates. To inquire regarding the availability of Espey, Huston, and Assoc. reports on the black-capped vireo and golden-cheeked warbler.

- 3 April 1991—Dr. Charles Sexton, Environmental and Conservation Services Department, Austin, TX. To inquire regarding his annotated bibliography on the golden-cheek, and his Ph.D. thesis.

- 3 April, 1991—Dr. David Steed, DLS Associates, Austin, TX. To obtain a copy of the Endangered Species Status Report on the 3M Austin Center.

- 3 April, 1991—Dr. James Reddell, Texas Memorial Museum, Austin, TX. To discuss information available on cave invertebrates that might occur on Fort Hood.

- 16 May, 1991—Mr. Phillip Clayton, U.S. Fish and Wildlife Service, Corpus Christi, TX. To obtain any available information on *Croton alabamensis*.

- 16 May, 1991—Ms. Jackie Poole, Texas Parks and Wildlife, Austin, TX. To obtain any available information on *Croton alabamensis*.

- 16 May, 1991—Dr. Robert Shaw, Colorado State University, Fort Collins, TX. To obtain any available information on *Croton alabamensis*.

- 16 May, 1991—Dr. Warren Pulich. To obtain additional background information on his experience with the golden-cheeked warbler. He said that he had no problem with the summary of conversation.

- 16 May, 1991—Mr. Clifton Ladd. To obtain further information on his experience with the golden-cheeked warbler and black-capped vireo; and to discuss his experience in conducting biological assessments. He said that he had no problem with the summary of conversation.

- 17 May, 1991—Dr. David Diamond. To obtain additional background on his experience with the golden-cheeked warbler and black-capped vireo. He said that he had no problem with the summary of conversation.

- 17 May, 1991—Dr. Joseph Grzybowski. To obtain his best estimate of juvenile survivorship in the black-capped vireo. He gave a range of 35 to 55 percent, and indicated that 50 percent or more may be reasonable. The data, however, are preliminary. He said that he had no problem with the summary of conversation.

- 17 May, 1991—Dr. Denice Shaw, EPA, 944 East Harmon Avenue, Las Vegas, NV. To discuss any recent development in her work with the golden-cheeked warbler. She has not been much involved since completing her dissertation but is soon to be involved in a project to map golden-cheek habitat throughout Texas via satellite imagery. Results of ground truth work indicated that the maps she had prepared for her dissertation were 90 percent accurate.

- 20 May, 1991—Ms. Cary Norquist, USFWS, Jackson Field Office, Jackson, MS. To discuss her knowledge regarding *Croton alabamensis*. Referred us to a publication by Robert Kral

(1983), and to Steve Ginzbarg of the University of Texas. She will complete field work on the species this year prior to submitting a listing proposal.

- 20 May, 1991—Dr. Charles Sexton, He called to make a minor correction in the summary of conversation with regard to the issue of "take." Otherwise, he found the summary accurate.

- 21 May, 1991—Mr. Steven Ginzbarg, Herbarium, University of Texas, Austin, TX. To inquire regarding taxonomy of *Croton alabamensis*. We discussed life history, taxonomy, and a manuscript soon to be published.

- 3 June, 1991—Mr. William Russell, to discuss further noise impacts on wildlife.

Summary of telephone conversation with:

Dr. Warren Pulich
University of Dallas
Biology Department
Irvine, TX 75062
214/721-5307

Dr. Warren Pulich has studied the golden-cheeked warbler since the mid-1950s. His monograph on the species is the most definitive work to date. He is familiar with the habits of the bird throughout its range.

Dr. Pulich believes that the golden-cheeked warbler requires virgin timber, oak-juniper areas that have not been cut over. He disagrees with Kroll's conclusion that the warbler is a typical edge species or that second growth juniper represents potential habitat. He believes that aging of junipers is too tenuous to accurately characterize stand age.

The most important thing to do for the warbler at Fort Hood is to protect the habitat. Although he did not believe that Fort Hood had particularly good warbler habitat when he visited the site 3 times in the 1970s, if birds did occur there now, then habitat protection would be the most important management action.

Although he said that there probably wasn't enough information to conclude that the species is endangered, such protection certainly benefitted the species. Someone should have revisited the sites that he inventoried to document status of the population on the ground and in the field.

More work is needed on the status of the population and its habitat in Central America. The effects of fire ants on nesting success also should be investigated.

The primary management action should be to preserve habitat for the warbler.

D.J. Tazik
USACERL
8 May 1991

Summary of telephone conversation with:

Mr. Clifton Ladd
Espey, Huston, and Associates
P.O. Box 419
Austin, TX 78767
512-327-6840

Mr. Ladd has worked with both the golden-cheeked warbler and black-capped vireo since 1983. He completed an M.S. thesis on the habitat of the golden-cheeked warbler in 1985. Presently, he is a Senior Staff Ecologist and Wildlife Biologist with Espey, Huston, and Associates. In this capacity he conducts endangered species habitat surveys, prepares biological assessments, and is involved in section 7 consultations.

Second growth cedar is known to provide habitat for the golden-cheeked warbler. Mr. Ladd believes that the habitat on Fort Hood is probably as good as anywhere else that he has visited. Although he has questions regarding the adequacy of the USFWS status survey, he believes the warbler does warrant protection. Also, the extent of the endangerment may not be as extensive as some might think.

Although he has visited Fort Hood, he does not have enough good information to form an opinion as to the status of either the warbler or the vireo on Fort Hood. He did recall having observed tanks and tank trails in the vicinity of warbler habitat during his visits during the mid-1980s. He also thought that the Army does a good job overall to protect habitat, but may need to do a better job staying out of some areas that require protection.

The cowbird probably is a significant threat to the warbler, and it is a good idea to manage cowbird populations.

Historical evidence suggests that the warbler was an inhabitant, not of large continuous blocks of juniper-oak habitat, but of isolated patches of woodland. Thus, fragmentation *per se* probably is not an inherent problem for the warbler as it seems to be for many eastern U.S. species. However, urbanization, which includes habitat fragmentation, does adversely affect the species.

While large blocks of habitat could do a better job of protecting the warbler from cowbird parasitism, direct cowbird control is needed. Changes in the existing cattle grazing systems in areas occupied by the vireo and warbler should be evaluated. It might be prudent to remove cattle during the breeding season from areas occupied by these species.

The most important actions for management of the vireo and the warbler are to protect habitat and reduce cowbird numbers. It may also be important to evaluate the effects of fire ants.

Mr. Ladd suggested that we may want to include *Croton alabamensis*, a category 2 plant species, in our biological assessment. This is a new variety of *C. alabamensis* recently discovered on Fort Hood.

D.J. Tazik
USACERL
8 May 1991

Summary of telephone conversation with:

Dr. David Diamond
Resource Protection Division
Texas Natural Heritage Program
4200 Smith School Road
Austin, TX 78744
512-448-4311

Dr. David Diamond is a plant ecologist and Coordinator of the Texas Natural Heritage Program, and has been working on endangered species related problems there for 6 years. He participated in the status survey of the golden-cheeked warbler and is familiar with the habitat requirements of both the golden-cheek and black-cap.

The greatest threat to both the black-capped vireo and golden-cheeked warbler is habitat destruction resulting from rangeland improvement practices and urbanization. Urbanization is especially critical in the case of the warbler. Deer management also is an important consideration in this regard. High deer densities and resulting over-browsing does negatively impact the habitat. Oak wilt disease can be a problem in some areas. Oak regeneration in some areas is hindered by browsing by both domestic and wild herbivores.

The warbler is a species of the taller, denser oak-juniper woodlands. The bird tends to occur in the more mesic sites, canyons and seepy slopes, where oaks and other deciduous hardwoods occur. Dry uplands tend not to have as much deciduous hardwood cover. Stand age *per se* is not that important although the size and structure of the stand is. Most of the existing oak-juniper woodlands have been cut over, so that there isn't much virgin timber left. The availability of peeling bark is not so important as the characteristic of the stand.

The vireo occurs across a broad climatic range from west Texas where rainfall averages 15 inches to the Balcones Escarpment where rainfall averages about 32 inches. The vireo does not occupy successional stands throughout this range. While many of the scrubby habitats occupied in the eastern portion of the range are successional and ultimately grow up into mature oak-juniper woodland, areas occupied in the west represent essentially climax conditions. Something commonly lacking from vireo habitat descriptions is that emergent trees are usually present.

Fire may not uniformly be the best tool for vireo habitat development and management. Experimental studies need to be done to evaluate a variety of habitat management techniques.

D.J. Tazik
USACERL
8 May 1991

Summary of telephone conversation* with:

Mr. Rex Wahl
National Audubon Society
3765 South Alameda Street
Suite 415
Corpus Christie, TX 78411
512-854-6070

Mr. Wahl was a biologist with Texas Parks and Wildlife when he conducted the status survey on the golden-cheek for the USFWS. He also was responsible for issues related to the black-capped vireo. He visited Fort Hood on numerous occasions during 1987 through 1989 in the course of his work on the warbler, and discussed issues related to both species with myself and the Fort Hood Fish and Wildlife staff.

Mr. Wahl expressed some concern with regard to the Benson report, particularly the conclusion that patch size is irrelevant to the golden-cheeked warbler. Mr. Wahl noted that the fact that 62 percent of urban habitat fragments were not occupied by the warbler was a demonstration of a fragmentation effect. Also, the fact that Fort Hood is not urbanized means that much of the suitable habitat on the Fort ought to be occupied by golden-cheeks. A major gap in our knowledge of both the vireo and the warbler is the impact of habitat patch size on nesting success.

Recent data collected by Carol Beardmore will shed some light on habitat use by the warbler for foraging and brooding of the fledged young. This information probably will have some significant habitat management implications.

With regard to the vireo, we probably do not yet know the extent and size of the total population. There needs to be more searching in areas not yet surveyed. Although the species probably should remain on the endangered list, the population probably is larger than was thought at the time of listing. In contrast, we do have a good idea of the number of warblers.

Habitat fragmentation due to military activities may be a concern on Fort Hood. The highest warbler densities are found in large blocks of habitat with large mature trees. Fort Hood warbler densities are about average for the species as Pulich observed. Nonetheless, the large area of habitat available makes the Fort an important area for eventual recovery of the species, especially considering the paucity of suitable habitat on adjacent lands. Wahl observed warblers in juniper-oak habitats on Fort Hood that contained post oak. He did not believe that the warblers would be disturbed by training activities in the absence of habitat disturbance, and thought the birds adaptable to those activities.

According to Wahl, the best golden-cheek habitat is large blocks of very old/mature, closed canopy oak-juniper. He observed highest warbler densities (62.5/100 ha) in a 51 ha area that was among the most mature area that he visited in the course of his status survey.

Cowbird parasitism is a major data gap with regard to the warbler. Although Pulich presented good data, the effect of habitat fragmentation was not considered.

Removal of cattle from Fort Hood will cut down cowbird densities and benefit all resident songbirds that may be parasitized. Cowbird densities do vary on the Edward's Plateau and may result in a variation in

*Supplemented by subsequent correspondence (undated).

the incidence of parasitism. Cowbird densities are ten times higher on areas with livestock compared to areas without.

Golden-cheek habitat protection on Fort Hood and elsewhere should allow existing areas to mature. Ultimately, this will produce the best warbler habitat. As regards fire ants, he is unaware of a significant problem for either the vireo or the warbler.

Dean Hector of Texas Parks and Wildlife is presently preparing a recovery plan for the warbler. Fort Hood should be a part of that plan.

D.J. Tazik
USACERL
9 May 1991

Summary of telephone conversation with:

Dr. Joseph Grzybowski
Department of Biology
Central State University
Edmond, OK 73060
405-341-2980

Dr. Grzybowski presently is the regional authority on the black-capped vireo and also is familiar with the golden-cheeked warbler. He has been studying the vireo since the early 1980s and continues research on the vireo in Texas and Oklahoma. USACERL researchers and Fort Hood Wildlife Biologists consulted with Dr. Grzybowski throughout the course of research on Fort Hood vireos. Most of the procedures employed in the study were based in part on consultations with Dr. Grzybowski. The USFWS has contracted with Dr. Grzybowski to prepare a black-capped vireo Recovery Plan.

Military-related disturbance on Fort Hood has led to the development of much black-capped vireo habitat and inadvertently benefitted the vireo. Fort Hood would be a good site to look at a variety of land management practices for development and maintenance of vireo habitat. It also is a good area to study dispersal of female and young birds. (Information on the latter would also be useful to obtain more accurate information on juvenile and adult survivorship and acreage requirements for viable populations of the species.)

Fort Hood is puzzling in that despite the high level of cowbird parasitism and low vireo production, the population seems to maintain itself. Why are vireos still present on Fort Hood? Answering this question may require surveys to identify productive populations that may be present off-post on private or other lands.

Total removal of cattle from Fort Hood should benefit the vireo. Data from other parts of Texas indicate that in the absence of cattle, parasitism is in the range of 35 to 40 percent. However, sheep and goats are often present on such areas. At Fort Sill, where there are no cattle, parasitism is in the range of 40 to 50 percent in contrast to areas on the adjacent Wichita Mountains Wildlife Refuge where parasitism is at 60 to 70 percent and buffalo and longhorn cattle are present. It seems clear that presence of cattle raises the incidence of parasitism.

Habitat protection and maintenance require attention to the configuration and patchwork of the habitat. Vireos in habitat patches, especially small patches surrounded by woodlands, are likely to be impacted by predators and cowbirds to a greater extent than in habitat patches surrounded by earlier successional habitats. The woodlands may have a higher predator load. In managing vireo habitat, issues to consider include the ability of birds to find patches, distance between patches, ephemeral nature of the habitat, patch size, and the location of small patches relative to large patches (i.e., small habitat patches near large patches are more likely to be occupied by black-caps than small isolated patches).

A wise management strategy might be to simply increase the size of existing habitat patches rather than to create many new patches. Also, preliminary data analysis suggests that individual habitat patches should be within about 11 km of one another to allow for interpatch dispersal. Preliminary data analysis indicates that juvenile survivorship may be substantially higher than what we have so far been able to document. Regarding the golden-cheeked warbler, the main issues are: the area/fragmentation effect, cowbird parasitism, and habitat requirements (e.g., oak:juniper ratio).

D.J. Tazik
USACERL
8 May 1991

Summary of telephone conversation with:

Ms. Carol Beardmore
c/o Corpus Christie State University
Campus Box 338
6300 Ocean Drive
Corpus Christi, TX 78412
512/888-3346

Ms. Carol Beardmore has conducted a graduate study of golden-cheeked warbler habitat and breeding season activity levels in the Austin, TX area. She is completing her thesis on her research findings and currently is employed by the U.S. Fish and Wildlife Service in Corpus Christi, TX.

Ms. Beardmore noted a lack of information on the effects of human disturbance on breeding golden-cheeked warblers. She suggested that future research activities focus on documenting the effects of disturbance on warblers since this has important management implications.

She has visited Fort Hood on one occasion during which she visited warbler habitats on the west side of the Fort. She noted that in the areas she visited the habitat was very "linear" but that warblers still occurred in those areas. She has no personal experience with the more extensive warbler habitat located in the eastern and north-central portions of the Fort.

She recommends no additional loss of warbler habitat and limiting access to warbler habitat during the breeding season to reduce potential disturbance.

T.J. Hayden
USACERL
14 May 1991.

Summary of telephone conversation with:

Dr. Charles Sexton
Environmental and Conservation Services Department
P.O. Box 1088
Austin, TX
(512) 449-2694

Dr. Sexton has studied both the black-capped vireo and golden-cheeked warbler as Environmental Specialist with the Environmental and Conservation Services Department, City of Austin. Much of his work has focused on the status and distribution of these species, and the effects of urbanization on their occurrence.

Dr. Sexton stated that the basic habitat requirements of golden-cheeked warblers are relatively well known. However, he expressed the need for more information on the effects of habitat fragmentation on this species. Several potential effects of habitat fragmentation have been well described such as increased cowbird parasitism and access by predators. The influence of other factors such as the type of surrounding habitat (e.g., urban vs. rural) may be less well known and require further study.

He cites a current study in the Austin area of the increased abundance of blue jays in urban warbler habitats compared with rural habitat patches. Blue jays are known to predate eggs and nestlings of small bird species, and preliminary data suggest a negative correlation between blue jay and warbler occurrence. Such a finding would have implications for minimum area requirements of urban versus rural reserves.

Dr. Sexton has not visited Fort Hood. Although increased urbanization does not affect endangered species habitats on the Fort, the effects of habitat fragmentation due to military activity such as the creation of tank trails should be assessed.

The black-capped vireo is adapted to a "patchy" habitat distribution due to the successional stage of its preferred habitat. Effects of habitat fragmentation on this species are difficult to discern.

He expressed the opinion that limited, occasional disturbance of these species during the breeding season is probably not detrimental. Moderate to high levels of disturbance (e.g., large numbers of people in the habitat over an extended period of time) could disturb several aspects of behavior, including disruption of territory establishment prior to nesting, disruption of foraging behavior, or prevention of adults from feeding young. Although such disturbance may affect relatively few birds, there is some indication that the USFWS may view this as a "take" under the provisions of the Endangered Species Act.

Because of the habitat preference and nesting ecology, black-capped vireos may be more susceptible to direct human disturbance than golden-cheeked warblers.

T.J. Hayden
USACERL
14 May 1991.

Summary of telephone conversation with:

Mr. Dean Hector
Texas Parks and Wildlife Department
Fountain Park Plaza, Suite 320
3000 South Interstate Highway 35
Austin, TX 78704
(512) 448-4311

Mr. Hector currently is writing the recovery plan for the golden-cheeked warbler for the Texas Parks and Wildlife Department. He is collating information on the warbler from all available sources and is well acquainted with the current state of knowledge on this species.

Mr. Hector expressed concern about the limited knowledge of the basic biology of golden-cheeked warblers. He cited Pulich's study as the only research that presents data on basic reproductive parameters such as the number of young fledged by breeding pairs and nest parasitism rates. These data are important when evaluating habitat quality and minimum area requirements. These data may continue to be limited due to the difficulty of locating warbler nests and because long-term studies similar to Pulich's may be impractical.

He stated the need to differentiate between secondary disturbance of warblers such as burning or clearing of habitat and direct effects such as the movement of troops through breeding habitat. There is a lack of information on the effects of direct human disturbance.

Some preliminary estimations of reserve size are based on population models with limited data specific to the golden-cheeked warbler. Banding studies at Fort Hood could help fill this gap.

Mr. Hector suggested that characterization of the warbler as an old-growth, "climax" species may be inappropriate. Evaluation of warbler densities and habitat parameters throughout Fort Hood would help address this question. Integration of this ground-truth data with satellite imagery will have important management value both specifically to Fort Hood and on a regional scale.

T.J. Hayden
USACERL
15 May 1991.

Summary of telephone conversation* with:

Ms. Susan Rust
Stewardship Services
168 Chevy Chase
San Antonio, TX 78209
512-826-4698

Ms. Rust is a field biologist with 19 years of experience in the State of Texas. She has conducted biological monitoring and site inventories of endangered species in Texas and has 4 years of experience with the black-capped vireo and 2 years of experience with the golden-cheeked warbler. She conducted vireo and warbler monitoring at the Camp Bullis Training Site of Fort Sam Houston, TX during 1990 and 1991 under contract with USACERL.

Black-capped Vireo

According to Ms. Rust, the black-capped vireo seems to be a well distributed species, and perhaps more abundant than was thought at the time of listing the species as federally endangered. At the present time, the population probably is stable except on the eastern and northern portion of its range. The status of the species should be reviewed in the near future to determine if it warrants federal endangered species status or could be downlisted to threatened.

She recognizes five major breeding population centers: (1) Mexican, (2) western Edward's Plateau to Big Bend and south to Mexico, (3) Kerr to Lampasas Cut Plain, (4) the eastern edge of the Edward's Plateau, and (5) Oklahoma. The Mexican and western portion of the population is probably reasonably secure. This area is dry and topographically complex so that succession is slow within the habitat type, and in some cases the "climax" vegetation may be suitable for the vireo. Habitats such as those at Kickapoo Cavern State Park and Devil's River are probably stable. The Kerr to Lampasas Cut Plain area contains considerable shinnery, which becomes excellent black-cap habitat following periodic disturbance. The vireo population in this region probably is fairly secure so long as fire and other vegetation control measures, extensively used in this part of Texas, continue to be applied. However, maintenance of vireo habitat in this area requires periodic disturbance. Here, game management practices favor the vireo. Along the southeastern portion of the range, for example, in northern Bexar County and around western Travis County, the local climate and land management practices favor rather rapid succession to a woodland climax unsuited to the vireo. Thus, active management using fire and other forms of disturbance is required to maintain vireo habitat here where it may be least cost effective. Unfortunately, fires are restricted around urban areas of this region (i.e., Austin and San Antonio). Regarding Oklahoma, Ms. Rust refers us to Dr. Grzybowski.

Ms. Rust is less concerned with the cowbird parasitism problem than many others seem to be. We simply do not know what the historical [normal] level of parasitism for this bird was (or is). Ms. Rust expressed the opinion that cowbirds have been a factor influencing the black-capped vireo for a long time, and that the vireo can probably handle even seemingly high levels of parasitism without serious impacts on reproductive success and population stability. In other words, the vireo is not necessarily doomed by cowbird parasitism. The vireo, in fact, often appears to abandon nests parasitized by the cowbird and start new nests, which is an evolutionarily adaptable response and indicates some level of parasite recognition. The relationship between cowbird and vireo has not been studied well enough to warrant placing excessive resources into cowbird control where conditions are reasonably natural. She notes, however, that in areas such

* The original summary prepared by D.J. Tazik was modified based on further correspondence from Ms. Rust dated 18 May 1991 and a telephone conversation on 24 May 1991. The revised summary is presented here.

as Fort Hood, where many cattle roam freely over wide areas, and/or where supplemental food is available/provided, cowbird abundance may be artificially high, and that some form of control is necessary to enhance vireo reproductive success.

She indicated that banding work is important to further document dispersal potential, site tenacity, and survival of adult and juvenile vireos.

Although Ms. Rust has never visited Fort Hood, she has conducted site surveys on Camp Bullis. Her experience has been that military activity is probably favorable to the resident population of the black-capped vireo. Although individual birds and pairs may be adversely affected by certain activities, the overall effect seems to be positive for the bird. At this location, maintenance of the habitat requires occasional disturbance.

In evaluating impacts of military activities and cowbird parasitism on the vireo, it is important to take a population-based view. If population trend data indicate that the local population is stable and relatively abundant, then adverse impacts that affect only a few individual birds should be considered insignificant. Also, disturbance due to occasional incursions of tracked vehicles into vireo habitat and occasional spot burning on the installation when the birds are on their wintering grounds may be beneficial to the habitat in the long run. Of course, such activities should be avoided when the birds are present on the installation.

Research in restorative management should be undertaken to study the possibility of creating additional habitat for the vireo in potentially suitable landscape areas currently not being used by the birds, but that are reasonably near to occupied black-capped vireo colony sites. This could be applied at Fort Hood in areas not likely to conflict with training activities.

Major information gaps with regard to the black-capped vireo include status of the population on breeding and wintering grounds in Mexico and the whole complex of interactions between vireos and cowbirds and alternative cowbird host species. Also, work needs to be done to evaluate the compensatory response of increased nest depredation in areas where cowbird populations are artificially lowered and parasitism on black-caps reduced.

Golden-cheeked Warbler

Ms. Rust is not convinced that the golden-cheek should be listed as endangered. In her opinion, the species seems to be much better distributed and more abundant within its winter and limited breeding range than formerly thought. Threatened status is probably more in order unless deterioration in the winter range warrants the stronger status of endangered. Further study is needed regarding the status of its winter range.

Golden-cheeks are found occupying areas outside of and smaller than those delineated according to Landsat satellite imagery used in the Status Survey (prepared by Wahl and co-workers). For example, on Camp Bullis, the warbler occupies areas not "picked out" by imagery. These include cedar elm bottoms that are bordered by junipers. On Camp Bullis, golden-cheeks occur wherever adequate stands of old (about 20+ years) to very old juniper is present in conjunction with a mixture of deciduous hardwoods. Early in the breeding season, the warblers seem to use the hardwoods extensively, but later on may use the juniper component to a greater degree. Live oak-juniper regrowth alone is generally not good habitat.

Land management is the key to long-term survival of the golden-cheeked warbler. Mature woodland habitat usually associated with drainage systems and topographic complexity must be protected to preserve the species. In Bexar County, deer seem to be a problem where dense populations hinder hardwood regeneration. This latter point is in need of empirical support. Exclosures in appropriate areas need to be established and monitored for long-term vegetation response (i.e., we need more experimental control sites).

Urbanization is a major threat to the golden-cheek. A large segment of the population does occur in the path of ongoing urbanization, and the species is sensitive to human intrusions that accompany urban development. Habitat loss and perhaps fragmentation due to urbanization is a problem for this species. However, county roads with narrow shoulders and fire breaks, and absent residential development, do not seem to be a problem. And the golden-cheek seems to be able to tolerate more edge than has been portrayed in the literature. Research on the effects of patch size and degree of patch isolation of this species habitat is essential.

Presently, there is insufficient information to determine if cowbird parasitism is a problem for the warbler. Trend analyses seem to be in order.

According to Ms. Rust, overall, military activity at Camp Bullis does not negatively impact the golden-cheek so long as vegetation clearing in sensitive golden-cheek areas is restricted. Occasional traffic through occupied areas should have little detrimental effect as long as the habitat is left undisturbed. For example, at Camp Bullis, one of the main paved roads goes through an area occupied by golden-cheeks, which seem to be unaffected by the local traffic.

Golden-cheeked warbler management requires habitat protection. Appropriate woodland areas should be allowed to mature into suitable habitat. Suitable or potentially suitable habitat fragmented due to military or other activities should be encouraged to develop into larger blocks of contiguous habitat or should be connected with woodland corridors. This would benefit a wide variety of other species in addition to the warbler.

Simultaneous management of the black-capped vireo, which prefers early successional habitats, and the golden-cheeked warbler, which requires late successional woodlands, will require tradeoffs. One approach is to manage for a landscape mosaic; i.e., burn or roller chop upland areas to create vireo habitat, and leave drainage areas alone for use by the warbler. Open grasslands can continue to be burned to minimize juniper invasion into rangeland.

D.J. Tazik
USACERL
15 May 1991
Revised 24 May 1991

Summary of telephone conversation with:

Dr. James R. Reddell
Texas Memorial Museum
2400 Trinity
Austin, TX 78705

Dr. James R. Reddell has spent 30 years studying cave invertebrates in Texas and Mexico and has authored numerous publications on the subject. Many of the currently known cave-restricted species in Texas were first collected by Dr. Reddell or by workers under his supervision. He has visited caves on Fort Hood in the early 1960s and in January and March 1990.

Dr. Reddell stated that cave invertebrates typically are found in moist caves with constant humidity and temperature. Caves in which invertebrates occur may be as shallow as 10 ft* and may have active streams or no running water. These caves may be relatively dry during some periods of the year when resident species retreat to deeper parts of the system.

He stated that several of the caves he visited at Fort Hood met the habitat requirements for the occurrence of cave invertebrates.

Biological surveys of caves on Fort Hood likely will identify species currently endangered or candidates for listing. Five species known from northern Williamson County likely will be listed as endangered after a taxonomic review is submitted to the USFWS. The distribution of these species may extend to Fort Hood.

The natural isolation of cave systems is one of the major factors in the evolution of rare, endemic cave species. Dr. Reddell indicated that if there is some limiting barrier to the occurrence on Fort Hood of endangered species from known localities south of the Fort, then caves in the Fort Hood area may have their own unique complex of species. Species endemic to the Fort Hood area would probably be candidates for endangered species listing.

Major threats to cave invertebrates listed by Dr. Reddell included: (1) any impermeable ground cover in the area of caves, e.g., parking lots or buildings, (2) general pollutants such as herbicides and pesticides, and (3) any drastic, permanent alteration of vegetation cover in the vicinity of caves.

These factors affect cave invertebrates by increasing sedimentation in caves, reducing food availability to cave residents, and altering environmental conditions within the cave. Cave invertebrates are particularly sensitive to changes in environmental conditions within the cave. Dr. Reddell stated that such factors as a change in pH level can have an adverse impact on some species.

Dr. Reddell witnessed several examples of disturbance of caves on Fort Hood. He noted that extensive tank trails around Runoff Cave had significantly reduced vegetation cover around the cave. This resulted in significant sedimentation in the cave. He also noted sedimentation in a sink that was probably an open cave at one time. He observed trash in several caves including rusting metals and old batteries, which would adversely affect resident populations of cave invertebrates by altering the cave environment.

Dr. Reddell recommended restricting maneuver vehicle traffic near caves, prohibition of trash dumping, and control of fire ants in the vicinity of caves. Limiting maneuver vehicle traffic near caves would reduce sedimentation and alteration of drainage into caves and would prevent cave collapse. He noted fire ants were

*1 ft = 0.305 m.

a significant threat to cave invertebrate populations in the Austin area, and it may require chemical treatment of ant hills within several acres around caves to eliminate the ants.

Tim Hayden
USACERL
23 May 1991

V. ONSITE INSPECTION

A. Plants

1. Croton alabamensis

A site visit was made during mid-March 1991 by researchers from Colorado State University to the area occupied by *C. alabamensis* (Shaw, personal communication). Specimens were collected in flower and sent to Robert Kral of Vanderbilt University. Surveys were conducted during June 1991 along two creek bottoms where populations are known to delineate extent of those populations (Figure 12). A final report is in preparation (Aplet et al. 1991). A summary based on a preliminary draft of that report follows.

Two major populations are known that occupy two canyon tributaries of Owl Creek in TAs 2 and 3 of the Fort. Five additional canyons were searched. Three plants were found in a canyon located between the first two, and several additional plants were found along the stretch of Owl Creek between these two tributaries. Further study was restricted to the two major populations and the intervening third canyon area where only three plants were found. The study was intended to describe population structure and habitat associations.

C. alabamensis on Fort Hood formed dense thickets typically situated within 60 m of the canyon creekbeds. Stands were composed of healthy populations of adults, juveniles, and recruits. Density in the two major canyon areas averaged 20.7 to 39.1 adults per 100 m^2. Aplet and co-workers (1991) estimate a total population of about 20,000 individuals in these canyons. Distribution and abundance within the canyons was unrelated to canopy closure and topography. However, much of the variability in density was explained by soil depth. *C. alabamensis* also appeared to be associated with the more mesic areas within each canyon.

Each of the three canyon areas examined exhibited similar plant community composition in both overstory and understory. Principal overstory species included Texas ashe, ashe juniper, Texas oak, and chinquapin oak. Overstory canopy cover ranged from 50 to 99 percent. Species abundant in the understory included Texas ashe, grape, Carolina buckthorne, ashe juniper, poison ivy, Texas oak, and deciduous holly. Understory cover ranged from 16 to 50 percent.

There was little to explain the absence of *C. alabamensis* in the middle canyon except that this area had a significantly steeper streambed gradient compared to the canyons with major populations.

The Fort Hood populations of *C. alabamensis* differ from those in Alabama in several respects. Alabama populations were associated with shallow soils, found in areas with few live trees, and adapted to drought conditions, and exhibited no asexual reproduction (Farmer 1962). In contrast, Fort Hood populations were associated with deeper soils and a denser overstory, occupied mesic canyon bottoms, and exhibited asexual reproduction via nodal rooting (layering). It is clear from these results that management recommendations for Fort Hood and other Texas populations must be based on site-specific studies, not on studies conducted in Alabama (Aplet et al. 1991).

Anecdotal observations on Fort Hood indicate that *C. alabamensis* responds to cutting by resprouting. Response to fire and soil disturbance is undocumented.

B. Animals

1. Black-capped Vireo

This section summarizes research on the black-capped vireo at Fort Hood. Unless otherwise noted, data discussed here were collected during the years 1987-89. Three previous reports provide additional information and supporting data on distribution and abundance (Tazik et al. 1992a), habitat preferences (Tazik et al. 1992b), and population and nesting ecology (Tazik and Cornelius 1992) of the black-capped vireo on Fort Hood. This information is also presented in Tazik (1991). Data from the 1990 (Hunt 1990) and 1991 (Hayden and Tazik 1991) field seasons are reported where appropriate.

a. Survey and Research Area

Survey and research areas for the onsite inspection included all known and potential black-capped vireo habitat within the Fort Hood boundary. Detailed descriptions of the geography, geology, climate, and vegetation associations of Fort Hood are presented in the "Site Description" chapter of this assessment (p 13).

b. Methods and Results

(1) Distribution, Abundance, and Potential Habitat

Distribution of vireos was determined by extensive on-the-ground searching aided by the use of aerial photographs, a helicopter overflight, and information from installation personnel.

Sites occupied by the vireo on Fort Hood (Figure 13) were associated with the more elevated areas of the Fort; the mesa-like hilltops and their side slopes. Vireos were common along a ridge running east southeasterly from the northwest corner of the post. Similar areas were occupied at West Fort Hood and along Pilot Knob Range in the south half of the Fort. The vireo also has been observed in the southeastern portion of the Fort. The distribution of vireo sites was related to geology, soils, elevation, slope, and aspect (see discussion of potential habitat below). Presently occupied sites constitute less than 1 percent (561 ha) of the Fort Hood land area.

Population size at individual vireo sites was determined by mapping individual vireo territories, which was facilitated by color banding of individual birds to positively identify territory occupants. In 1987, 85 males and 33 females were observed on Fort Hood (Table 1). (All tables are included in Chapter IX, p 81.) Observed numbers increased to 132 males and 93 females in 1988 and 143 males and 108 females in 1989. The large increase in numbers reported for 1988 and 1989 compared to 1987 is due to expanded and more detailed survey work during the latter years compared to 1987. Only five sites were well surveyed in 1987 compared to 15 in 1988 and 16 in 1989 (Table 1). During 1990, observations were made of 111 males and 63 females. However, the survey effort in 1990, especially in the live fire training area, was less than in 1988 and 1989. During 1991, 152 territories were observed, 11 of which were located in areas not surveyed previously.

Data for 1989 represent the most thorough survey of the Fort Hood vireo population prior to 1991. The inferred presence due to observed nestings of an additional 29 females, beyond the 108 actually observed, resulted in an estimate of 280 adult vireos on Fort Hood in 1989. Data collected during 1991 are comparable and will be reported fully in due course. A preliminary assessment of these latter data indicate a population of 300 adult vireos. Over one-half of the population is located within the live fire training area.

Numbers of territorial males at sites that were thoroughly surveyed (Table 1) indicate vireo populations on Fort Hood were relatively stable during the years 1987 through 1990. At five sites which were surveyed

completely in both 1987 and 1988, 26 territories were located in both years. In 1988 and 1989, 118 and 128 territories respectively were located at 12 sites adequately surveyed in both years. In 1989, 81 territories were located at 10 sites, compared with 82 territories at these same sites in 1990. This stability appears to have carried over into 1991 (Hayden and Tazik 1991).

Some individual sites did show annual changes in territory numbers. For example, increases occurred between 1988 and 1989 at Area 2 Top, Red Bluff, and Robinette Point. Declines in populations occurred at Area 6, Jack Mountain, and west Fort Hood.

In most cases, the cause of population changes at individual sites is unknown. However, the loss of four pairs at west Fort Hood between 1988 and 1989 was due to an accidental fire of unknown origin in the fall of 1988 that destroyed habitat within four territories occupied during 1988. These territories were recolonized in the 1990 breeding season. A fire at Lone Mountain in December 1989 destroyed most of existing vireo habitat at this location that was occupied by three territories during the previous breeding season. No vireos were observed at Lone Mountain during the 1990 breeding season, but the site has since been recolonized. On 4 June 1991, three males, one female, and one nest were observed on Lone Mountain.

Potential vireo habitat was delineated based on an expected association between known vireo territory locations and several landscape features including geology, soils, elevation, slope, and aspect. Vireo preferences for specific categories within each landscape feature were quantified by comparing the frequency of map layer categories in a 3-year composite of vireo occupied areas to the frequency of categories on Fort Hood as a whole using chisquare analysis. Spatial analyses were performed using the Geographic Resources Analysis Support System (GRASS) geographic information system (GIS).

Vireos exhibited distinct preferences for specific categories of geology, soils, elevation, slope, and aspect. Vireos were most closely associated with the dense and loose limestone geologic formations typical of high elevation ridges on the Fort (Figure 3). Two soil types associated with these geologic formations, Eckrant and Real-Rock, accounted for 81.4 percent of vireo occupied areas. Not surprisingly, elevations under 271 m were underrepresented, while vireos were significantly more common than expected at elevations above 309 m. Vireos were more common on slopes between 15 and 25 percent which are typically associated with the Real-Rock outcrop complex. Vireos were not highly selective with respect to aspect but west facing slopes were favored.

Based on these results, a map was created delineating potential vireo habitat on Fort Hood (Figure 14). Areas of very low, moderate, and very high vireo habitat potential were defined that accounted for 35.9, 8.7, and 22.1 percent of the installation, respectively. Thirty-three percent of the installation was considered unsuitable as potential vireo habitat. Geology alone delineated most of the potential habitat.

This map **does not represent existing habitat**, but rather, potential habitat that has the combination of landscape features necessary to support vireo habitat. Creation of actual habitat would require management interventions or natural succession.

(2) Observation of Banded Vireos

Minimum estimates of survival were based on the proportion of banded birds returning each year. Vireos were captured using mist nets and recordings of vireo song. Captured vireos were banded with a unique combination of color bands for individual recognition.

The average annual male return rate in main colony sites was 57.2 percent compared with an average annual female return rate of 47.7 percent for the years 1988 and 1989 (Table 2). The 2-year return rate for

males was 22.7 percent. Four females out of a sample of 17 banded on main colony sites (23.5 percent) were observed 2 years after banding.

The return rate appears to have declined in 1990. In those areas adequately surveyed, the return of banded males was only 30.2 to 39.6 percent. A range is given because five males were not observed adequately to determine if they were banded. The estimated return rate for 1991 is between 51.2 and 65.1 percent.

(3) Population Age Structure

Vireos were aged at the time of capture using plumage characteristics (Grzybowski 1988b, 1989b). Aging categories included birds banded during their hatching year (HY), birds captured in the first breeding season after hatching (SY, second year), and birds captured at least two breeding seasons after hatching (ASY, after second year).

The SY male component of the Fort Hood black-capped vireo population of banded birds was nearly constant during the years 1987-89, ranging between 10.0 and 11.8 percent. The female component of the population exhibited a higher proportion of SY birds than males, averaging 23.3 percent. During 1990, the male and female SY component among known banded birds was higher at about 30 percent. This increase in SY birds may have resulted from increased vireo productivity during 1989 (see below). However, the number of unbanded birds and birds for which banding was uncertain leaves room for error in these estimates of the population age structure.

Observations during 1991 indicate that SY birds are found in marginal habitats that were not surveyed in earlier years. SY males accounted for 29.1 percent of the adult male population during 1991.

(4) Productivity

Vireo mating, nesting, and pair success, and annual production (young/pair) were documented through weekly to bi-weekly territory monitoring. Nest success was quantified using the Mayfield method (1975). The median of the minimum and maximum possible number of young fledged per nest was used to estimate production for the years 1987-89. The minimum number fledged was used to estimate production in 1990. This difference in methods results in a more conservative estimate of production in 1990 compared with earlier years.

Vireo nesting success increased from 2.4 and 6.9 percent in 1987 and 1988 to 23.7 and 25.5 percent in 1989 and 1990. The percentage of pairs that fledged young also increased from 9.5 and 18.8 percent in 1987 and 1988 to 61.4 percent in 1989 and 73.5 percent in 1991.*

Vireo production (Table 3) in 1987 was 0.238 young/pair (median estimate). This increased to 0.328 in 1988 and 1.686 young/pair in 1989, and 1.871 in 1991. A minimum estimate of production in 1990 was 1.267 young/pair. Minimum estimates of production for the years 1987-89 were 0.190, 0.297, and 1.500, respectively.

The percentage of nests deserted during the years 1987-89 was inversely related to the percentage of nests destroyed. As desertion levels are reduced, the number of nests available for destruction increases. During the years 1987-89, the percentage of nests deserted decreased from 81.7 to 62.5 to 47.6 percent.

*Pair success data are presently unavailable for 1990.

During this same period, the percentage of nests destroyed (nonmilitary causes) increased from 16.0 percent in 1987 to 30.6 percent in 1988 and 28.8 percent in 1989.

(5) Habitat

Site age was determined by tree growth ring analysis of woody vegetation at vireo sites.

Habitat data were collected at six vireo sites and one unoccupied site with vireo-like habitat during June and July 1988 to determine vireo habitat selection. Habitat both within (VIREO plots) and outside vireo territories (NONVIREO plots) was sampled using a modified James and Shugart (1970) technique.

Tree growth ring analysis determined that all major sites were in the range of 5 to 20 years of age. The exception was Area 6 at 28 to 29 years of age. On Fort Hood, these areas represent mid-successional habitats that typically developed after fire or mechanical disturbance in areas of potential habitat.

Habitat structure was different between VIREO and NONVIREO plots (Table 4). Vireos preferred areas with abundant low hardwood vegetation and low density and cover of live junipers. Tall hardwood vegetation, grass ground cover, and the density of dead juniper stems and trees were less important in vireo habitat selection.

The most common woody species in VIREO plots included shin oak, flame-leaved sumac, ashe juniper, Texas oak, skunkbush sumac, red bud, and Texas ashe (Table 5). Species more common in VIREO than in NONVIREO plots were flame-leaved and skunkbush sumac, Texas oak, grape, greenbriar, Mexican buckeye, and poison ivy. Species less common in VIREO compared to NONVIREO plots included ashe juniper and live oak. Species diversity was similar in the VIREO and NONVIREO plots sampled.

Habitat structure was more variable among NONVIREO plots than VIREO plots. In contrast, plant species composition was more variable among VIREO than NONVIREO plots. This result indicates habitat structure is more important than plant species composition in vireo habitat selection.

Species most commonly used as nest substrate in order of importance were shin oak (28 percent), Texas oak (25 percent), red bud (15 percent), Texas ashe (10 percent), flame-leaved sumac (8 percent), ashe juniper (4 percent), Carolina buckthorne (3 percent), and Mexican buckeye (3 percent). These accounted for 96 percent of the 249 nests sampled.

Average nest height among Fort Hood vireos was 108.4 cm. Over 95 percent of all nests observed were in the range of 50 to 200 cm, which is within the zone of maximum vegetation volume on VIREO plots.

(6) Territory Size

Territory maps for each year were digitized into separate GRASS vector files, and territory size was estimated using the GRASS program *report*. Territory size ranged from 2.92 ha in 1987 to 4.08 ha in 1989 (Table 6). Black-capped vireo territory size was unrelated to territory quality as reflected in habitat structure and species composition.

(7) Site Fidelity

Site fidelity of males and females was significantly different. Distances moved by banded birds between years are summarized in Table 7. Two of 157 males (1.3 percent) changed sites while 4 of 49 females (8.2 percent) were observed at different sites in subsequent years. Only 8.6 percent of males moved more than

1 km between years (median = 119 m), while 36.8 percent of females moved farther than 1 km (median = 327 m).

(8) Cowbird Parasitism and Its Effect on Nesting Success

The incidence and effect of cowbird parasitism on monitored vireo nests were recorded and evaluated.

In 1987 and 1988, the incidence of parasitism was 90.8 percent, while vireo production during these same years was 0.238 and 0.328 young/pair, respectively (Table 3). In 1989, the incidence of parasitism declined to 65.1 percent while the number of young/pair increased to 1.686. Overall, vireos fledged 0.68 young/nest from unparasitized nests compared with 0.10 vireo young/nest fledged from parasitized nests. Regression of vireo production on percent parasitism (Figure 15) was significant and accounted for 55.6 percent of the variation in vireo production.

Nest success calculated from exposure and excluding the construction phase was different for parasitized and unparasitized nests (Figure 16). Parasitized nests were deserted over six times as frequently, but destroyed less frequently than unparasitized nests. Proportionately, fewer parasitized nests were destroyed because the number of nests available for destruction was reduced substantially due to desertion. Unparasitized nests fledged young over twice as often (35.0 percent) as parasitized nests (16.6 percent).

Parasitism in 1990 was estimated at 61.6 percent with a minimum estimated production of 1.267 young/pair. During 1991, parasitism was 38.8 percent, the lowest yet observed on Fort Hood, while production was at a high of 1.871 young/pair.

(9) Cowbird Control

Trapping and shooting were used in attempts to control cowbird numbers in the vicinity of vireo sites. Live decoy cowbirds were placed in traps along with abundant seed and water to attract other cowbirds. Decoy traps were checked at least twice per week from April through mid-July. Effects of this control effort were evaluated.

At Area 6 during 1988, three traps were operated for a total of 270 trap-days. During this period 79 male, 10 female, and 13 immature cowbirds were removed from the population. Female removal success during 1988 was 0.04 female per trap-day. Eight traps operated at six sites during 1989 yielded 639 trap-days and resulted in the removal of 60 males, 36 females and 90 immatures. Female removal success ranged from zero at west Fort Hood to 0.10 per trap-day at Brown's Creek and averaged 0.06 per trap-day. Shooting at five sites during 1989 removed 39 male and 119 female cowbirds, 3.3 times more females than by trapping. Females removed by shooting averaged 0.30 per day, five times higher than by trapping, and was similar among most sites.

Trapping effort increased in 1990 and 1991. Trapping removed 207 female cowbirds from the population in 1990, 1403 during 1991. An additional 247 female cowbirds were removed by shooting during 1991.

The decline in the incidence of cowbird parasitism in 1989 and 1990 could not be attributed to cowbird control efforts. However, cowbird occurrence has been related to the presence of livestock, and cattle numbers on Fort Hood dropped from approximately 3800 animal units in 1987 and 1988 to 1500 to 2000 animal units in 1989 and 1990 due to a brucellosis epidemic. In contrast, the steep decline in parasitism during 1991 was certainly related to effective cowbird control efforts. During 1991, 4578 cowbird trap-days and 18.8 percent parasitism outside the live fire training area contrast with 507 trap-days and 57.1 percent parasitism within the live fire training area.

c. Discussion and Summary

(1) Vireo Numbers and Population Trends

(a) Fort Hood supports a substantial number of black-capped vireos. The estimated population of 300 adults during 1991 on the Fort represents 16 to 23 percent of the currently documented population of 1313 to 1844 adults. Vireos on Fort Hood constitute the largest known population currently under a single land management authority.

(b) Total vireo numbers at sites that were adequately sampled show no substantial annual change for the years 1987-90. This indicates populations on the Fort were stable during this period. Population stability was maintained during 1991 as well. Some individual sites did show annual fluctuations in numbers of territories.

(c) Band returns for adult male vireos indicate a minimum annual survival rate of about 60 percent. Survival rates for females based on band returns may be underestimated due to the significantly greater movement of females between years and their lower observability.

(d) Second-year males comprised an average 10.6 percent of the banded adult male population during 1987 through 1989, but about 30 percent during 1990 and 1991. Factors such as the failure of some SY males to have established territories may cause SY males to be underrepresented in the population of banded birds. Also, recent observations suggest SY birds may be found scattered throughout marginal habitats that were not surveyed prior to 1991.

(e) The present vireo population age structure indicates that the Fort Hood population should be declining. At an adult annual survival rate of 60 percent, the SY component should be 40 percent. This is more than the 10 to 30 percent estimated for males and females on Fort Hood during 1987 through 1991. However, as noted above, the proportion of SY males in the population may be underestimated, and inventory data indicate that vireo numbers on Fort Hood are stable.

(f) Annual productivity during the years 1987-89 (0.929 young/pair) was below estimated productivity necessary to replace annual losses due to mortality (1.45 to 2.29 young/pair, p 55). Even if all young fledged on Fort Hood returned to their natal area, maintenance of a stable population would have required immigration from unknown sources outside the Fort. However, productivity appears to have increased substantially during 1989 through 1991 due to a reduction in the incidence of cowbird parasitism.

(2) Vireo Distribution and Habitat

(a) Occupied vireo sites constitute less than 1 percent of Fort Hood land (561 ha) but are distributed widely throughout the Fort. Sites are most common along a ridge running east southeasterly from the northwest corner of the post. Vireos are also found in similar areas at west Fort Hood, Pilot Knob Range in the south half of the Fort, and in the southeastern portion of the Fort.

(b) Vireo sites are associated primarily with the mesa-hills and side slopes. Vireo territories are associated with certain landscape features on Fort Hood including geology, soils, elevation, slope, and aspect, which are all interrelated. Vireo territories were associated with geologic and soil types that co-occur on the higher elevations of the Fort.

(c) The black-capped vireo prefers habitats with an abundant layer of low hardwood vegetation under 3 m and low density of ashe juniper trees.

(d) Vireo habitat on Fort Hood is typical of a mid-successional stage of vegetation development that follows disturbance such as fire or mechanical clearing. Sites are occupied 3 to 5 years after disturbance and may become unsuitable as vireo habitat after 25 to 30 years of age.

(3) Carrying Capacity

(a) Territory size of the vireo on Fort Hood is relatively large for a small passerine species. A site supporting 10 territories would require a minimum of 30 to 40 ha of suitable habitat, more if buffer areas are included.

(b) Territory size was not correlated with habitat parameters. A correlation of territory size and habitat quality would be expected if vireo numbers were near the carrying capacity of available habitat.

(c) The integration of vireo territory location and landscape features in GRASS allowed development of a map of potential vireo habitat on Fort Hood. This map indicates substantial potential for development of habitat beyond that which currently exists. Note, however, that this overlaps considerably with potential golden-cheeked warbler habitat.

(d) Data on annual movements when integrated into a formula estimating reserve size requirements (Pease and Gingerich [1989]) indicate an area of at least 100,000 ha would be necessary to maintain a self-contained and sustainable vireo population. This area is larger than Fort Hood, indicating satellite populations are necessary to maintain the vireo population on Fort Hood.

(4) Effects of Cowbird Parasitism on Vireo Populations

(a) The black-capped vireo is highly susceptible to cowbird nest parasitism. Parasitism on Fort Hood during 1987 and 1988 (91 percent) was among the highest recorded for the species.

(b) Declines in the incidence of parasitism rates in 1989 (65.1 percent) and 1990 (61.6 percent) could not be attributed to cowbird control efforts. A lower cattle stocking rate was the only identifiable factor contributing to the decline in parasitism. Data for 1991 indicate a substantial decline in cowbird parasitism rates that is linked to an effective control effort.

(c) Cowbird parasitism was a major factor limiting reproductive success of the vireo on Fort Hood. Unparasitized nests fledged 0.68 young/pair compared with 0.10 young/pair fledged from parasitized nests. Nest success of unparasitized nests was twice as high as for parasitized nests.

(d) Recent information suggests juvenile survival may range between 35 and 55 percent (Grzybowski, personal communication). On this basis and assuming 60 percent adult survival, the range of annual production necessary to maintain a stable population is 1.45 to 2.29 young per female.

(e) Applying the regression of vireo production on percent parasitism (Figure 15), annual production of 2.29 young can be sustained at a parasitism level of 45 percent. An annual production of 1.45 young per female can be sustained at a parasitism level of 66 percent. Caution is advised here. Although this represents our best scientific estimate, parasitism accounted for only a little more than half the variability in production, and the regression did not include much data for parasitism in the range of 0 to 50 percent. Thus, estimates of "acceptable" rates of parasitism can only be a first approximation that must be refined as additional data are obtained in the future.

2. *Golden-cheeked Warbler*

Field studies of the golden-cheeked warbler on Fort Hood were initiated on 15 March 1991 as a proactive response to the listing of the warbler as an endangered species by the USFWS on 27 December 1990. Goals of this on-site inspection are to assess the distribution, abundance, and habitat of golden-cheeked warblers on Fort Hood lands, and to assess the impacts of military training and other activities on this species.

a. Survey and Research Area

As part of the status survey of the golden-cheeked warbler in Texas (Wahl et al. 1990), Landsat MSS data were integrated with a GIS to determine potential golden-cheeked warbler habitat based on known quality nesting habitat in Texas.

To show existing potential habitat on Fort Hood, Fish and Wildlife Division personnel modified this regional allocation of habitat by eliminating from the map potential warbler habitat on the Fort that was cut over or burned since the satellite images were taken. The resulting areas of potential habitat were overlain on 1:50,000 training area maps of the Fort to create working maps of endangered species habitat on the installation. These maps supplemented the revised training guidelines for endangered species issued in June 1990.* Black-capped vireo protection areas also are shown on this map.

The 1991 survey of golden-cheeked warbler distribution and abundance focused on areas identified on the endangered species map as potential warbler habitat.

b. Methods and Results

On Fort Hood, 13,900 ha were identified as potential warbler habitat for the purpose of the survey (Figure 12). The majority of potential golden-cheeked warbler habitat is located in the northern portion of the live fire training area (Henson Mountain) and the East Range area of the Fort. Smaller, more linear and isolated habitat is scattered throughout the western side of the installation and at west Fort Hood.

Surveys of golden-cheeked warbler occurrence are conducted from sunrise until approximately 1100 hours. Surveys are conducted by one to three people moving by vehicle or on foot through potential habitat, stopping frequently to listen for singing males and to play recorded tapes of warbler song to elicit a response. Warbler locations are then noted on USGS topographic maps or on 1:4800 scale aerial photos.

A total of 515 territorial male warblers were observed in 57 training areas during the 1991 survey (Table 8). Golden-cheeks were distributed throughout all of the training areas surveyed, and in almost all of the areas identified as potential warbler habitat within those areas. The exceptions are two small areas in TA 27 in which extensive juniper cutting occurred during the summer of 1989. Suitable-appearing habitat within the ammunition storage area at west Fort Hood was not surveyed.

The number of golden-cheeked warblers observed during 1991 is **not** a complete enumeration of warblers on the Fort. Although virtually all potential habitat patches were surveyed, typically, not all of the habitat within those patches was fully examined.

In addition to areas designated as potential warbler habitat, warblers also were located in areas currently designated as black-capped vireo protection areas on the endangered species training area map and in areas

*These maps are available through: HQIII Corps and Fort Hood, ATTN: AFZF-DEH-EMO, Fort Hood Environmental Management Office, Fort Hood, TX, 76544-5057.

not designated as habitat for either species. Sixty-six territories were located in vireo designated areas. Fifty warbler territories were located in areas not currently designated habitat for either species.

Data on the density of golden-cheeked warblers on selected areas of Fort Hood were collected using variable circular plot counts (VCP; Reynolds et al. 1980) and a single Emlen transect count (Emlen 1971). Intensive surveys of an approximately 270 ha area in TAs 2 and 3A also provides information on warbler density. This is an area identified as "good" warbler habitat by installation Fish and Wildlife personnel and is contiguous, except for tank trails, with extensive warbler habitat on its eastern, western, and southern margins.

Thirty-one territories were delineated within the intensive study area. This yields an estimated density of 11.5 males/100 ha (pairs/ha if all males are mated). Further research will evaluate if this is typical of occupied habitats throughout the Fort. In contrast, data from 123 VCPs yielded a density estimate of 47.6/100 ha. Data from one Emlen transect yielded a density estimate of 15.6 males/100 ha. The latter is similar to results from data collected on this same transect during 1987 (Wahl et al. 1990).

Population trends of warblers on Fort Hood are unknown. To address this question, warblers are being banded and individually color-marked to evaluate return rates and population age structure. Ninety-four golden-cheeks were banded during 1991. Preliminary evaluation of plumage characteristics indicates 43 ASY males, 26 SY males, 14 AHY males, 1 ASY female, 1 SY female, 8 hatchling year birds of unknown sex, and 1 of undocumented sex and age.

Data on habitat preferences have not been collected to date. Future analyses will correlate warbler occurrence with landscape features and vegetation characteristics.

Habitat disturbance related to military activities has destroyed golden-cheeked warbler habitat. An accidental burn during 5-6 March 1991 destroyed 354 ha, of which an estimated 273 ha were potential warbler habitat. Surveys in 1991 located several territories in habitat adjacent to the burn (Figure 17). Fish and Wildlife personnel indicate the burned habitat was similar to surrounding, existing habitat.

Estimates of productivity and the incidence of cowbird parasitism among golden-cheeked warblers are difficult to obtain due to the habitat type and the difficulty of locating nests. During 1991, six warbler nests were located on Fort Hood. A total of at least seven warbler young fledged from three of these nests. Cowbird parasitism was documented in three nests, two of which fledged cowbirds including one that also fledged at least two warblers. Warbler pair success on nine of 21 territories adequately monitored on the intensive study areas was 42.9 percent, with average production of 1.89 young/successful territory.

c. Discussion and Summary

Data summarized here were collected during mid-March through July 1991 and are preliminary in nature. However, they do represent the best scientific data available with which to prepare this biological assessment.

(1) Based on satellite imagery, 13,900 ha of Fort Hood land have been identified as potential warbler habitat for survey purposes (Figure 12).

(2) The golden-cheeked warbler is distributed widely throughout the installation. Warblers were observed in all training areas surveyed containing potential habitat (Table 8). The most extensive areas of warbler habitat occur in the northern portion of the live fire training area and the East Range region of the Fort. Golden-cheeked warblers also occur in areas not currently identified as habitat and in certain vireo

protection areas. A total of 515 male golden-cheeks were observed. This is not a total enumeration of the population on the Fort.

(3) Within the 270 ha intensive study area, 31 territories were identified, resulting in a density estimate for this area of 0.115 pairs/ha (assuming all males were mated). This is less than Wahl et al.'s (1990) overall median estimate for the species of 0.15 pairs/ha but similar to Pulich's (1976) estimate for warbler densities in "excellent" habitat (0.123 pairs/ha). Wahl et al. (1990) reported an estimated density of 0.15 pairs/ha on Fort Hood based on 2 survey-days each at two Emlen transects located on the Fort. A repeat of one of those transects during 1991 yielded a similar density estimate. The density estimate of 0.476/ha based on VCP counts appears to be biased upward due to the inadvertent location of points within the better habitat areas (Hayden and Tazik 1991). Note that results of the three methods are not directly comparable because they were not conducted on the same areas. Additional fieldwork and analyses will be conducted to derive accurate and repeatable density estimates for this species on Fort Hood.

(4) Information on trends in warbler populations on the Fort is not currently available. Banding studies have been initiated to address this question. To date, 94 golden-cheeks have been banded. The percentage of SY males in the banded population (33.3 percent) indicates a healthy level of recruitment in the warbler population on Fort Hood (Hayden and Tazik 1991).

(5) Productivity of Fort Hood warblers is unknown at present and may be troublesome to document due to the difficulty in finding nests. Three of six nests located are known to have fledged young.

(6) The incidence of cowbird parasitism in the Fort Hood warbler population is not well documented. Three of six nests located are known to have been parasitized.

(7) Habitat preferences of warblers on Fort Hood have not been quantified. Future analyses will correlate warbler occurrence with landscape features and vegetation characteristics.

(8) Military-related impacts on warblers have been documented, most notably a fire in early March 1991 that destroyed 273 ha of habitat. At an estimated density of 0.115 pairs/ha, this burned habitat would have supported 31 pairs of adult warblers during the nesting season.

3. Cave Invertebrates

The cave fauna of Fort Hood is poorly known. Twenty caves have been visited by Dr. James Reddell, a noted expert on cave invertebrates. Only nine of these caves were biologically studied, and only two (Nolan Creek Cave and Tippit Cave) were visited more than once. Collections were made at seven caves visited in January and March 1990. The rest were visited in 1963 and 1964.

Caves are located within limestone formations on Fort Hood. Nine known cave sites are shown in Figure 12. Many others have not yet been mapped. Three caves surveyed in 1990 are located in the area of the Cold Springs Helicopter Gunnery Range (Figure 8) in TA 75. Two others are located in TA 2, and one each is located in TA 5A and 80.

Five cave-restricted species are known from caves on Fort Hood (Appendix H). Four of these species, three aquatic and one terrestrial, are known from other locations in Texas. None is listed as threatened or endangered, but one is a category 2 candidate species—*Stygobromus bifurcatus*. The latter is an aquatic amphipod collected from Tippit Cave near the Cold Springs Helicopter Gunnery Range in Area 75 in the early 1960s. According to Reddell (Appendix H), *S. bifurcatus* is widespread through central Texas. One undescribed spider (*Cicurina* sp.) also was collected from Tippit Cave in the early 1960s. Attempts to locate this cave during the 1990 survey were unsuccessful.

During his site visits, Dr. Reddell witnessed several examples of disturbance of caves on Fort Hood. He noted that extensive tank trails around one cave had significantly reduced vegetation cover around the cave, resulting in significant sedimentation within. He also noted sedimentation in a sink that was probably an open cave at one time. Dr. Reddell observed trash in several caves including rusting metals and old batteries.

VI. ASSESSMENT OF THE EFFECTS OF FORT HOOD ACTIVITIES ON FEDERALLY THREATENED AND ENDANGERED SPECIES

In evaluating the effects of Fort Hood activities on threatened and endangered species, it is useful to distinguish direct and indirect impacts. Direct impacts are those that have a direct and immediate impact on mortality of adults, young, or nests; or that disrupt essential foraging and nesting behavior. Indirect impacts are those that do not have a direct and immediate impact. Examples of the latter include habitat destruction and the effect of grazing on reproductive success via cowbird parasitism.

A. Plants

1. Croton alabamensis

The two known populations of this candidate species are in locations that do not receive much training use. Therefore, these populations are not likely to be impacted from military activities. Although the Alabama population of the species is not fire tolerant, fire tolerance of the Texas variety is undocumented. In any case, location of the populations near Owl Creek provides some protection from fire. There is some indication that cutting, whether or not related to military activity, is not detrimental as individuals appear to resprout, but further study is needed to be conclusive. Impacts of soil disturbance are undocumented.

B. Animals

1. Black-capped Vireo

a. Maneuver Training

Several activities associated with maneuver training may have direct or indirect impact on the vireo and its habitat: bivouacs, tracked vehicle maneuver, engineer obstacle construction, and use of obscurant smokes.

Bivouac sites have been observed on or in the vicinity of vireo territories. This may result in direct effects on nests and foraging and breeding activity, and indirect effects on the species as a result of habitat damage. Disturbances may be caused by digging activity, cutting brush for camouflage, setting up and tying down tents, stringing of communication wire, clearing brush and trails, and direct encounters between man and bird. The effects of generator noise on the species is undocumented.

Forward observation points are established in conjunction with artillery live fire training. There is a forward observation point at the Area 2 Slope site occupied by the vireo (Figure 13). Similarly, portions of the Manning Mountain site are frequently used for bivouac and observation sites, and there often is heavy traffic through this area. Vireo territory use has been observed to shift as a result, but with little apparent negative impact on nesting success. Trampling of vegetation by troops within one territory at the west Fort Hood site resulted in abandonment of a territory (Tazik and Cornelius 1992).

There is frequent vehicular traffic on existing roads through the Area 2 Top and Slope vireo sites (Figure 13), and units often park their vehicles in the vicinity of vireo territories located there. Some tracking has been observed through portions of occupied territories. National Guard activity has been particularly heavy throughout this area during May and June. Traffic moving along existing roadways and tank trails does not appear to impact the species. Movements off-road/trail into a vireo site proper may have an adverse impact on any birds or nests present.

Habitat disturbance caused by occasional use of existing bivouac sites and forward observation points within or around vireo sites may indirectly benefit the vireo by maintaining an early successional vegetation structure. Frequent or intensive use that results in degradation of the habitat will have an adverse effect. Because vireos nest within about 1 m above the ground on the edge of vegetation, such activities occurring during the breeding season may have a direct adverse effect on nests and nesting activity.

Tactical vehicle maneuver training can damage vegetation resources on areas throughout the Fort outside of the live fire training area. Vireos and vireo habitat located outside of the live fire training area may be affected by maneuver training if actions are not taken to protect those sites. Areas of highest training intensity are most likely to be impacted (Figure 7). These include Area 2 Slope and Top (TA 2, 4, and 5). Area 12 (TA 12), Manning Mountain (TA 44), Williamson Mountain (TA 43), and Shell Point (TA 45). Areas that fall within the lowest training intensity category and least likely to be impacted include Red Bluff (TA 3), Area 6 (TA 6), and west Fort Hood (TA 22 and 24). Potential impacts can be minimized by clearly demarcating known vireo sites and instructing troops to avoid these areas, especially during the breeding season.

Movement of tactical vehicles and personnel into vireo sites is most detrimental when the birds are present on the installation during late March through August. Such events may affect active nests and disrupt breeding and foraging behavior directly. Disturbance to the habitat when the birds are absent will not have a direct adverse impact and is potentially beneficial.

Bulldozers used by engineer units can cause damage similar to other tracked vehicles, but also can inflict further damage if used to remove vegetation. Engineer units also request areas for demolition missions. All dozer work or demolition missions require digging permits. These permits are coordinated through the Environmental Management Office.

Obscurant smokes are used in some training exercises to create realistic battlefield conditions. The most commonly used obscurants include fog oil, tank diesel fuel, and hexachloroethane. Some of the compounds generated are mutagenic or carcinogenic. Other components are neurological and renal toxins or produce other toxicological damage. Also, compounds similar to those contained in commonly used smokes (aromatic hydrocarbons and heavy metals) cause ecosystem damages. Controlled field studies at Fort Irwin documented direct effects of the acute exposure of plants and animals to smokes including decreased fertility, changes in energy production, decreased survivability, and increased genotoxic damage (Schaeffer et al. 1986). Population, community, and ecosystem effects are unknown, and no direct effects on wildlife have been observed on Fort Hood.

Frequency, location, and scheduling of smoke use, and the types and amounts of smokes used have not been documented for this biological assessment. However, most of these large scale exercises are conducted on West Range, and smokes are used most commonly on the open grasslands, not on the mesa-hills where vireo sites are located. Drifting smoke may intrude upon existing vireo sites, but the effects, if any, are unknown.

b. Live Fire Training

Observations over a 3-year period gave no indication that artillery noise affected vireo behavior or habitat use. In general, blast noise has not been shown to affect wildlife (Holthuijzen 1989, Petit 1991). Also, different species seem to respond differently to noise and differ in their ability to habituate to it (W. Russell, personal communication).

Artillery rounds are directed only at the Artillery Impact Area (Figure 13). Only one SY male vireo has ever been observed in this area. Limited observations indicate that habitat within the area is otherwise unsuited to the vireo. Little direct adverse impact on the vireo due to artillery rounds is expected.

Fires resulting from tracer ammunition and pyrotechnics, such as flares, can alter habitats on Fort Hood. Although there is the possibility of destroying existing habitat and directly impacting nests and young present, in balance, such fires have had a positive effect on the vireo by creating habitat. Much of the existing vireo habitat on Fort Hood undoubtedly is the result of accidental fires related to live fire training; and one of the largest, most densely occupied vireo sites is located in an area affected by such training (Robinette Point). Portions of vireo sites that are burned may be recolonized in subsequent years if the burn is not too extensive nor too intense. This is exemplified by an area at west Fort Hood that burned during fall 1988 destroying habitat that was occupied by four pairs during the previous breeding season. The area was recolonized in 1990. Similarly, a burn on the Lone Mountain vireo site was recolonized the second breeding season following the fire.

Maintenance of ranges within the live fire training area may affect the vireo. For example, a fire set on 26 December 1989 by contract personnel hired to construct a range complex resulted in loss of habitat on Lone Mountain that was occupied by three vireo territories during the previous breeding season. As noted above, this site has since been recolonized.

c. Aviation Training

Use of aircraft gunnery ranges that include vireo habitat may have a direct adverse impact on the vireo. The Cold Springs Helicopter Gunnery Range depicted in Figure 8 is no longer in use (Summerford, 1991). The primary gunnery ranges now are located on the Henson and Dalton Mountain Ranges. Vireos have been documented on Henson and Dalton Mountain within the firing fans of these gunnery ranges (J. Cornelius, personal communication).

d. Controlled Burning

As with accidental, military-related fires, fire used to control juniper encroachment can inadvertently destroy vireo habitat. Although burned-over vireo habitat may be recolonized in future years, this activity, unlike military-related fires, can and should be closely regulated in order to avoid adverse impacts. Controlled burns and fire suppression activities are coordinated through the Environmental Management Office to avoid negative impacts on the vireo.

e. Juniper Cutting

In addition to the use of fire, juniper encroachment has been controlled by hand and mechanical clearing. Such activities are not likely to take place within existing vireo sites as these usually have a low abundance of junipers. Juniper clearing in areas adjacent to existing vireo sites may benefit the vireo indirectly by creating more habitat, although steps must be taken not to disrupt vireos that may include portions of oak-juniper woodland within their breeding territories. Coordination through the Environmental Management Office will ensure that vireos are not adversely affected by this activity.

f. Grazing

While military activities on Fort Hood have had a net positive impact on the vireo, extensive cattle grazing indirectly has had a significant negative impact on vireo reproductive success. (That is, vireo reproductive success, overall, between 1987 and 1989 was below that required to maintain a stable population.) Cattle do not directly impact the vireo, but they do attract cowbirds and help to maintain suitable cowbird foraging areas (short grass areas). Cowbirds in turn parasitize vireo nests thereby reducing vireo nesting success.

Over 90 percent of all nests observed during 1987 and 1988 were parasitized; 60 to 65 percent were parasitized during 1989 and 1990. Parasitized nests were deserted by adult vireos over six times as often and were half as successful as unparasitized nests. On average, unparasitized nests produced nearly seven times as many vireo young per nest as parasitized nests. Unfortunately, cowbird control efforts attempted during 1988 and 1989 were ineffective in reducing cowbird nest parasitism and in enhancing vireo reproductive success. Greater success has been achieved during 1991.

g. Recreation

Recreational land users should be considered as major land users because over 1500 personnel use Fort Hood training areas for recreation each month (Summerford, 1991). Additionally, approximately 300 personnel use the live fire training area for recreation each month. Nonetheless, opportunities to impact the vireo appear to be minimal.

Regarding hunting, only the spring turkey season overlaps with the vireo nesting season. However, vireo habitat does not represent good turkey habitat, thus no conflicts have been observed, nor are they expected. No conflict is anticipated with small game hunters.

Recreational ORVs used during the vireo nesting season have the potential for disrupting breeding activity. An annual spring motocross race in the past has been scheduled to run through the west Fort Hood vireo site. Coordination of this and other organized off-road races through the Environmental Management Office will avoid adverse impacts on the vireo.

h. Ongoing Scientific Studies

Permanent field inventory plots have been placed in known vireo sites in conjunction with the LCTA Program as a means of characterizing and monitoring the habitat. Vegetation and avian sampling techniques used by LCTA are nondestructive and have little impact on the vegetation (Tazik et al. 1991). Small mammal censuses require placement of snap traps on the ground. Since the vireo does not forage on the ground, it is not likely to be captured in such traps. Sampling within vireo occupied areas is coordinated with the Environmental Management Office to avoid interfering with any active nests that may be located on or in the vicinity of LCTA plots. This activity will not adversely affect the species.

Fort Hood intends to continue to inventory and monitor population size, survival, and reproductive success of the vireo on Fort Hood, and impacts, if any, of military and land management activities on the vireo. This will involve territory mapping, use of a tape recording of the male's song to document presence, banding adults and juveniles with numbered metal bands and color bands, and periodic monitoring of active nests. Other associated activities include removal of cowbird eggs from vireo nests, trapping and shooting cowbirds in and around vireo sites, and selected habitat development and maintenance. These activities may have a direct adverse effect on individuals of the species and do require permits from USFWS.

2. *Golden-cheeked Warbler*

a. Maneuver Training

The majority of golden-cheeked warbler habitat on Fort Hood is not conducive to maneuver training. Tree density does not permit room for maneuvering of tanks and other tactical vehicles. Furthermore, much of the potential habitat for the species occurs on steep slopes where vehicles do not or should not venture. Thus, maneuver training is not likely to have an adverse effect on the warbler or its habitat except on the edge of occupied habitat where maneuver activities are most likely to occur.

Authorities agree that maneuver activity probably has little direct impact on warbler behavior (Wahl, personal communication, Rust, personal communication). Vehicles travelling on existing roads and tank trails, and small unit bivouacking within existing bivouac sites are not likely to adversely impact the warbler provided the habitat is not disturbed. The impact of cutting new trails through existing warbler habitat is unknown, aside from the obvious loss of habitat and possibility of impacting active nests during the breeding season.

Bivouac sites established within warbler habitat can result in habitat damage due to brush cutting for camouflage and clearing brush and trails. Warbler nest sites are less likely to be affected than vireo nests as the golden-cheek tends to nest higher in the vegetation.

As discussed in regard to the vireo (p 65), engineer activities can cause vegetation destruction. The potential to impact warbler habitat is minimized by a requirement to coordinate digging permits through the Environmental Management Office.

As discussed with respect to the vireo, the effect of obscurant smokes is unknown at this time. Given that smoke usage is most extensive on West Range where warbler habitat is least extensive, the direct effect of smokes, if any, will be minor.

b. Live Fire Training

Potential warbler habitat within the Artillery Impact Area (TA 94) has not been surveyed. Potential impacts on the warbler in this area are unknown at this time. The effect of blast noise from artillery, if any, is unknown. As noted above, blast noise has not been shown to affect wildlife (Holthuijzen 1989, Petit 1991).

Accidental fire resulting from live fire training has the greatest potential to impact warbler habitat. For example, a recent accidental fire within the live fire training area in TAs 66, 74, and 80 destroyed 273 ha of warbler habitat (Figure 17).

c. Aviation Training

Use of aircraft gunnery ranges that include warbler habitat may have a direct adverse impact on the warbler. The Cold Springs Helicopter Gunnery Range depicted in Figure 8 is no longer in use (Summerford, 1991). The primary gunnery ranges now are located on the Henson and Dalton Mountain Ranges. Warblers have been documented on Henson Mountain within the firing fans and around the target areas of these gunnery ranges.

d. Controlled Burning

Controlled burns and fire suppression activities are coordinated through the Environmental Management Office to ensure that warbler habitat is not purposefully destroyed. All controlled burns for juniper control are restricted to areas where junipers invade the grasslands. Warbler habitat does not exist in such areas. Thus, if properly controlled, such burns are not likely to affect the golden-cheek.

e. Juniper Cutting

Removal of junipers from golden-cheeked warbler habitat will adversely affect the species. Although warbler habitat has been lost in the past due to juniper cutting (i.e., prior to listing), coordination of this activity through the Environmental Management Office will ensure that no additional habitat is destroyed in this manner in the future. As with controlled burns, juniper cutting is now restricted to areas where junipers invade the grasslands. Thus, the existing juniper cutting program is not likely to affect the golden-cheek.

f. Grazing

Cattle do not directly impact the golden-cheeked warbler. The extent of any indirect effects of cattle due to cowbird parasitism have not yet been documented on Fort Hood.

g. Recreation

No recreational-related disturbances are known or expected.

h. Ongoing Scientific Studies

The discussion on the black-capped vireo is applicable here. Note, however, that research into habitat development for the vireo may adversely affect the golden-cheeked warbler and its habitat. Thus, any such activity will be coordinated with and conducted only with the permission of USFWS.

3. Bald Eagle

Aircraft overflights are restricted during winter to avoid bald eagle roosting sites. No other impacts are known or expected.

4. Peregrine Falcon

No impacts are known or expected.

5. Whooping Crane

No impacts are known or expected.

6. Cave Invertebrates

A survey of cave invertebrates on Fort Hood must be completed before the impacts, if any, of Fort Hood activities can be evaluated.

VII. ANALYSIS OF ALTERNATIVES

Fort Hood is one of the Army's major training installations and is of great importance to national defense. Activities that impede training also impede the military mission to maintain combat readiness. It is essential that units be able to train under scenarios that represent actual combat conditions. No other alternatives will enable Fort Hood to accomplish its training mission. However, specific training related activities can be conducted in a manner to minimize adverse effects on the listed species with little impact on the training mission.

Controlled burning, juniper clearing, grazing, recreation activities, and ongoing scientific studies are coordinated through the Environmental Management Office in order to avoid adverse impacts on protected species. No alternatives to these activities as currently conducted need to be considered.

Alternatives to current grazing activities that would minimize the level of cowbird parasitism include: (1) no grazing, (2) reduction in the number of cattle, (3) grazing only during the vireo and warbler nonbreeding season (August through February), and (4) a rest-rotation system that controls the location and movement of cattle. It is not likely that any of the alternatives will completely eliminate cowbird parasitism on Fort Hood. However, reduction or elimination of grazing (alternatives 1, 2, or 3) is expected to reduce cowbird parasitism sufficiently to enhance reproductive success. For example, a reduction in the number of cattle after 1988 was associated with a decrease in parasitism from 90 percent (1987 and 1988) to 60 to 65 percent (1989 and 1990). Reduction in grazing intensity has the additional benefit of improving the condition of the land for military training by retaining more ground cover to protect the soil. Alternatives 1 and 3 may be more effective than alternative 2 in reducing the density of cowbirds on the installation during the breeding season. Alternative 4 may be most effective if properly coordinated with cowbird trapping. For example, incidence of cowbird parasitism in black-capped vireo nests at the Kerr Wildlife Management Area was reduced from 90 percent to 10 percent by placing traps in areas being used by the cattle, and moving the traps from pasture to pasture along with the cattle. Additional research is needed to evaluate the effectiveness of these alternatives as well as their compatibility with the military mission.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. Plants

1. Croton alabamensis

Best current information suggests that Fort Hood activities are not likely to have an adverse impact on this taxon.

B. Animals

1. Impact of Fort Hood Activities on the Black-capped Vireo and the Golden-cheeked Warbler

a. Direct Impacts

(1) Military Training and Testing

Direct impacts are those that directly cause mortality, modify essential behavioral activities, or destroy active nests. In the vireo, adult mortality and nest destruction due to maneuver training were never observed and are expected to be infrequent in both species. In the case of the vireo, its well-documented ability to renest minimizes any adverse impact that may occur. Warbler nests, which are less accessible than vireo nests, are expected to be impacted even less frequently, if at all.

Maneuver activity caused abandonment of vireo nests in no more than about 1 percent of all nests observed. Given the vireos ability to renest, the effects of such activity, if any, are not likely to adversely affect reproductive success. The golden-cheek nests higher above ground than the vireo such that impacts from maneuver training are expected to be even less frequent.

In the case of the vireo, about 6 percent of all pairs were affected by military activities as evidenced by shifts or abandonment of territories. No data are available for the warbler, but such impacts are not likely to be any more significant than for the vireo. Given that warbler habitat is more abundant and less accessible than vireo habitat on Fort Hood, such impacts are likely to be less on a percentage basis. Furthermore, experts agree that warbler behavior will not be affected by these military activities (Wahl, personal communication, Rust, personal communication).

Relatively minor precautions can be followed to minimize direct impacts of maneuver training on both the vireo and the warbler.

Live fire training, including aircraft gunnery, results in an increased probability of fire in habitats occupied by the vireo and the warbler. Fires that occur during the breeding season may directly affect either species. Although adult birds can escape direct mortality from fire, active nests and young incapable of strong flight may be destroyed. Also, any birds located within the vicinity of target areas may be adversely affected by direct fire.

Habitat destruction caused by fire will also cause the birds to alter their foraging and nesting behavior by displacing them from their established territories. If existing habitat is already fully occupied, displaced individuals may not be able to find suitable nesting and foraging areas. This problem is addressed by

Command Policy No. 91-6 (5 April 1991) which restricts use of pyrotechnics and other incendiary munitions during periods of high temperatures and dry windy conditions in order to prevent range fires on Fort Hood.

(2) Other Activities

Controlled burning and juniper cutting in habitats occupied by the vireo or the warbler are not likely to cause direct mortality in adults, but may destroy nests and young. The likelihood of this occurring on Fort Hood is minimized by a policy of coordinating such activities through the Environmental Management Office. Grazing, recreation, and ongoing scientific studies are not likely to have a direct impact on mortality in either species.

Controlled burning and juniper cutting in habitats occupied by the vireo or the warbler may affect the behavior of these species in the same way as habitat loss due to military-related fire. The likelihood of this occurring on Fort Hood is minimized by a policy of coordinating such activities through the Environmental Management Office.

Recreational ORV activity may affect the vireo if routes go through existing habitat. Impacts on the vireo due to other recreation activities have not been documented. Coordination of recreation activities through the Environmental Management Office will minimize the probability of any impacts.

The LCTA program is not likely to adversely affect either species. It will have a positive effect by providing information on the current condition and trend in habitat of both species on Fort Hood. Inventory and monitoring of the populations of these species also will have a net positive effect by providing critical information on the status and reproductive success of each. Negative impacts may arise due to nest monitoring and banding. Nest monitoring activities occasionally cause nest abandonment, but primarily during the construction and early stages of the nest cycle leaving time for the birds to renest. Banding requires netting and handling the birds. Researchers on Fort Hood have banded over 400 birds without any known injury to those birds. Permits to conduct these activities are obtained from the USFWS.

b. Indirect Impacts

Grazing indirectly affects vireo nesting activity. Cattle attract and help maintain foraging habitat for cowbirds. Cowbirds in turn parasitize and reduce the productivity of vireo nests. The impact of cowbirds on golden-cheeks on Fort Hood has not yet been documented. Pulich (1976) indicates that the incidence of cowbird parasitism can be high. Modification of the existing cattle grazing program is appropriate and could be pursued as a means of mitigating incidental effects of military activities.

c. Impacts on Habitat

Range-wide habitat loss is cited as a major factor threatening the existence of both the black-capped vireo and golden-cheeked warbler. Fort Hood presently supports about 300 adult vireos within approximately 560 ha of occupied habitat. Golden-cheeked warbler habitat is even more abundant but not as well quantified at present. Over 500 male golden-cheeks have been documented to date. Clearly, the presence of the military at Fort Hood has benefitted these species by protecting their habitats from extensive rangeland improvement and urbanization. In the case of the vireo, habitat disturbance, especially that due to fires has been beneficial.

(1) Military Training and Testing

The habitats of the black-capped vireo and golden-cheeked warbler are not conducive to extensive maneuver training. Thus, in general, maneuver training will have limited impact on the habitat of these species. Although the early successional nature of vireo habitat makes it more accessible than warbler habitat,

a small amount of disturbance will not adversely impact vireo habitat. Warbler habitat is most likely to be affected along the edge of habitat patches where vehicles park or bivouac sites are established, and along existing tank trails and roadways. Damage to or loss of juniper trees and deciduous hardwood foliage within warbler habitat will reduce habitat quality. Simple precautions can be taken to minimize these impacts that will have little impact on maneuver training.

Live fire training, including aircraft gunnery, has the greatest potential to affect vireo and warbler habitat. Fire will damage or destroy existing habitat of either species. The vireo and the warbler will be adversely affected by fire within their respective habitat, but the vireo will be benefitted in the long run by fire in warbler habitat.

(2) Other Activities

Cutting and burning to control juniper encroachment into grassland areas is not likely to affect vireo or warbler habitat. Accidental or other extension of these activities into adjacent vireo or warbler habitat may be detrimental. Coordination of these activities through the Environmental Management Office will minimize the possibility of adverse impacts.

Existing recreation activities do not affect the habitat of these species. Deer management activities may affect both species. Deer shooting lanes destroy and fragment warbler habitat, but enhance habitat for the vireo. Dense deer populations have reduced quality of warbler habitat in other parts of the range. There is no evidence to suggest that deer populations are affecting either species on Fort Hood.

Ongoing scientific studies and cattle grazing on Fort Hood presently do not impact vireo or warbler habitat.

2. Impact of Fort Hood Activities on Cave Invertebrates

According to Dr. Reddell, there is a reasonable likelihood that more extensive studies of the Fort Hood cave fauna will reveal additional undescribed species or species known from other locations that are listed as endangered. Two species (*Texella* new species and *Batrisodes* new species) known from northern Williamson County (adjacent and south of Coryell County), after taxonomic review, will be found to be species already listed, or will warrant listing as threatened or endangered. Three others known from this area likely will be petitioned for listing in the future: *Rhadine noctivaga*, *Circurina* (*Cicurella*) new species, and *Neoleptoneta anopica*.

Surveys will be conducted in the near future to evaluate the Fort Hood cave invertebrate fauna. As discussed below, simple precautions can and should be taken now to protect known cave sites.

3. Impact of Fort Hood Activities on Other Species

Fort Hood activities presently do not affect the bald eagle, peregrine falcon, or whooping crane.

C. Management Considerations

Numerous factors must be taken into consideration in evaluating the overall impact of Fort Hood activities on these species and in developing an endangered species management plan. Important issues that must be addressed include: (1) minimum population size and habitat area, (2) relationship to the regional population, (3) habitat fragmentation, (4) single species management, and (5) integration of endangered species management with the military mission.

1. Minimum Population Size and Area

The minimum population size and habitat area required to maintain stable populations of these species are unknown. Preliminary analyses by Pease and Gingrich (1989) suggest that the population size of the warbler must be between 500 and 1000 to avoid extinction due to natural variability in the environment and population size. The area required to support this population varies depending upon habitat quality. At a territory size of 3 ha, this population would require 1500 to 3000 ha of habitat. They go on to suggest that a reserve area containing >5000 ha of habitat will be required to prevent extinction of the species. The situation for the black-capped vireo is complicated by the ephemeral nature and patchy distribution of its habitat. Preliminary analysis by Pease and Gingrich (1989) indicate that an area much larger than 10,000 ha would be required to maintain a stable, viable vireo population. Application of their approach to Fort Hood data shows that Fort Hood may not be sufficiently large to support a self-sustaining population of the vireo on its own (Tazik 1991).

Despite the uncertainty as to the appropriate population and area size for these species, achievable goals must be established for the installation and refined as better data are obtained.

2. Regional Population Management

In the case of both species, it is clear that a single reserve area cannot be depended on to ensure long-term survival. Successful recovery of these species will require protection and management at a regional scale. Thus, a regional partnership must be established that brings together elements of private, state, and federal land management interests together with state and federal agencies responsible for the protection of threatened and endangered species.

3. Habitat Fragmentation

Quality of the habitat of these species also is affected by fragmentation. Breaking up of large blocks of habitat into smaller patches can reduce habitat suitability. In some cases, the habitat patch may be too small to consistently support the species. Also, predation and cowbird parasitism are more intense near the edges of habitat patches than in the interior, and fragmentation increases accessibility to the whole patch. The impact of fragmentation on the black-capped vireo and the golden-cheeked warbler has not been documented. Thus, the impacts, if any, of Fort Hood operations on these birds as a result of habitat fragmentation is presently unknown.

4. Single Species Management

In formulating a management plan for an endangered species, it is inappropriate to artificially and intensively manage to maximize the carrying capacity of that species while neglecting the needs of the multitude of other species that are traditional components of the ecosystem (e.g., Mount et al. 1988). We are too ignorant of the importance of the many interspecific interactions among these species to ignore their importance even where they seem to be insignificant. Furthermore, we do not wish to contribute to the detriment of various species which, although now abundant, may one day become rare or endangered.

The need to avoid single species management is quite clear at Fort Hood. Management to maximize the carrying capacity of either the vireo or the warbler will be to the possible detriment of the other. It will be necessary to manage these species in the context of a habitat mosaic that permits their coexistence in sufficient numbers to ensure a continuing viable population of each on the installation. In doing so, it will be important to realize that while warbler habitat on Fort Hood is more extensive than vireo habitat, vireo habitat develops in a much shorter period of time (3 to 5 years at Fort Hood) than does warbler habitat (decades). Thus, loss of warbler habitat is potentially more serious than loss of vireo habitat.

Figure 12 shows that existing or potential habitat for the black-capped vireo, golden-cheeked warbler, cave invertebrates, and *Croton alabamensis* are overlapping. Thus, it may be possible to locate areas on the installation where intensive management can be applied to these species as a group. This may be most cost effective and have the least impact on military training.

5. Integration of Endangered Species Management With the Military Mission

Fort Hood has supported two divisions for 20 years while also managing to support two bird species that now are federally endangered. With proper leadership and discipline in military training and land management, there is no reason to assume that Fort Hood cannot continue this relationship indefinitely. Although some incidental loss may occur, a balance can be achieved that provides for protection and recovery of both species with minimum impact on the mission.

D. Conservation and Management

1. Croton alabamensis

Surveys have been conducted to characterize sites occupied by this taxon, and to evaluate its distribution and abundance, population structure, demography, density, stem dynamics, and reproductive potential on Fort Hood. Permanent plots have been established at the two major population sites. Conservation efforts should focus on continued monitoring of these populations and protecting them from disturbance. Additional survey work is needed to document presence/absence of the taxon on other parts of the installation to minimize the potential for future conflicts with the mission. If significant additional populations are discovered on the Fort, it will be desirable to conduct more detailed research to evaluate population ecology, habitat requirements, propagation potential, fire tolerance, and impacts of soil disturbance and cutting.

2. Black-capped Vireo and Golden-cheeked Warbler

a. Military Training and Testing

Preliminary guidelines have been issued to regulate troop activities in the vicinity of vireo sites. Sites in high use areas are designated with signs. While in the vicinity of designated vireo sites, military personnel, and others, have been directed to: (1) keep vehicles on established tank trails and open areas, (2) use only previously established fighting positions and emplacements, (3) report all range fires to Range Control, (4) comply with range rules regarding use of flares and incendiary munitions, (5) park equipment only in open areas, and (6) limit time spent during the nesting period (1 March through 31 July) to 2 hours or less. Personnel should not (1) start fires, (2) dig emplacements, (3) drive equipment through or over brush, (4) cut brush or trees for camouflage or other purposes, (5) set up bivouac or other long term posts, or (6) tamper with cowbird traps. These guidelines should be broadened to include the warbler, and should be included in Fort Hood regulations.

Development of new target sites within the vicinity of vireo and warbler habitat should be evaluated with respect to potential impacts on these species.

Military training activities are restricted in TAs 3B and 6A. These areas have been set aside as golden-cheek protection areas, and should continue to receive limited military use.

b. Grazing, Cowbird Parasitism, and Production

There is good evidence to support the relationship between the presence and abundance of cattle and the incidence of cowbird parasitism. The existing cattle allotment is for a maximum of 3813 animal unit months. Actual use was reduced to 1500 to 2000 during 1989-1991 due to a brucellosis epidemic (Don Jones and Dennis Herbert, personal communication). This resulted in a concurrent decrease in cowbird parasitism among vireo nests from 90 percent during 1987 and 1988 to 60 to 65 percent during 1989 and 1990. The latter may be near the high end of what the vireo can sustain while just maintaining its numbers. With more intense cowbird trapping during 1991, parasitism was reduced further to under 40 percent. As such, the existing grazing allotment should be maintained at no more than the existing level of 2000 animal units or less.

There is a statistically significant relationship between cowbird parasitism and vireo production on Fort Hood. This must be taken into consideration in establishing an acceptable or preferred cattle allotment. Other considerations include normal annual variability in production, the likelihood that predation will become more important as cowbird parasitism decreases, and the desirability of surplus vireo production that can contribute to region-wide recovery. Present knowledge indicates that the minimum level of production the vireo requires to maintain a stable population is between 1.45 and 2.29 young per female per year. This corresponds to parasitism in the range of about 45 to 66 percent. Nevertheless, parasitism should be reduced to the maximum extent possible to offset incidental loss due to other military-related activities, and to ensure surplus production.

A substantial reduction in parasitism is attainable through further cutback in cattle numbers and a more effective cowbird control program. Other options to be investigated are: (1) elimination of grazing, (2) grazing only during the avian nonbreeding season, and (3) a rest-rotation system. Note also that a reduction in cattle numbers may benefit the condition of Fort Hood lands thereby providing a greater carrying capacity for training. Many other songbird species will benefit from reduced cowbird parasitism as well.

In the short run, and until more effective measures are developed (see **Research** below), cowbird control efforts should include trapping, shooting, and cowbird egg and nestling removal. Trapping and shooting at all major vireo sites and vicinity and cattle concentration areas, including areas within the live fire training area, must begin early in the breeding season during late March and continue through mid-July. An effective effort early in the season will permit greater success among the early vireo and warbler nesting attempts and increase the chance for double broods. Removal of cowbird eggs and nestlings should be viewed as a supplementary rather than a primary means of control.

Future grazing lease agreements should require that grazing activities do not negatively impact legally protected, threatened, and endangered species. Revenue might be used to offset the cost of cowbird control activities.

c. Recreational Off-Road Vehicle Use

Recreational ORV use should be prohibited within known golden-cheek and black-cap habitat during March through August.

d. Habitat and Population Management

The greatest threat to vireo and warbler habitat on Fort Hood is fire from live fire training activity. This can result in direct mortality of young birds and active nests, alter nesting and foraging behavior, and damage or destroy habitat. In the case of the vireo, the effect of fire is more often positive than negative because it

can lead to development of new habitat. In contrast, fire within warbler habitat has an adverse effect on this latter species. Warbler habitat that is destroyed requires several decades to recover.

Given that the black-cap is benefitted by fires within warbler habitat, some loss of warbler habitat is acceptable. On-going surveys of the warbler on Fort Hood will lead to an evaluation of the conflicting interests of these two species, and establishment of guidelines for the protection and enhancement of each.

Accidental fires caused by military activity will probably maintain a sufficient quantity of habitat to support a large population of the vireo on Fort Hood. However, this haphazard means of management could aggravate the potential for conflict between the vireo, the warbler, and the Fort Hood mission. The Army should not depend on this as the sole means of habitat management.

Serious consideration should be given to development of vireo habitat in areas least likely to be impacted by military activities. The GRASS potential habitat map layer combined with training intensity maps can be used to help delineate such areas. Although significantly more habitat than presently exists could be developed and maintained with adequate resources, any purposeful increase in total habitat area must be evaluated with regard to possible conflicts with essential mission activities and requirements of the warbler.

The Fort Hood vireo population should be maintained at least at its current level. In doing this, maintenance of existing habitat should be done to the extent compatible with mission activities. In some cases it might be appropriate to allow certain existing sites to become unsuitable through natural succession while offsetting their loss through development of habitat in areas less likely to conflict with the mission as discussed above.

e. Inventory and Monitoring

An annual inventory is required to monitor current numbers, population trends, and distribution of the vireo on Fort Hood. This should take place between early April and the first of June and include areas within the live fire training area.

Fort Hood should continue to search for and document numbers of vireos, especially SY birds, in areas surrounding existing sites. On-going surveys of the golden-cheeked warbler will contribute to this effort. Personnel should also search for vireo populations in the vicinity of Fort Hood to document possible dispersal on and off post. Surrounding populations may be helping to support the Fort Hood population and vice-versa.

A representative sample of about 60 vireo territories in major sites throughout the Fort, including the live fire training area, should be monitored each year to evaluate parasitism, predation, and reproductive success. Sites outside the live fire training area should be monitored at least biweekly from mid-April to late July and include Area 2, Red Bluff, Manning Mountain, and west Fort Hood. Sites within the live fire training area should be monitored approximately biweekly from mid-April to the first of June and every 3 to 4 weeks thereafter. These include Robinette Point, Jack Mountain, Area 75, and Pilot Knob Range. Brown's Creek, although located within the live fire training area, does not fall within a firing fan and can be monitored more frequently. Monitoring should coincide, in part, with the annual inventory recommended above.

Continue to band adult vireos to document trends in annual survivorship, population age structure, and dispersal. In any given year, at least 50 percent of the males and 25 percent or more of the females should be banded. Continuation of banding studies will help determine if the low return rate observed in 1990 is a trend or associated with normal annual variability in returns. Extensive banding of nestlings should be conducted as long as the population remains stable and productivity remains high. This will provide information on juvenile survivorship, which is critical to establishing production requirements and acceptable levels of parasitism.

The ongoing warbler inventory should continue through 1992 and 1993, and a long term monitoring system should be established. The value of TAs 3B and 6A as warbler protection areas should be evaluated.

3. Cave Invertebrates

The highly localized nature of cave systems within the Edward's Limestone formation has led to the evolution of rare, endemic cave species. Coupling this with the inherently poor dispersal capabilities of cave invertebrates makes this group of species particularly vulnerable to extinction, and necessitates the maximum possible protection.

Policies established now to protect cave environments on Fort Hood will permit the Army to avoid present and future adverse effects on any protected species that do occur. This will have little if any impact on the training mission. The following protections are recommended: restrict maneuver activity and vegetation alteration, prohibit vehicle traffic and trash dumping, control fire ants, limit use of herbicides and pesticides, and prohibit dumping of petroleum products within the vicinity of known cave sites. Appropriate buffer zones for each cave site should be determined based on site evaluations to be conducted in the near future.

A few cave sites are protected from many military and other activities by virtue of their location within the live fire training area (Figure 12). It may be appropriate to place grates over cave entrances. However, other protection measures should be designed so as not to draw attention to existing cave sites.

4. Other Species

The policy of restricting helicopter flights during winter in the vicinity of eagle roosting areas at Belton Lake should be continued.

5. Integrated Training Area Management Program

The objective of the U.S. Army Integrated Training Area Management Program (ITAM), of which LCTA is a part, is to assist the military in maintaining a realistic training environment while also pursuing sound land stewardship and meeting environmental compliance requirements. Major elements of the program, in addition to LCTA, include Environmental Awareness, Land Rehabilitation and Maintenance, and Training Requirements Integration. The LCTA portion of the ITAM program has been in implementation since 1988.

The LCTA program includes inventory and monitoring of the condition, trend and carrying capacity of the land, a comprehensive floristic collection, and endangered species surveys and status reports. LCTA plots have been established on Fort Hood in a random fashion stratified by soil type and land cover category based on satellite imagery. Additional special use plots have been established in vireo-occupied areas to characterize and monitor long-term vegetation change. Additional plots will be established as appropriate in warbler-occupied areas for the same purpose.

Data are collected from all LCTA plots annually (Tazik et al. 1991). These data are being used to quantify the carrying capacity of Fort Hood lands with respect to military training and other multiple uses. This information can be used to establish a balance in land use activities that will ensure long term availability of land for training while also protecting critical natural resources such as rare and endangered species.

A mechanism is also being established to report periodically on the status of threatened and endangered species on Army lands. For Fort Hood, this will include reporting information on the status and habitat of species addressed in this biological assessment.

6. Research and Development

a. Habitat

Fire is an effective means of vireo habitat development and maintenance. However, because of the inherent danger in carrying out controlled burns, alternative means of habitat development and maintenance should be explored. For example, large machinery used at Fort Hood for juniper clearing should be evaluated for this purpose. A combination of mechanical and hand clearing and fire might prove effective.

Research should continue in developing a procedure that can be used to identify existing and new vireo habitat patches using satellite imagery and/or aerial photography. Because vireo habitat results primarily from fire, likelihood of success appears high. Application to mapping of warbler habitat on Fort Hood should also be investigated.

b. Grazing and Cowbird Parasitism

Research into the range use and mating system of the cowbird on Fort Hood should be pursued to optimize the control effort. Development of better solutions to the cowbird problem will benefit both the vireo and the warbler as well as many other songbirds, and may save money and manpower in the long run. The relationship between cowbirds and cattle should be examined to determine if cattle movements can be manipulated to concentrate cowbirds and enhance control efforts.

Several alternatives to the existing cattle grazing regime should be evaluated: (1) elimination of grazing, (2) reduction in the maximum allotment, (3) grazing only during the nonbreeding season, and (4) a rest-rotation system. This evaluation should be comprehensive in nature and not focus solely on the needs of endangered species. The carrying capacity of the land for military use and the impact of grazing on that capacity must also be addressed. This is necessary to attain a proper balance in competing land use, i.e., military, cattle grazing, and rare and endangered species.

c. Nest Predation

With a reduction in parasitism resulting from successful cowbird control, predation is likely to increase in importance as a factor limiting vireo reproductive success. As such, future research and monitoring should pay closer attention to nest predation.

d. Database and Reporting Capabilities

A database of all Fort Hood banding and reproductive data has been completed and will be turned over to the Fort's endangered species management staff. However, a database management system also should be provided along with programming designed to facilitate rapid data input, analysis, and reporting of annual inventory and monitoring data. The Fort's endangered species management staff will also require access to and training on a GRASS workstation to manage, analyze, and display the variety of spatial data relevant to endangered species management on the installation: past and current territory and site locations, territory size, dispersal distances, potential habitat maps, satellite imagery, training intensity maps, records of the various landscape features, etc.

IX. TABLES

Table 1

Number of Territorial Black-capped Vireo Males Observed at Fort Hood Vireo Sites

Vireo Sites[a]	1987	1988	1989	1990
Maneuver Area				
AR2T Area 2-Top	6	9	15	17
AR2S Area 2-Slope	4	3	4	6
AR 6 Area 6	14	11	3	0
AR12 Area 12	ns[b]	2[c]	2	0
REBL Red Bluff	ns	4	6	5
BHMT Brookhaven Mountain	ns	1	ns	0
MAMT Manning Mountain	10[c]	7	10	9
WMSP Williamson Mountain	4[c]	3	ns	1
WMSP Shell Point	1[c]	3	2	1
NWFH Northwest Fort Hood	3[c]	2[c]	3	3[c]
WEFH West Fort Hood	11[c]	18	14	19
Subtotal	53	63	59	61
Live Fire Training Area				
AR75 Area 75	12[c]	18	18	17
ROPT Robinette Point	9[c]	19	30	8[c]
RAPT Rambo Point	1[c]	ns	2	ns
BRCR Brown's Creek	2[c]	9	7	8
JAMT Jack Mountain	6[c]	15	11	9[c]
NOLF Ruth Cemetery	ns	1[c]	4[c]	1
NOLF Dalton Mountain	ns	2[c]	1[c]	ns
NOLF Henson Mountain	ns	2[c]	ns	0
LOMT Lone Mountain	ns	ns	3	0
PKRA Pilot Knob Range	1	2	8	8[c]
AR81 Area 81	1	1	ns	ns
Subtotal	32	69	84	50
Total	85	132	143	112

[a] Four letter codes correspond to those in Figure 13.
[b] ns indicates sites that were not surveyed.
[c] Indicates sites not adequately surveyed to reliably determine number of territories.

Table 2

Black-capped Vireo 1-Year and 2-Year Banding Returns for 1988 and 1989 in Percent by Sex, Site Type, Region, and Site

	Total 1-Year Returns				Total 2-Year Returns			
Type/Site[a]	Male		Female		Male		Female	
Main/Monitored								
Area 2-Top	50.0	(14)[b]	42.9	(7)	0.0	(6)	20.0	(5)
Area 2-Slope[c]	37.5	(8)	85.7	(7)[c]	0.0	(4)	66.7	(3)
Red Bluff	0.0	(1)						
Area 6	47.8	(23)	36.4	(11)	16.7	(12)	14.3	(7)
Area 75	60.0	(20)	50.0	(2)	28.6	(7)		
Manning Mt	63.6	(11)			25.0	(4)		
Brown's Creek	66.6	(6)	33.3	(3)				
West Fort Hood	64.3	(28)	50.0	(10)	45.5	(11)	0.0	(2)
	57.3	(110)	50.0	(40)	22.7	(44)	23.5	(17)
Peripheral								
Brookhaven Mt	0.0	(1)						
Shell Point	50.0	(2)	0.0	(1)				
Williamson Mt	16.7	(6)	0.0	(2)	0.0	(3)		
NW Fort Hood	50.0	(2)	0.0	(1)	0.0	(1)	0.0	(1)
Ruth Cemetery	0.0	(1)	0.0	(1)				
North Live Fire	50.0	(2)						
Black Mt	50.0	(2)						
	31.3	(16)	0.0	(5)	0.0	(4)	0.0	(1)
Unmonitored								
Jack Mt	55.6	(18)	50.0	(2)	33.3	(3)		
Robinette Pt	58.3	(12)	0.0	(2)				
	56.7	(30)	25.0	(4)	33.3	(3)		
Overall	53.5	(157)	42.9	(49)	21.6	(51)	22.2	(18)

[a] Site is the original banding site.

[b] Numbers previously banded.

[c] Includes one female banded in 1987 at Area 2-Slope that was present in 1989 at Area 2-Top but not observed in 1988.

Table 3

Median Estimates of Black-capped Vireo Production (Young/Mated Pair) by Year and Site

Site	1987		1988		1989		1990[a]	
Area 2-Top	0.000	(6)[b]	0.917	(6)	2.050	(10)	1.231	(16)
Area 2-Slope	0.875	(4)	0.333	(3)	3.250	(4)	0.500	(4)
Red Bluff					2.833	(6)	1.500	(2)
Area 75			0.100	(10)	1.278	(9)	1.273	(11)
Area 6	0.136	(11)	0.200	(10)	2.167	(3)		
Area 12					2.500	(2)		
Manning Mountain			0.750	(6)	1.625	(8)	1.000	(9)
Williamson/Shell Pt			0.000	(4)	1.250	(2)		
Brown's Creek			0.000	(4)	1.071	(7)	1.333	(3)
Robinette Point			1.000	(3)	0.667	(3)		
Jack Mountain			0.875	(8)	0.583	(6)	1.444	(9)
West Fort Hood			0.000	(13)	1.500	(10)	1.611	(18)
Pilot Knob Range							1.000	(3)
Overall								
Median	0.238	(21)	0.328	(64)	1.686	(70)		
Minimum	0.190		0.297		1.500		1.267	(75)

[a] Minimum estimates of productivity. Median estimate for 1990 productivity not available.
[b] Number of pairs monitored.

Table 4

Means and 95 Percent Confidence Limits of Habitat Structure Variables for VIREO and NONVIREO Plots and the Results of F and t Tests

Variable[a]	VIREO Plots			NONVIREO Plots			F test[b]	t Test
	Mean	LL	UL	Mean	LL	UL	p	p
WOCVR	51.12	47.51	54.73	43.08	35.50	50.83	0.000***	0.062
WOCVR_CV	28.98	25.46	32.50	36.68	29.30	44.07	0.000***	0.061
WOCVR_HARD	45.47	41.57	49.39	30.73	25.09	36.68	0.018*	0.000***
STEM	1772.9	1602.89	1951.54	1036.3	794.67	1309.99	0.001***	0.000***
STEM_CV	32.51	28.38	36.65	42.41	29.35	55.46	0.000***	0.149
STEM_JL	99.7	56.21	155.60	167.8	95.89	259.53	0.259	0.135
STEM_JD	39.9	20.82	65.00	42.2	22.67	67.71	0.828	0.881
STEM_HL	1474.9	1302.87	1657.64	675.1	489.87	889.89	0.010**	0.000***
STEM_HD	67.3	45.83	92.74	56.9	38.07	79.38	0.682	0.500
STEM_DD	129.6	99.05	164.13	106.9	70.65	150.49	0.146	0.374
TREE	27.4	18.74	37.55	37.3	24.52	52.77	0.228	0.221
TREE_CV	96.45	75.38	117.52	70.50	47.80	93.20	0.815	0.092
TREE_JL	7.8	4.46	11.96	14.2	8.33	21.45	0.188	0.074
TREE_JD	3.8	1.31	7.45	1.6	0.59	2.85	(0.001)***	0.121
TREE_HL	7.4	4.06	11.56	14.2	8.39	21.54	0.243	0.055
TREE_HD	2.9	1.84	4.28	3.9	2.27	5.97	0.160	0.359
TREE_DD	8.0	4.37	12.54	5.9	3.46	8.90	0.109	0.387
TREE_JLA	5.6	2.98	9.00	8.7	4.93	13.39	0.565	0.225
TREE_JLB	1.3	0.70	2.02	3.9	2.21	5.91	0.003**	0.004**
TREE_JLC	0.6	0.26	0.98	1.5	0.78	2.29	0.027*	0.028*
TREE_JDA	2.6	0.91	4.98	0.8	0.24	1.57	(0.000)***	0.059
TREE_JDB	1.0	0.35	1.89	0.6	0.21	1.01	(0.007)**	0.278
TREE_JDC	0.6	0.15	1.16	0.3	0.04	0.53	(0.002)**	0.219
TREE_HLA	6.0	3.41	9.36	11.5	6.77	17.34	0.192	0.058
TREE_HLB	1.0	0.32	1.93	2.2	1.03	3.66	0.352	0.112
TREE_HLC	0.2	0.05	0.42	0.3	0.06	0.64	0.059	0.545
TREE_HDA	2.7	1.68	3.93	3.5	2.10	5.16	0.369	0.397
TREE_HDB	0.2	0.01	0.42	0.4	0.07	0.91	0.004**	0.276
TREE_HDC	0.0	0.00	0.00	0.0	0.00	0.00		
V5	111.0	102.96	119.40	91.1	85.06	97.37	0.231	0.000***
V10	149.3	138.98	159.91	113.0	96.64	130.55	0.002**	0.001***
V15	124.7	116.50	133.10	83.2	65.55	102.99	0.000***	0.001***
V20	96.1	87.52	105.04	61.9	45.24	81.17	0.000***	0.003**
V25	67.7	57.53	78.65	46.9	33.42	62.64	0.011*	0.028*
V30	44.1	34.98	54.37	38.3	25.89	53.10	0.042*	0.484
V40	39.1	27.43	52.77	45.0	28.59	65.15	0.151	0.580
V50	15.9	9.39	24.09	24.8	13.92	38.60	0.142	0.194
V60	5.5	2.69	9.09	11.3	5.71	18.56	0.078	0.080
V70	1.9	0.65	3.60	4.1	1.63	7.51	0.075	0.146
V70+	0.7	0.13	1.42	2.5	0.50	5.65	0.000***	0.103
VLT30_CV	23.11	19.74	26.48	26.68	21.60	31.76	0.041*	0.237
VGT30_CV	104.54	88.89	120.19	74.37	53.09	95.65	0.135	0.022*
VGRAS	46.6	35.17	59.59	58.0	44.19	73.76	0.783	0.224
VFORB	37.7	30.64	45.52	30.4	18.32	45.46	0.000***	0.355
WOOD	66.39	62.49	70.18	61.24	53.98	68.26	0.003**	0.200
GRAS	24.80	18.66	31.51	34.81	28.37	41.54	0.568	0.032*
FORB	16.72	13.21	20.56	14.93	8.52	22.75	0.000***	0.656
ROCK	11.26	8.06	14.92	8.59	5.41	12.43	0.542	0.275
CACT	0.11	0.01	0.31	0.22	0.07	0.46	0.535	0.366
TRAC	0.36	0.04	1.01	0.40	0.03	1.15	0.748	0.921

[a] See variable descriptions if APPENDIX I.

[b] For F values, the variance was higher among NONVIREO plots unless p is enclosed in parentheses: * $0.01 \le p \le 0.05$, ** $0.001 \le p \le 0.01$, *** $p \le 0.001$.

Table 5

Means and 95 Percent Confidence Limits of Woody Plant Cover by Species for VIREO and NONVIREO Plots and the Results of F and t Tests

Species	VIREO Plots			NONVIREO Plots			F Test[a]	t Test
	Mean	LL	UL	Mean	LL	UL	p	p
Shin Oak	17.45	13.18	22.18	14.24	9.93	19.18	0.668	0.316
Flame-leaved Sumac	7.94	3.90	13.25	1.03	0.29	2.24	(0.001)***	0.000***
Ashe Juniper	5.17	2.92	8.02	12.24	7.05	18.60	0.033*	0.017*
Texas Oak	3.16	1.12	6.18	0.63	0.18	1.35	(0.000)***	0.017*
Skunkbush Sumac	1.58	0.91	2.42	0.47	0.18	0.90	0.316	0.005**
Red Bud	1.19	0.64	1.90	1.04	0.51	1.77	0.859	0.742
Texas Ashe	1.07	0.45	1.96	1.92	0.69	3.75	0.036*	0.285
Grape	0.76	0.44	1.18	0.20	0.05	0.47	0.816	0.008**
Elbow Bush	0.65	0.24	1.23	0.93	0.46	1.57	0.593	0.444
Greenbriar	0.62	0.33	0.98	0.19	0.07	0.38	0.359	0.012*
Live Oak	0.35	0.13	0.66	1.09	0.44	2.01	0.007**	0.039*
Mexican Buckeye	0.34	0.11	0.69	0.02	0.00	0.09	(0.002)**	0.003**
Texas Persimmon	0.13	0.04	0.27	0.05	0.00	0.15	0.775	0.230
Poison Ivy	0.12	0.05	0.21	0.03	0.01	0.08	0.373	0.040*
Netleaf Hackberry	0.05	0.01	0.14	0.08	0.02	0.20	0.941	0.507
Rusty Blackhaw	0.05	0.01	0.13	0.07	0.00	0.23	0.097	0.664
Gum Bumelia	0.10	0.03	0.19	0.07	0.02	0.16	0.929	0.642
Evergreen Sumac	0.06	0.00	0.22	0.04	0.00	0.13	0.096	0.669
Carolina Buckthorne	0.06	0.01	0.14	0.01	0.00	0.03	(0.031)*	0.062
False Willow	0.02	0.00	0.10	0.00	0.00	0.02	(0.000)***	0.272
Deciduous Holly	0.02	0.00	0.07	0.01	0.00	0.04	0.456	0.443
Cedar Elm	0.01	0.00	0.07	0.03	0.00	0.09	0.618	0.613
Mountain Laurel	0.01	0.00	0.03	0.00	0.00	0.00	(0.000)***	0.083
Eve's Necklace	0.01	0.00	0.03	0.00	0.00	0.01	(0.005)*	0.326
Virginia Creeper	0.01	0.00	0.02	0.00	0.00	0.01	(0.021)*	0.126
Mexican Plum	0.00	0.00	0.02	0.01	0.00	0.04	0.060	0.657
Post Oak	0.00	0.00	0.01	0.11	0.01	0.62	0.000***	0.171
Blackjack Oak	0.00	0.00	0.00	0.09	0.00	0.36		0.055
White Honeysuckle	0.00	0.00	0.00	0.02	0.00	0.05	0.000***	0.026*

[a]For F values, the variance was higher among NONVIREO plots unless the p value is enclosed in parentheses; symbols as in Table 4.

Table 6

Mean Black-capped Vireo Territory Size on Fort Hood by Year and Site[a]

Sites	1987		1988		1989	
Area 2 Top	3.36	(6)a	5.05	(9)ab	6.59	(11)b
Area 2 Slope	2.72	(4)	5.62	(4)	4.85	(5)
Area 6	2.79	(14)a	3.58	(9)a	7.04	(3)b
Red Bluff					4.45	(6)
Area 12					6.64	(2)
Manning Mountain			3.61	(7)a	6.91	(7)b
Williamson Mountain			3.45	(3)		
Shell Point			4.57	(3)	5.54	(2)
West Fort Hood			3.63	(12)	3.86	(12)
Area 75			2.31	(15)	2.66	(13)
Robinette Point			2.34	(11)a	1.88	(23)b
Brown's Creek			1.96	(6)	3.18	(7)
Jack Mountain			2.76	(15)a	5.04	(11)b
Pilot Knob Range					3.61	(5)
Overall	2.92	(24)a	3.26	(94)a	4.08	(108)

[a] Sample size is in parentheses; means in the same row with the same letter do not differ significantly; no letter indicates no difference between row means at $p \leq 0.05$.

Table 7

Between Year Dispersal Distances of Male and Female Black-capped Vireos

Distance (m)	Males (%)			Females (%)[a]		
0 to 49	11	(13.6)		2	(11.1)	
50 to 99	21	(25.9)	58 (71.6)	1	(5.6)	7 (36.8)
100 to 249	26	(32.1)		4	(22.2)	
250 to 499	14	(17.3)	16 (19.8)	4	(22.2)	5 (26.3)
500 to 999	2	(2.5)		1	(5.6)	
1000 to 2499	5	(6.2)		5	(22.2)	
2500 to 4999	1	(1.2)		0	(0.0)	
5000 to 9999	0	(0.0)	7 (8.6)	1	(5.6)	7 (36.8)
10000 +	1	(1.2)		1	(5.6)	
Median[b]	119			327		

[a] X^2 (Distance*Sex) = 11.919; df = 2, $0.001 < p < 0.005$.
[b] t_s (Medians) = 2.030; $0.02 < p < 0.05$ (Wilcoxon test).

Table 8

Number of Golden-cheeked Warbler Territories in Fort Hood Training Areas Surveyed During 1991

Training Area	Warbler Territories	Training Area	Warbler Territories
1A	8	36B	2
1B	4	43A	4
1C	2	43B	2
2	15[a]	43C	2
3A	37[a]	44B	3
3B	9	44C	1
4A	29	45A	5
4B	12	45B	7
5A	9	48A	1
5B	33	48B	3
6A	27	51A	1
6B	20	52B	6
7A	2	53C	4
7B	10	63	14
8A	2	64	17
11A	5	65	7
12B	13	66	6
13A	3	72	5
13B	16	73B	1
15B	4	74	13
16A	4	75	13
17A	12	80	36
17B	9	82	3
17D	3	84	6
18	2	90	6
22A	2	92	5
24A	7	93	2
24B	4	Intensive Study Area	31
27A	4		
35D	2	TOTAL	515

[a] Does not include territories observed in intensive study area.

X. FIGURES

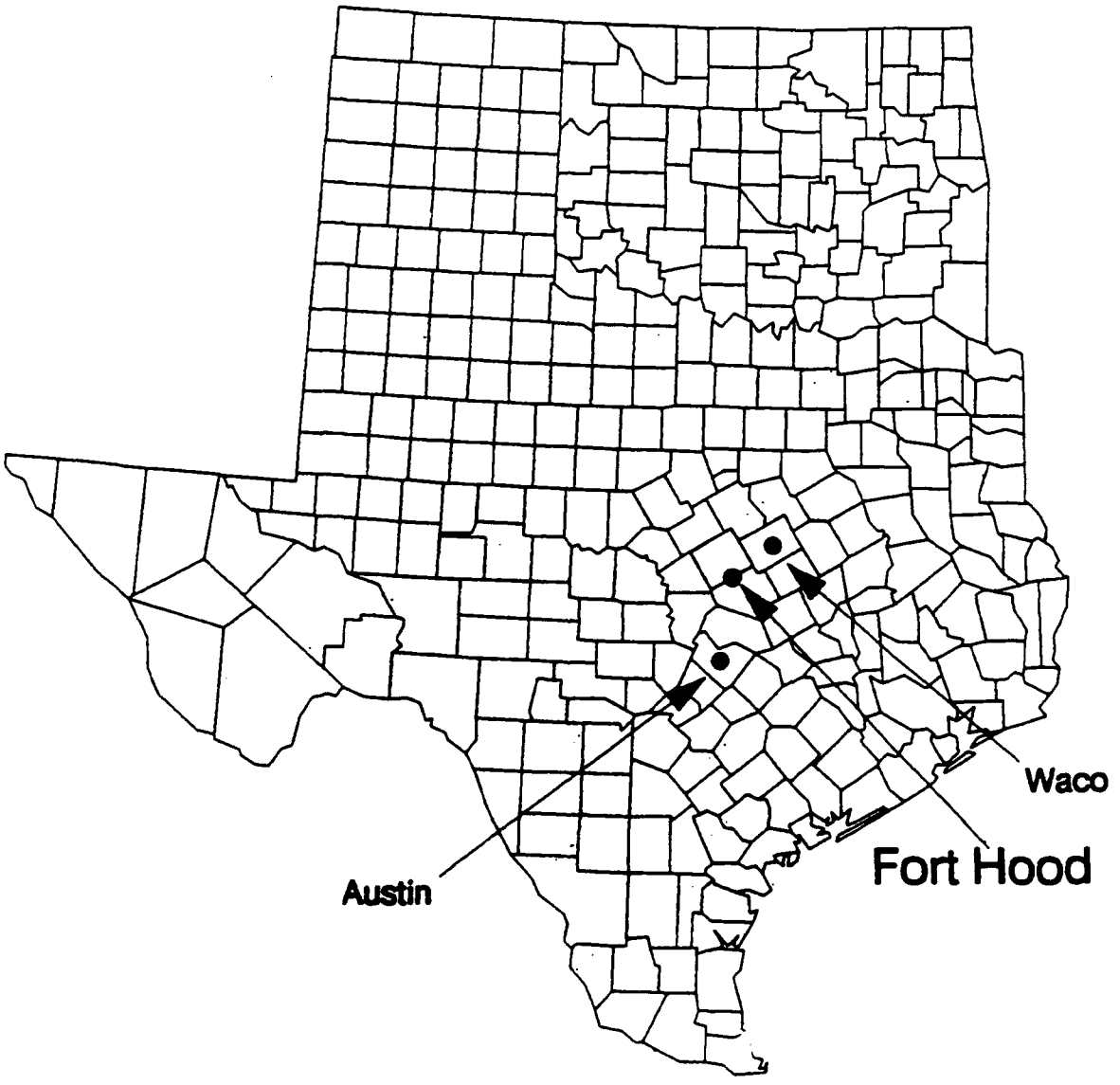


Figure 1. Location of Fort Hood, Texas.

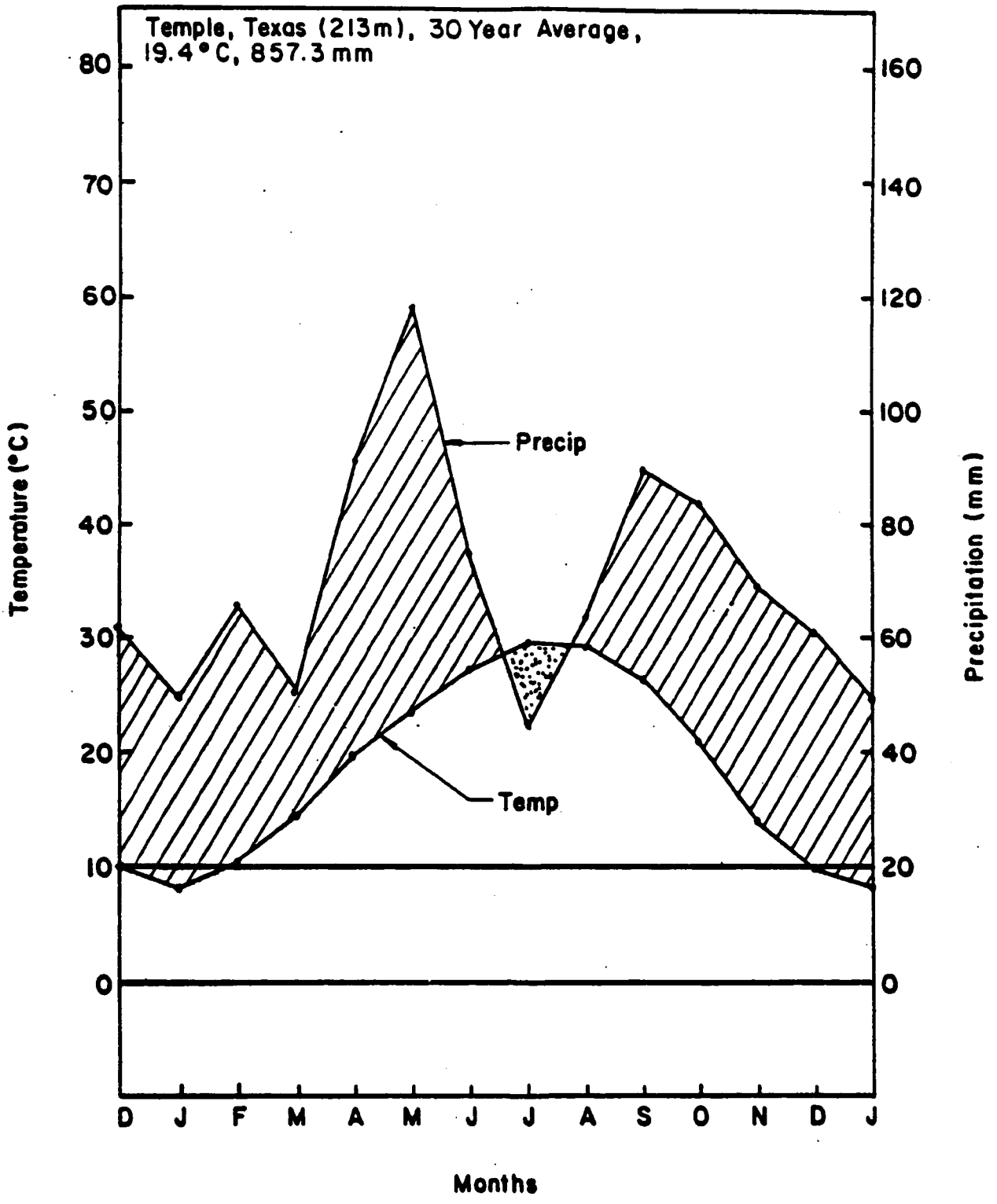


Figure 2. Climate diagram for Temple, Texas showing patterns of temperature and precipitation typical of Fort Hood and vicinity.

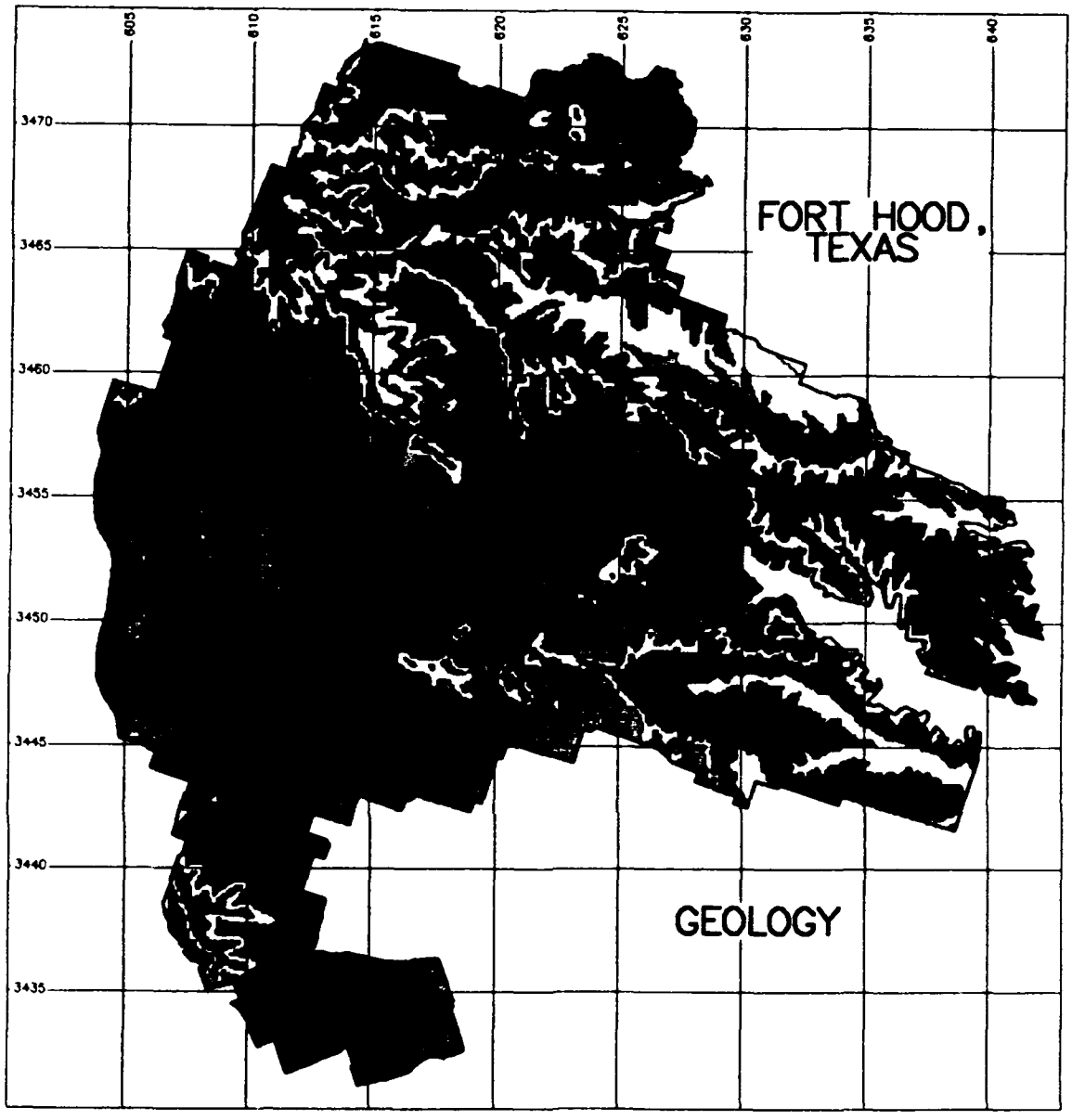


Figure 3. Fort Hood geology (grid: 5000 m).

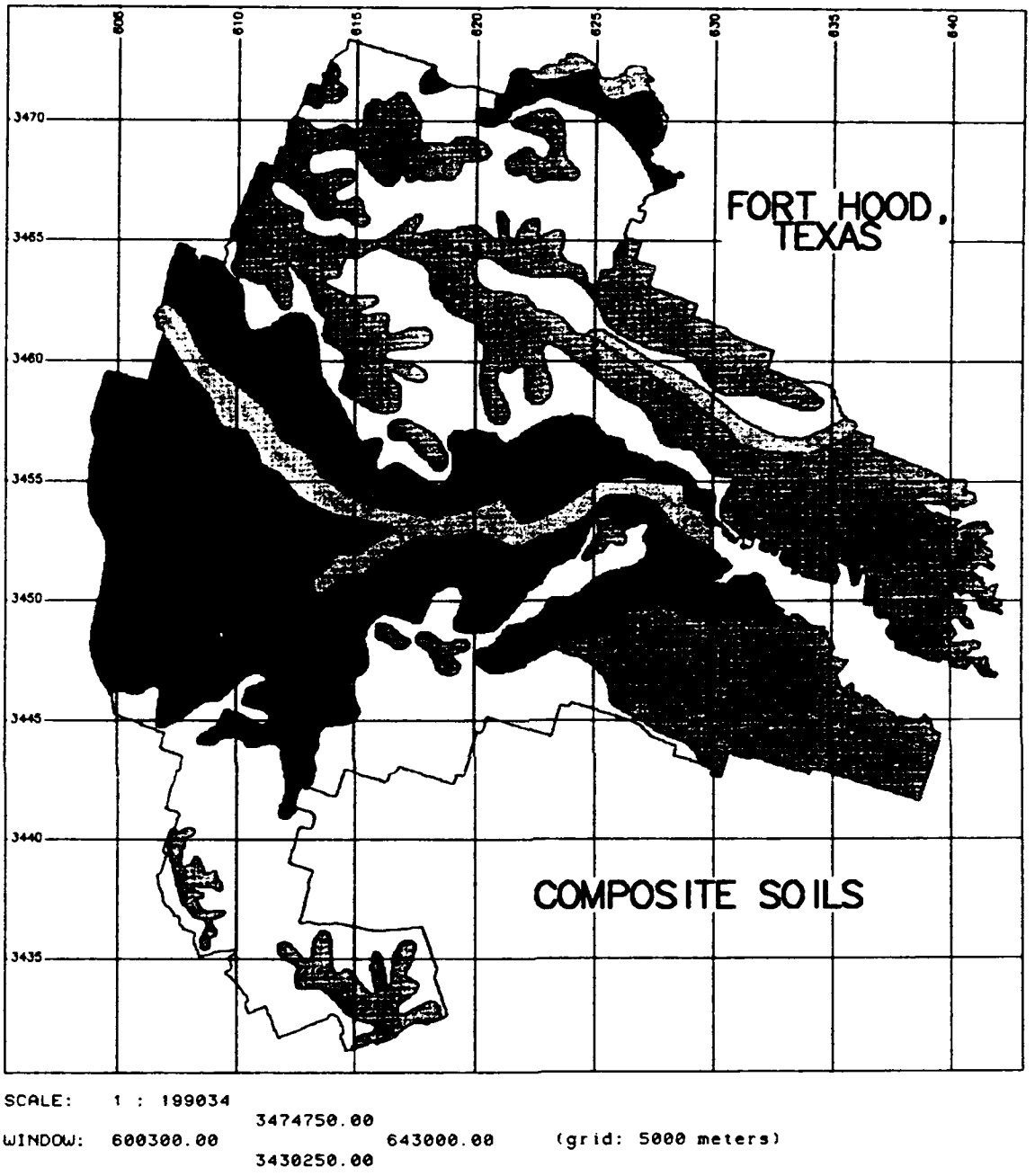


Figure 4. Fort Hood soil associations (grid: 5000 m).

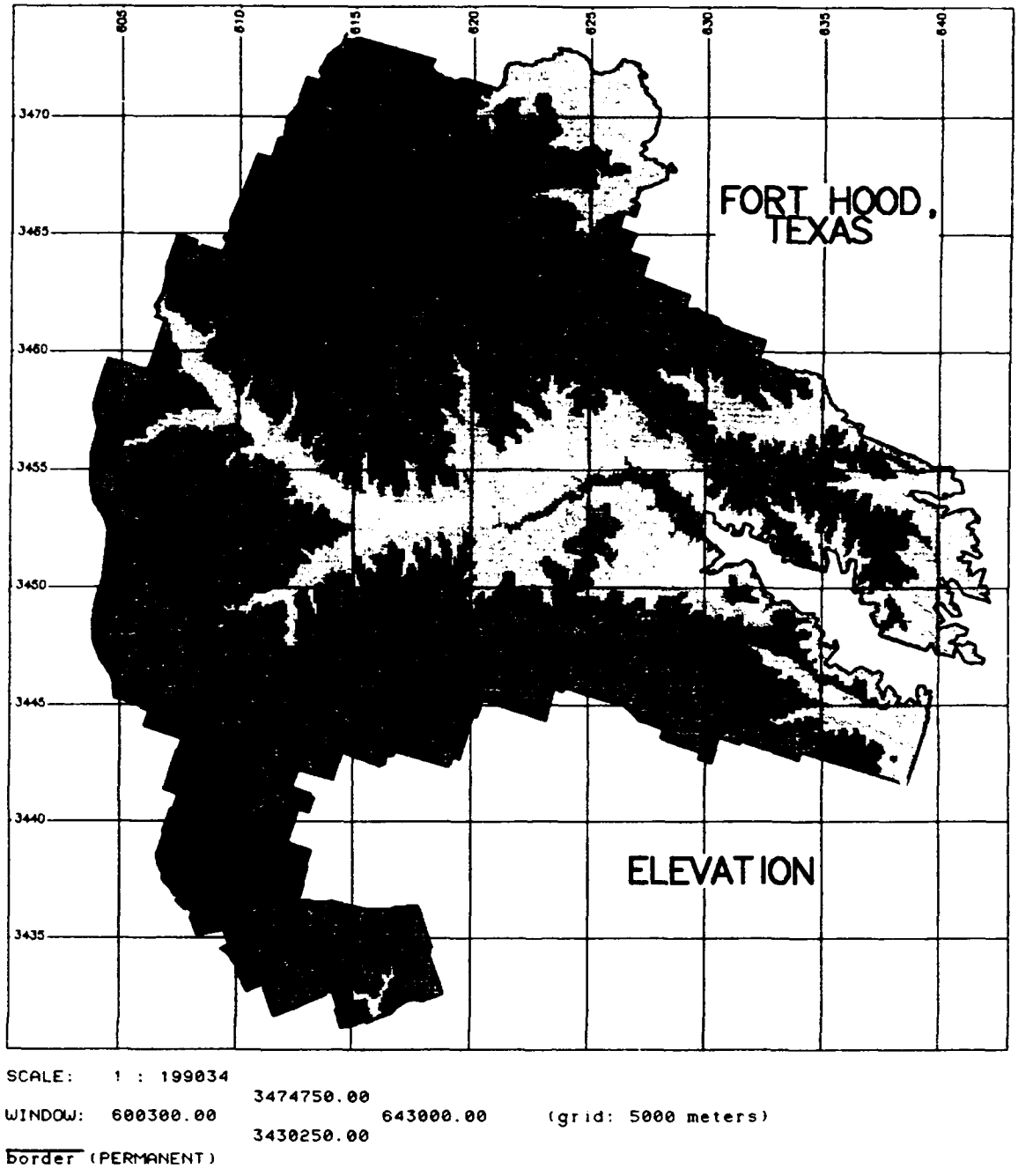


Figure 5. Fort Hood elevation map (grid: 5000 m).

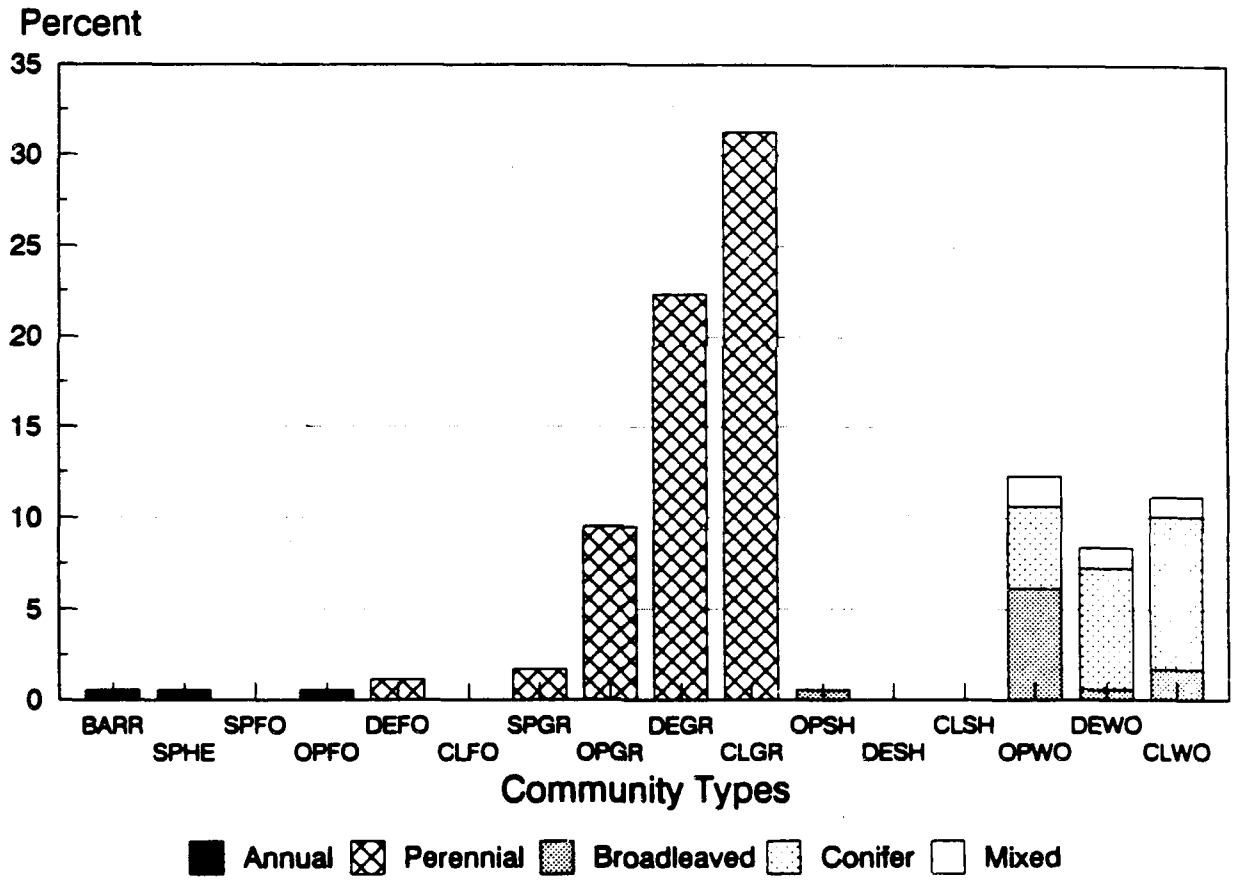
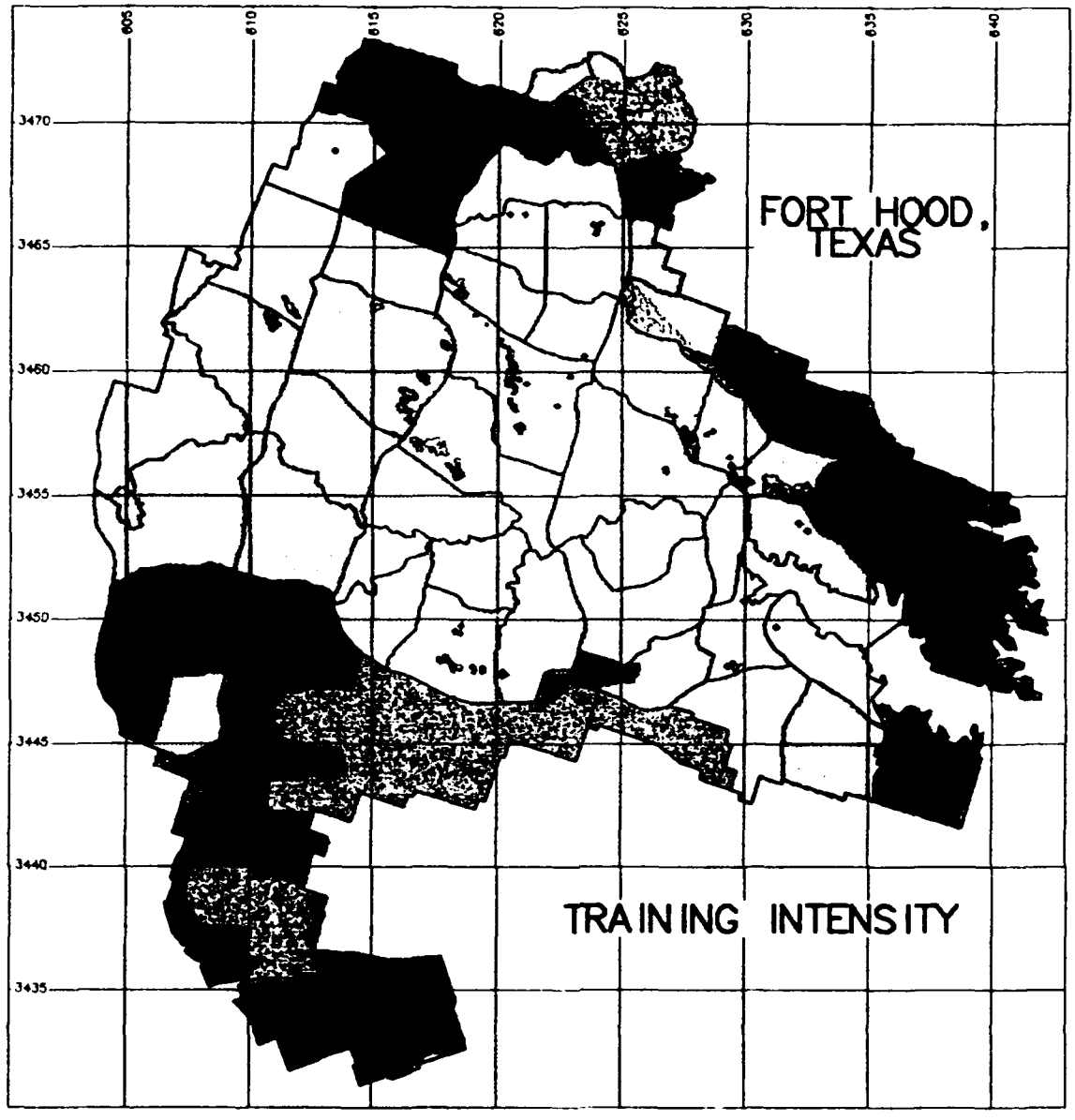


Figure 6. **Fort Hood plant community types (see APPENDIX B for explanation of community type codes).**

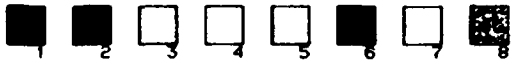


SCALE: 1 : 199034

WINDOW: 600300.00 3474750.00 643000.00 3430250.00 (grid: 5000 meters)

vireo.all (grass)

trn_areas (PERMANENT)



1 1-10 dtve/day - sq mi
2 11-20 dtve/day - sq mi
3 21-30 dtve/day - sq mi
4 31-40 dtve/day - sq mi
5 41-60 dtve/day - sq mi
6 61-96 dtve/day - sq mi
7 live fire zone
8 cantonment and low use areas

Figure 7. Fort Hood training intensity map (grid: 5000 m).

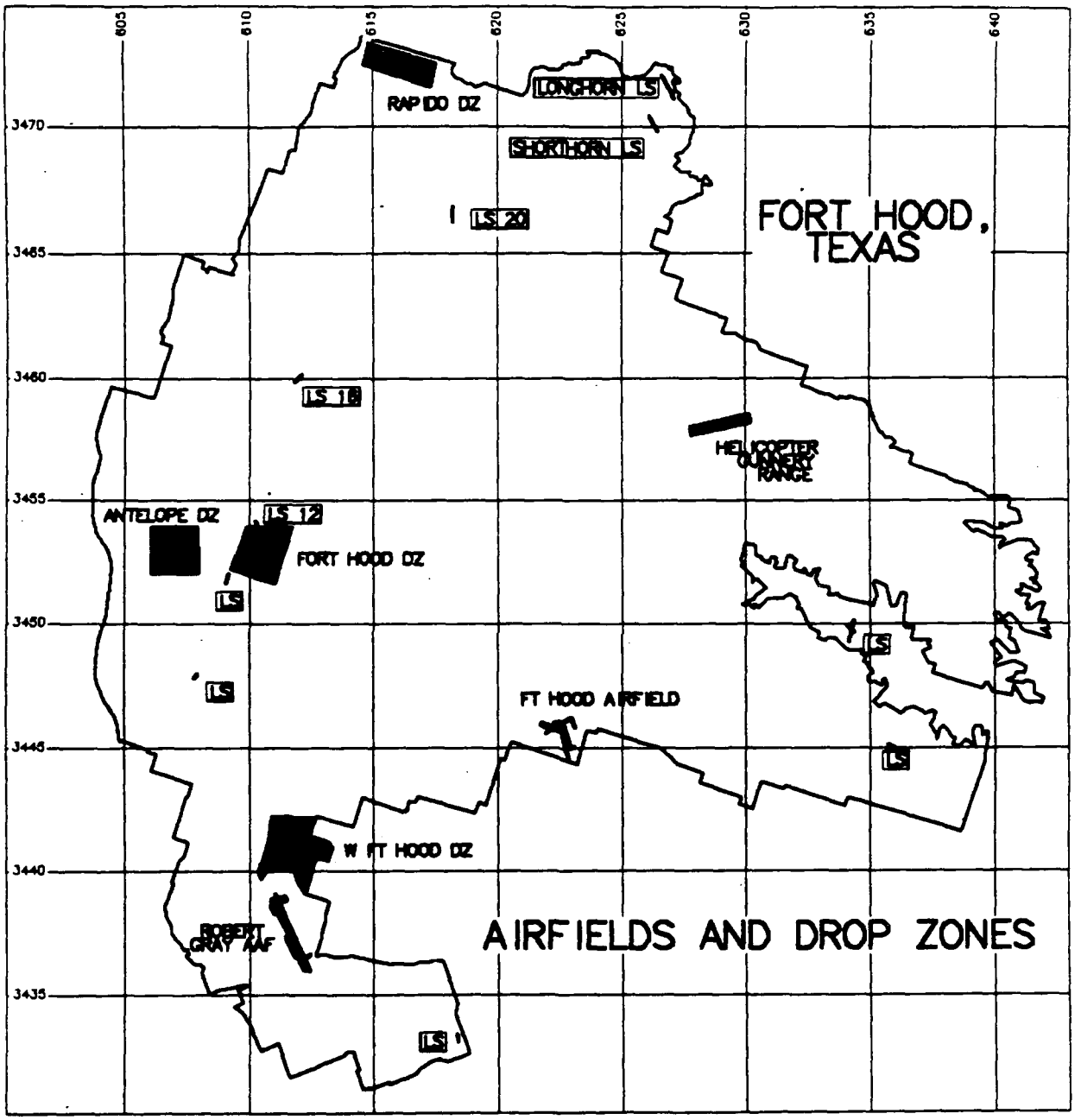
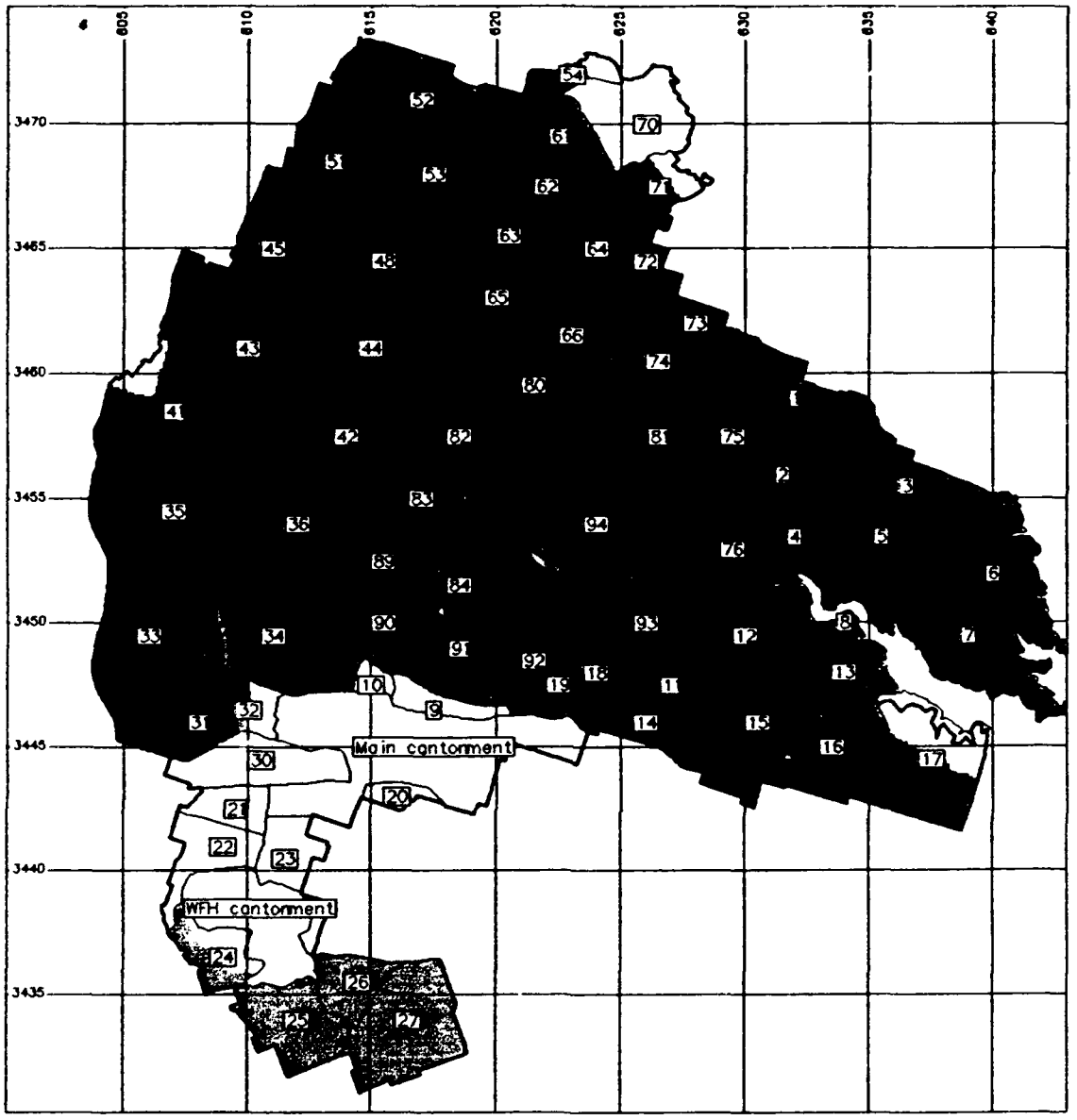


Figure 8. Fort Hood air operations (grid: 5000 m).



SCALE: 1 : 199034

WINDOW: 600300.00 3474750.00 643000.00 3430250.00 (grid: 5000 meters)

trn_areas (PERMANENT)

boundary (PERMANENT)

1 CTCA Lease
2 Mayberry Lease

Figure 9. Fort Hood grazing lease map (grid: 5000 m).

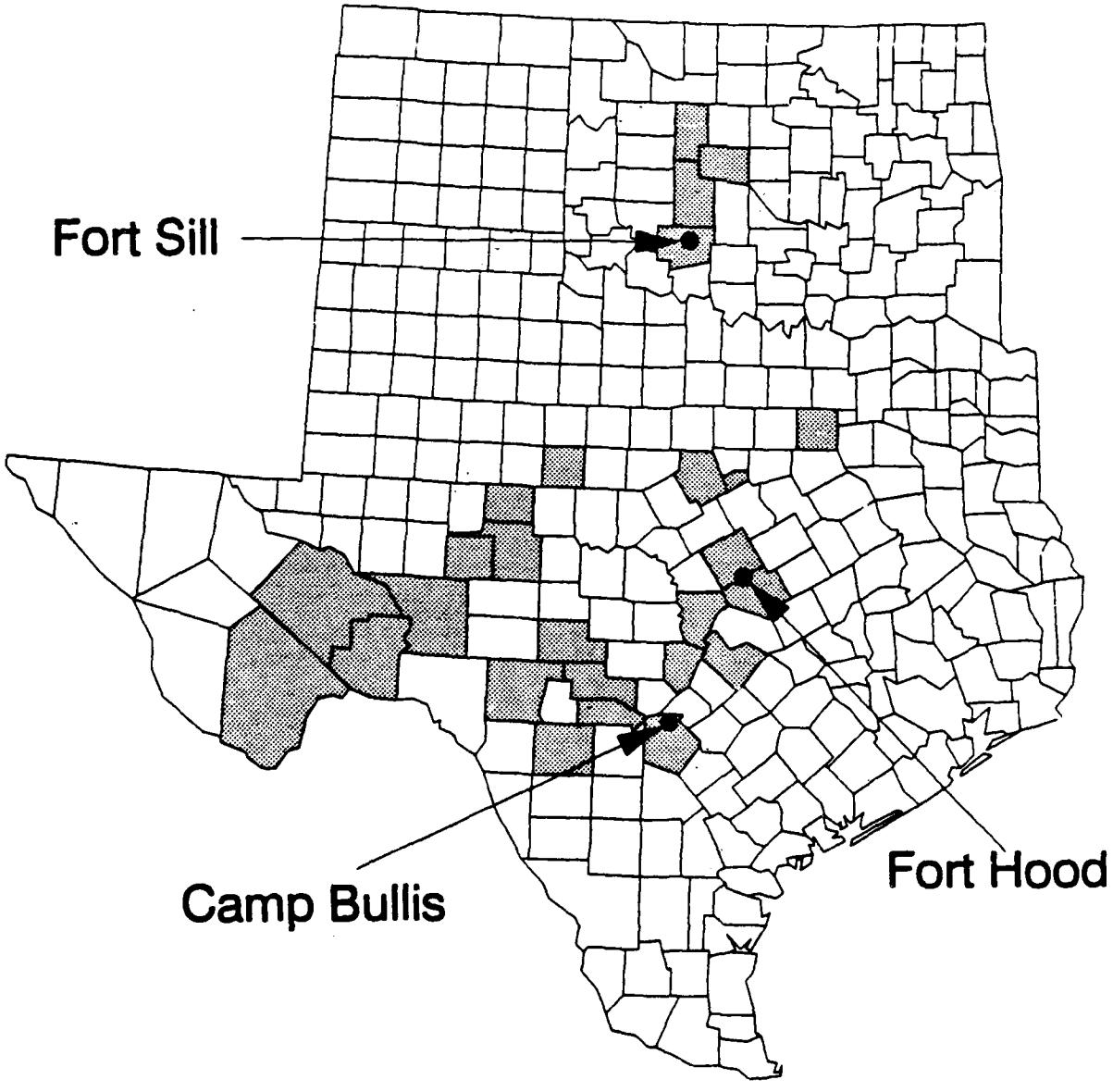


Figure 10. Present breeding range of the black-capped vireo in Texas and Oklahoma (modified from Marshall et al. 1985), and location of Fort Hood, Texas.

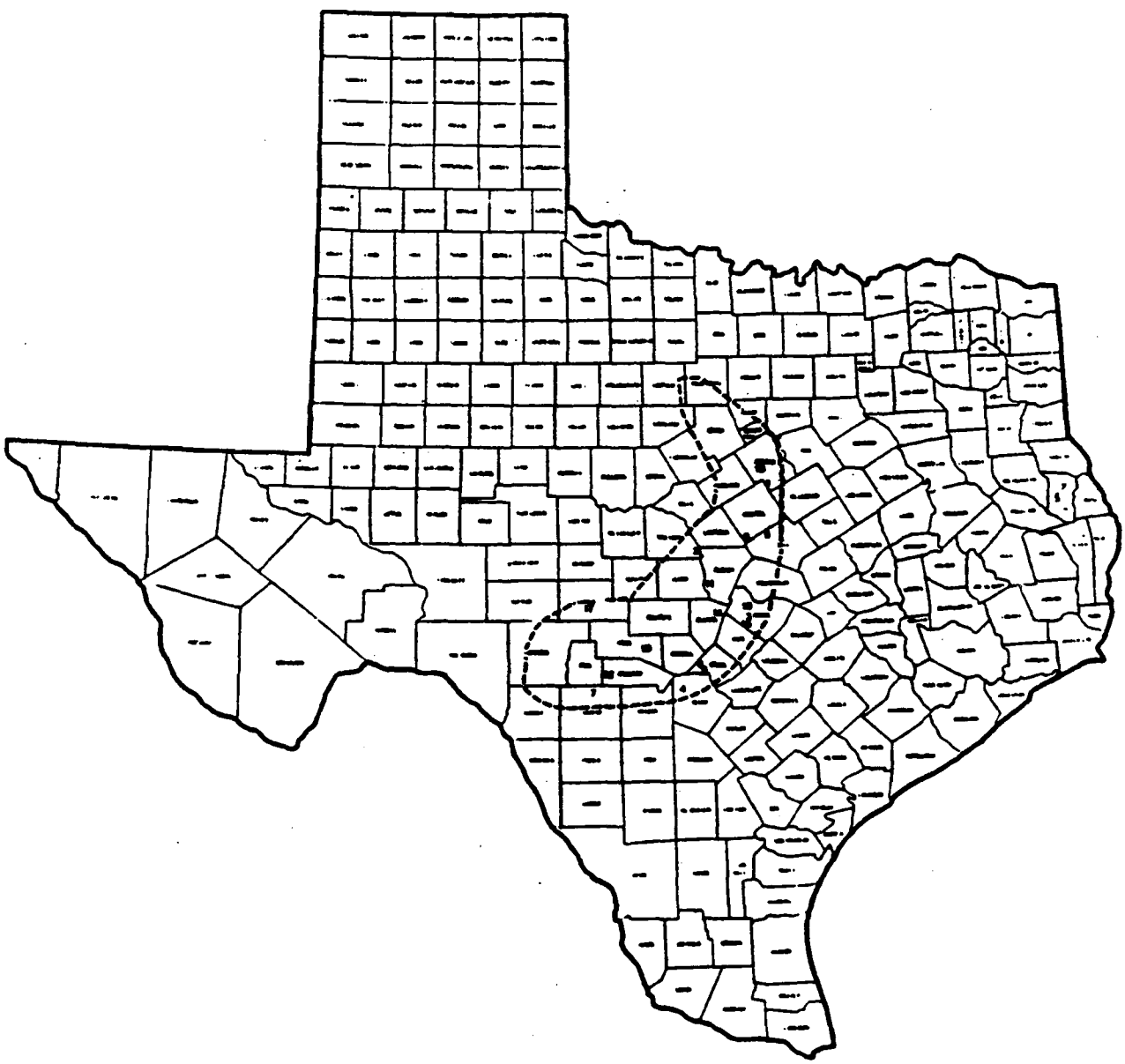


Figure 11. Present breeding range of the golden-cheeked warbler (from Wahl et al. 1990.)

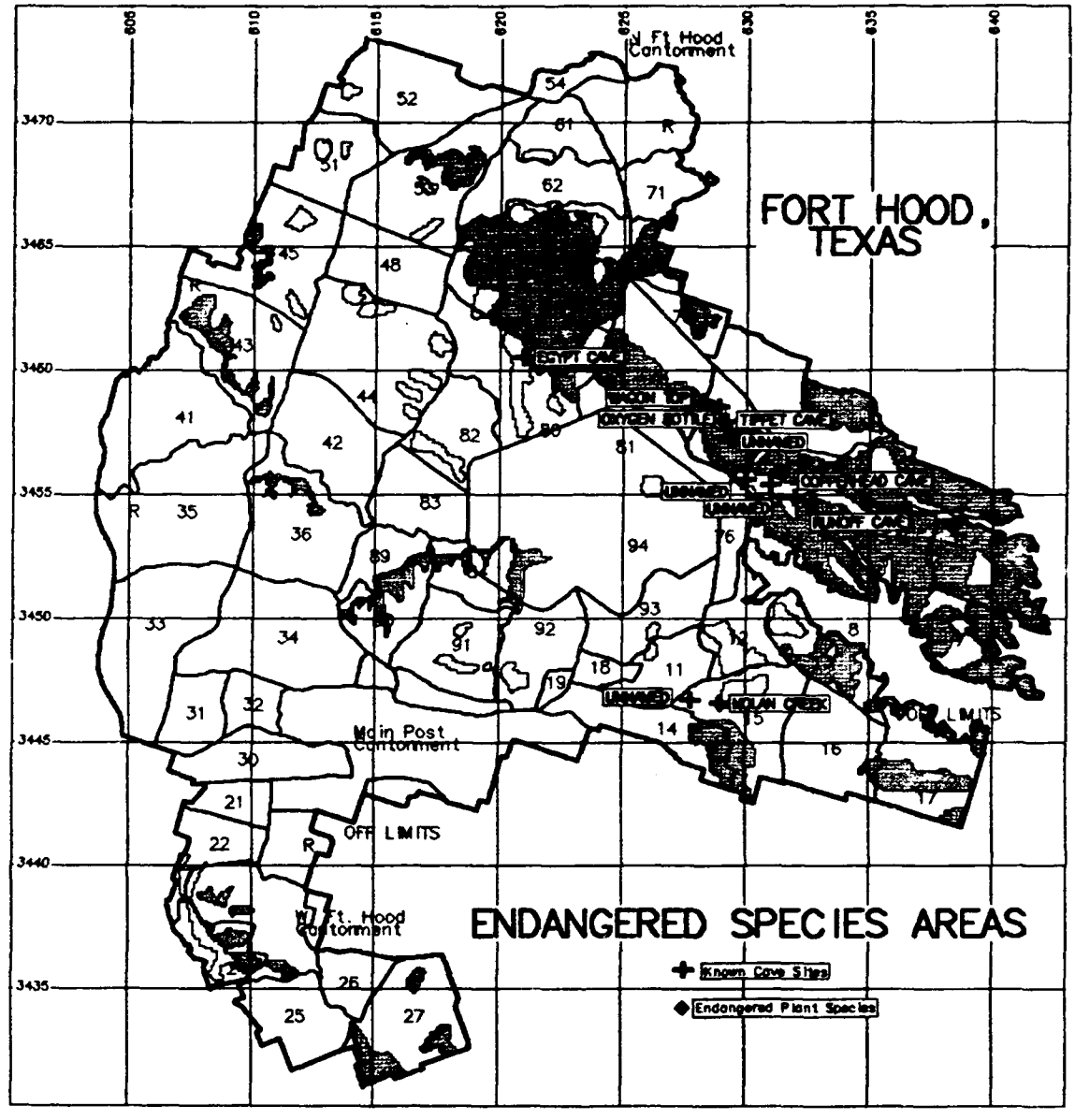


Figure 12. Habitat areas of the black-capped vireo and golden-cheeked warbler, cave sites, and locations of *Croton alabamensis* on Fort Hood.

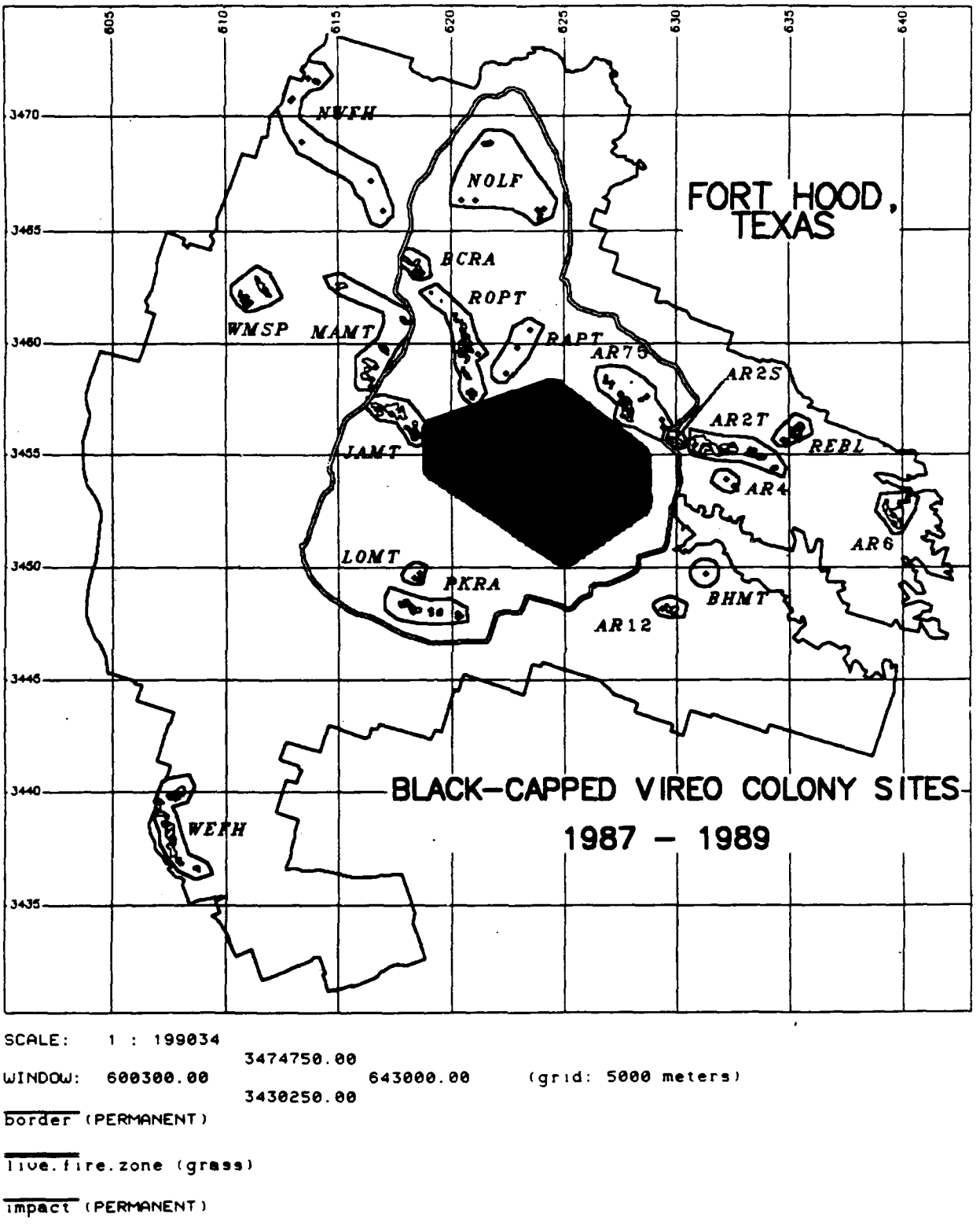


Figure 13. Black-capped vireo occupied sites on Fort Hood (grid: 5000 m). (See Table 1 for code descriptions.)

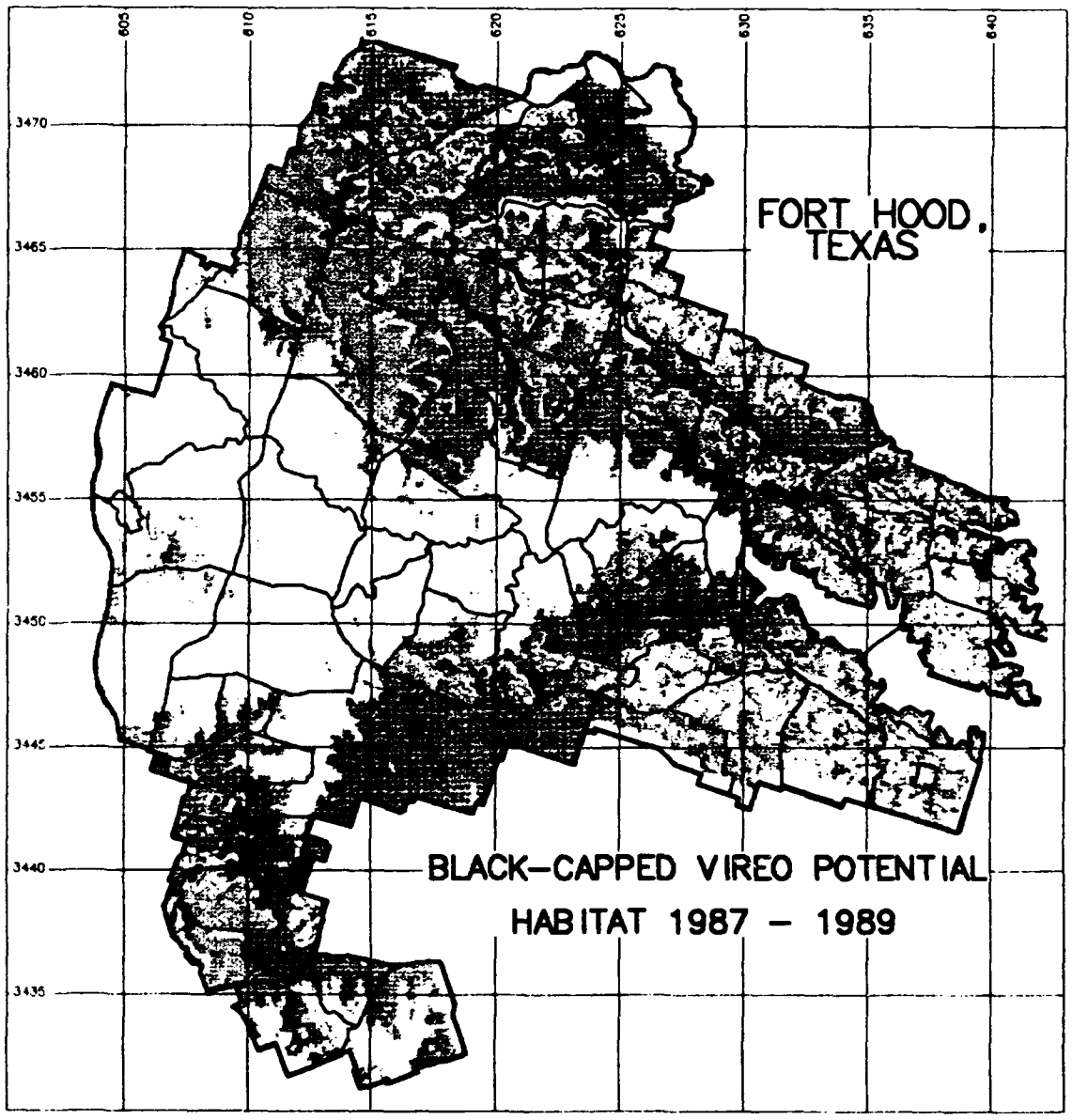


Figure 14. Potential black-capped vireo habitat on Fort Hood based on a GRASS model (grid: 5000 m).

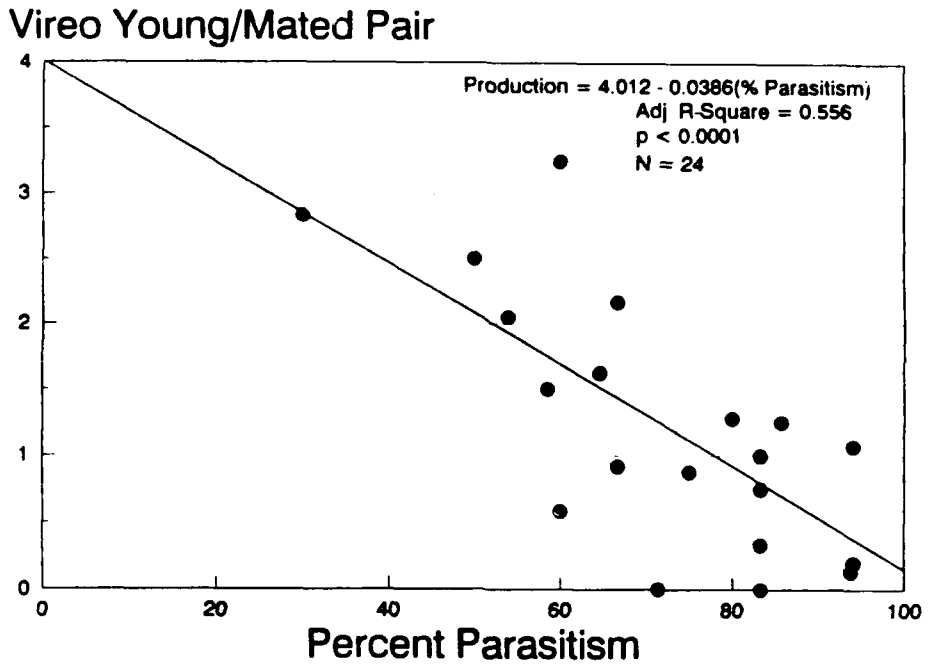


Figure 15. Results of regression of black-capped vireo production on percent cowbird parasitism based on data recorded on Fort Hood during 1987 through 1989. (Modified from Tazik 1991.)

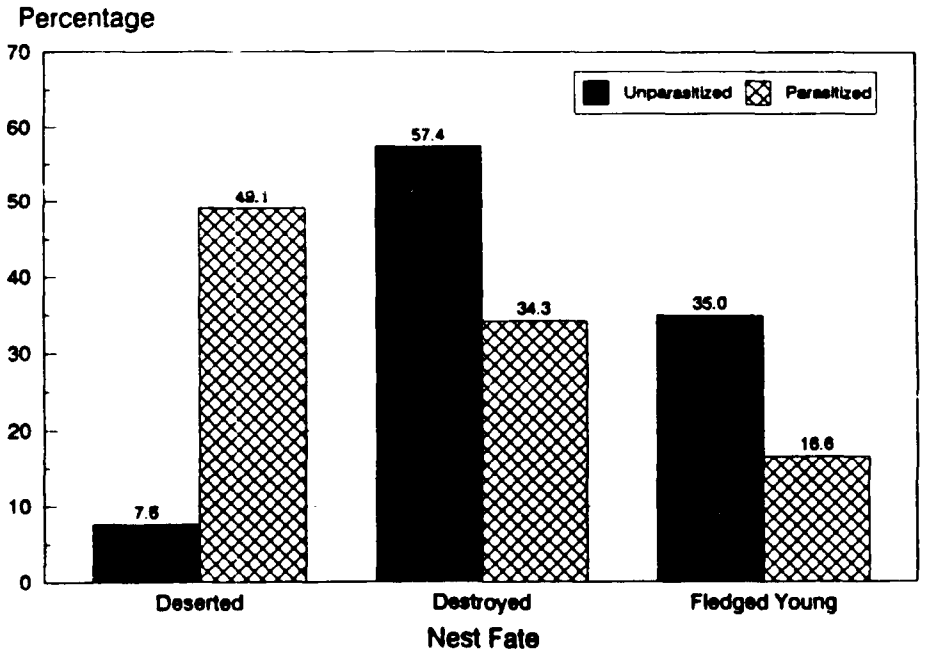


Figure 16. Comparison of the fates of unparasitized and parasitized black-capped vireo nests during laying through the nestling stage as calculated from exposure.

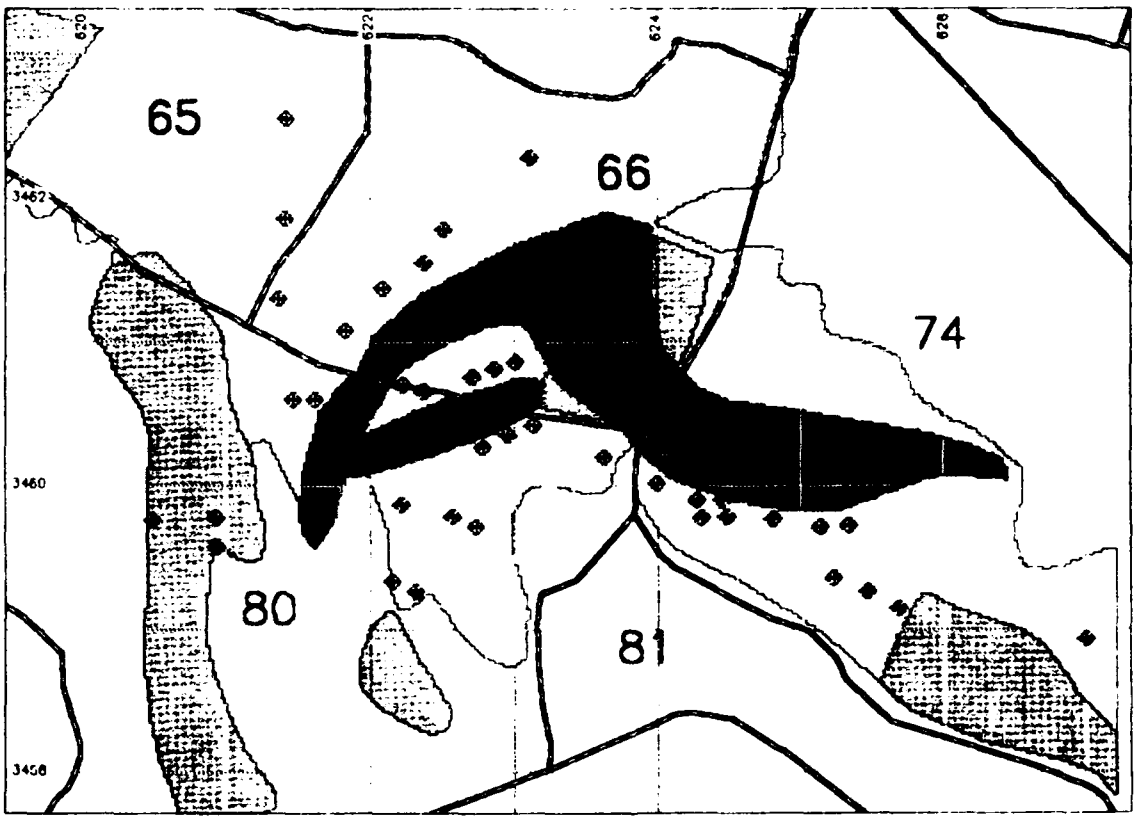


Figure 17. Area of a recent burn on Fort Hood showing locations of golden-cheeked warblers recorded during spring 1991.

XI. BIBLIOGRAPHY AND LITERATURE CITED

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APPENDIX A: Common and Scientific Names of Plant and Animal Species

Common Name	Scientific Name
Woody	
Alabama croton	*Croton alabamensis*
Ashe Juniper	*Juniperus ashei*
Arizona Walnut	*Juglans major*
Bigtooth Maple	*Acer grandidentatum*
Blackjack Oak	*Quercus marilandica*
Carolina Buckthorne	*Rhamnus caroliniana*
Cedar Elm	*Ulmus crassifolia*
Chinquapin Oak	*Quercus Muhlenbergii*
Deciduous Holly	*Ilex decidua*
Elbow Bush	*Foresteria pubescens*
Eve's Necklace	*Sophora affinis*
Evergreen Sumac	*Rhus virens*
False Willow	*Baccharis salicina*
Flame-leaved Sumac	*Rhus lanceolata*
Grape	*Vitis* spp.
Greenbriar	*Smilax bona-nox*
Gum Bumelia	*Bumelia lanuginosa*
Lacey Oak	*Quercus glaucoides*
Live Oak	*Quercus fusiformis*
Mexican Buckeye	*Ugnadia speciosa*
Mexican Plum	*Prunus mexicana*
Mountain Laurel	*Sophora secundiflora*
Netleaf Hackberry	*Celtis reticulata*
Poison Ivy	*Rhus toxicodendron*
Post Oak	*Quercus stellata*
Red Bud	*Cercis canadensis*
Rusty Blackhaw	*Viburnum rufidulum*
Shin Oak	*Quercus sinuata*
Skunkbush Sumac	*Rhus aromatica*
Texas Oak	*Quercus texana*
Texas Persimmon	*Diospyros texana*
Texas Ashe	*Fraxinus texensis*
Virginia Creeper	*Parthenocissus quinquefolia*
White Honeysuckle	*Lonicera albiflora*
Herbaceous	
Little Bluestem	*Schizachyrium scoparium*
Prairie Dropseed	*Sporobolus asper*
Texas Wintergrass	*Stipa leucotrichia*
Birds	
Bald Eagle	*Haliaeetus leucocephalus*
Bell's Vireo	*Vireo bellii*
Bewick's Wren	*Thryomanes bewickii*
Black-capped Vireo	*Vireo atricapillus*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue Jay	*Cyanocitta cristata*
Brown-headed Cowbird	*Molothrus ater*
Carolina Chickadee	*Parus carolinensis*
Carolina Wren	*Thryothorus ludovicianus*
Chuck-will's Widow	*Caprimulgus carolinensis*
Eastern Screech Owl	*Otis asio*
Field Sparrow	*Spizella pusilla*
Golden-cheeked warbler	*Dendroica chrysoparia*
Greater Roadrunner	*Geococcyx californianus*
Lark Sparrow	*Chondestes grammacus*
Mourning Dove	*Zenaida macroura*
Northern Cardinal	*Cardinalis cardinalis*
Painted Bunting	*Passerina ciris*
Northern Mockingbird	*Mimus polyglottus*

APPENDIX A (Cont'd)

Common Name	Scientific Name
Peregrine Falcon	*Falco peregrinus*
Rufous-crowned Sparrow	*Aimophila ruficeps*
Srub Jay	*Aphleocoma coerulescens*
Summer Tanager	*Piranga rubra*
Tufted Titmouse	*Parus bicolor*
White-eyed Vireo	*Vireo griseus*
Whooping Crane	*Grus americana*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-breasted Chat	*Icteria virens*

APPENDIX B: Plant Community Code Descriptions

Code	Description
BARR	Barren; <10% ground cover
SPHE	Sparse Herbaceous
SPFO	Sparse Forb
OPFO	Open Forb
DEFO	Dense Forb
CLFO	Closed Forb
SPGR	Sparse Grass
OPGR	Open Grass
DEGR	Dense Grass
CLGR	Closed Grass
OPSH	Open Shrub
DESH	Dense Shrub
CLSH	Closed Shrubland
OPWO	Open Woodland
DEWO	Dense Woodland
CLWO	Closed Woodland
Sparse:	< 25 % cover
Open:	25 to 50 % cover
Dense:	51 to 75 % cover
Closed:	76 to 100 % cover

APPENDIX C: Fort Hood Physical Plant, Military Equipment, and Military Units[a]

Physical Plant	
Roads--Miles	
Paved	373
Dirt	413
Railroads	9
Major Construction--Approved	
FY 87	$23,382
FY 88	$28,369
FY 89	$42,090
FY 90	$25,650
FY 91	$49,820
Major Construction--Underway	
FY 87	$ 0
FY 88	$ 0
FY 89	$19,046
FY 90	$10,800
Miles of Utilities	
Gas	235
Electrical	786
Water	371
Sanitary	246
Buildings	
Active	4,700
(Sq Ft)	24,982,258
Number of Family Quarters	
Officer	910
Enlisted	4,646
Approved for Construction	0
Military Assets	
Tactical Equipment	
Tracked Vehicles	
Tanks	
M1A1	348
Bradley M2A2/M3A2	264
Other Tracked Vehicles[b]	741
Wheeled Vehicles[b]	4,994
Air craft	
Fixed Wing	9
Rotary Wing	349
Military Units	
Divisions	1
Brigades	13
Groups	2
Battalions	35
Companies	250
Detachments	58

[a] Based on March 1991 data supplemented with information furnished by G3 Training
[b] Number does not include plus-ups to units from Saudi Arabia

APPENDIX C (Cont'd)

Military -- Authorized	37,171
1CD	12,907
2AD	6,549
3D SIG BDE	1,913
6 CBAC	1,525
13 SUPCOM	5,201
31ST ADA BDE	1,408
HQ CMD	2,396
89TH MP BDE	814
504TH MI BDE	1,144
3D FIN GP(CORPS)	937
Apache Training BDE	520
Other Unit/Act	1,608
Military -- Assigned	37,196
Fort Hood's Community	
Post Population	62,021
On Post Family Members	15,015
Fort Hood Volunteers	1,647

[a] Based on March 1991 data supplemented with information furnished by G3 Training
[b] Number does not include plus-ups to units from Saudi Arabia

APPENDIX D: HQ III Corps and Fort Hood Organization

Major Subordinate Commands

1st Cavalry Division
2nd Armored Division (Inactivates by 1 Oct 91)
3rd Finance Group
3rd Personnel Group
3rd Signal Brigade
6th Cavalry Brigade (Air Combat)
13th Corps Support Command (COSCOM)
31st Air Defense Artillery Brigade
89th Military Police Brigade
504th Military Intelligence Brigade
Apache Training Brigade
III Corps Artillery (Fort Sill)

Separate Units and Detachments

13th Public Affairs Detachment
47th Explosive Ordnance Detachment
51st Chemical Detachment
555th Engineer Company (TOPO)
 55th Engineer Detachment
 62rd Engineer Detachment
568th Engineer Detachment (TERRAIN)
584th Engineer Detachment (SURVEY)

Special Staff and Directorates

Headquarters Command
Adjutant General
Aviation
Chaplain
Chemical
Civilian Personnel Office
Communications-Electronics
Equal Employment Opportunity Office
Inspector General
Operations Security (G2)
Provost Marshal
Public Affairs
Plans and Training (G3)
Staff Judge Advocate
Trial Defense Service

Directorate of Civilian Personnel
Directorate of Contracting (DOC)
Directorate of Engineering and Housing (DEH)
Directorate of Information Management (DOIM)
Directorate of Logistics (DOL)
Directorate of Personnel and Community Activities (DPCA)
Directorate of Program Integration and Leadership (DPIL)
Directorate of Reserve Component (DRC)
Directorate of Resource Management (DRM)
Directorate of Security (DSEC)

Tenant Organizations

Air Force Liaison Office
AMC Logistics Assistance Office
AMC R&D Field Support Activity
Army and Air Force Exchange Service
Army Audit Agency, Fort Hood Area Office

APPENDIX D (Continued)

Army Research Institute Field Unit
Commissary (TSA)
Corps of Engineers, Central Texas Area Office (Fort Worth Engineer District)
Criminal Investigation Division, Fort Hood District -- 3rd Region USACIDC
Defense Investigative Field Service Office
Defense Property Disposal (DLA)
Dental Activity (DENTAC)
French Liaison Officer
Medical Department (MEDDAC)
Military Judges, 3rd Judicial Court
NCO Academy
Office of the Scientific Advisor
Operational Test and Evaluation Agency (OTEA) Liaison Office
Special Security Detachment (WIJI); SSD (CEUSPT)
Test and Experimentation Command (TEXCOM)
USA Information Systems Command
USAR/ROTC Units
Det 14, 5th Weather Squadron
204th CMD Squadron
Det 1, 602nd Tactical Air Control Wing
92nd Military Intelligence Group Office

APPENDIX E: Maneuver Training Area Inventory

Training Area	Number of Acres	Utilization (%)	Remarks
1	4940	94	Hilly, rugged terrain with dense vegetation. Platoon and company size dismounted infantry. Excellent for scouting and patrolling.
2	1468	82	
3	3373	86	
4	2390	93	Cross-country mechanized infantry training. Armor and infantry conduct team training. Limited task force training.
5	3359	87	Hilly, rugged terrain with dense vegetation. Platoon and company size dismounted infantry training. Excellent for scouting and patrolling.
6	3077	79	
7	3260	95	
8	2444	85	Used for engineer and amphibious training and for fixed locations by combat support and combat service support units. Located on civil works (Belton Reservoir) -- land permitted to Fort Hood.
11	1878	91	Cross-country armored and mechanical infantry terrain. Armor and infantry conduct team training. Limited task force training.
12	2223	94	
13	2160	92	
14	2184	97	Phantom Run, Bradley or Tank Crew Proficiency Course (BCPC or TCPC)
15	3826	93	Expert Field Medical Badge (EFMB) Training/Testing Area
16	6224	92	Used for signal site, TCPC course, and small unit training area
17	1508	92	
18	655	79	
19	247	42	Soldier's qualification test training area.
21	1250	88	Small materiel testing. Signal, medical, military intelligence, and maintenance battalions and companies use these areas for tactical training. III Corps NCO Academy uses are for land navigation training.
22	1659	90	
23	967	70	
24	2220	90	
25	3161	93	
26	1442	93	
27	4446	95	
31	1778	95	Cross-country armored and mechanized infantry terrain.
32	1319	95	
33	6267	96	Task Force level tactical exercises. Emergency deployment readiness exercises (EDRE). Three drop zones and one dirt landing strip.
34	6309	96	
35	6932	99	
36	5407	100	
41	4752	96	

APPENDIX E (Cont'd)

Training Area	Number of Acres	Utilization (%)	Remarks
42	3823	100	
43	4286	100	
44	6291	98	
45	4328	100	
46	2821	100	
51	2781	94	
52	4549	99	
53	4802	99	
54	596	70	North Fort Hood close-in training area. Used mainly by reserve components when conducting annual training or weekend training at Fort Hood.
61	1876		Live fire areas used for multi-purpose exercises. Subcaliber tank tables, Vulcan firing, helicopter door gunnery, helicopter staging areas for live fire events, high performance aircraft bomb run (inert munitions).
62	3368		
63	2370		
64	3111		
65	2362		
66	1637		
71	1604	78	Hilly, rugged terrain with dense vegetation. Individual and platoon dismounted infantry training. Expert Infantry Badge testing area, patrol training area, and locations for command post exercises.
72	929	70	
73	1829	72	
74	3303		Live fire/maneuver multi-purpose area.
75	2123		
76	1437		
80	5530		Live fire impact areas.
81	6402		
82	4887		
83	3358		
84	2370		
89	1335		
90	2214		
91	3616		
92	3593		
93	4442		
94	2666		

APPENDIX F: Outdoor Range Inventory and Weapons Fired on Fort Hood

Range Inventory[a]

No.	Range Description	Firing Points/Lanes	Utilization (%)[b]	REMARKS
1	Black Mountain Subcaliber 1	5	10	Tank and M2/M3 Bradley Subcaliber tables
2	Black Mountain Subcaliber 2	5	21	Tank and M2/M3 Bradley Subcaliber tables
3	Pilot Knob Hand Grenade/Claymore	12 Grenade 3 Mine	15	Concrete throwing bays for grenade
5	Blackwell Multi-Use	N/A	61	Tank tables, helicopter gunnery tables, mech.infantry platoon attack and defend
6	Pilot Knob Grenade Launcher	6	11	M79/M203 grenade launcher
7	Pilot Knob Submachine Gun/Shotgun	10	12	M3/M3A1 submachine gun, 12 gauge shotgun
8	Pilot Knob Mortar Sabot	N/A	0	Mortar subcaliber training on 1:10 scale
9	Leaders Reaction Course	N/A	N/A	16 station leadership training course
10	Blackwell Pistol Alpha	30	23	Pistol training
11	Blackwell Pistol Bravo	30	14	Pistol training
12	Pilot Knob Rifle Alpha	35	5	M16A1 rifle
14	Combat Pistol Qualification Course	10	31	Pistol qualification
15	Pilot Knob Small Arms Delta	20	1	Pistol training, small bore, rifle zeroing
16	Pilot Knob Sportsman	30	4	Privately-owned weapons firing, M16A1 zeroing
17	Pilot Knob Pistol Charlie	85	10	Pistol course, competition firing
18	Pilot Knob Multi-Use	12	55	Tank tables, mech. infantry platoon attack and defend
20	Clear Creek Artillery Subcaliber	4	2	Artillery subcaliber
21a	Clear Creek Machine Gun Alpha	50	28	M60/M2 machine gun, M16A1 rifle
21b	Clear Creek Record Fire	16	39	M16A1 record fire -- day
21c	Clear Creek Field Fire	35	45	M16A1 field fire -- M16A1 record fire -- night
21d	Clear Creek Zero Delta	50	40	M16A1 zeroing, quick fire training
21e	Clear Creek Echo	50	39	M16A1 zeroing, quick fire training
21f	Clear Creek Machine Gun Bravo	50	33	M60/M2, M16A1 rifle
22	Clear Creek Demolition	4	2	Explosives and demolitions
23	Forced March Live Fire West	N/A	20	Anti-personnel/mine/grenade launcher live fire
24a	House Creek Multi-Use	N/A	5	Mech. infantry firing proficiency exercises
24b	House Creek Night Infiltration Course	N/A	7	Live fire obstacle course
25	Cowhouse Fire Coordination Exercise	6	7	1:10 scale area for direct and indirect fire support
25a	Cowhouse AT-4			Light Antitank Weapon (LAW) Subcaliber Range
	Dalton Mountain Multi-use	N/A	67	M2/M3 Bradley and Helicopter gunnery, Vulcan live fire
26	Cowhouse Machine Gun Transition	6	44	M60/M2 machine gun
27	Cowhouse Night Obstacle Course	N/A	0	11 obstacles
28	Elijah MOUT Facility	N/A	--	Company and below (non-live fire) MOUT Collective Training Facility (CTF) (32 buildings)
29	Hargrove Creek MOUT Facility	N/A	--	Platoon and below (non-live fire) MOUT CTF (16 buildings)
30	Jack Mountain Multi-Use	N/A	9	Tank, tables, M2/M3 bradley firing exercises
31	Jack Mountain MOUT Facility	N/A		Squad/Individual (live fire capable) MOUT CTF (7 training sites)
32	Clabber Creek Multi-Use	N/A	0	Tank tables, M2/M3 bradley firing
33	Round Mountain Helicopter	N/A	Data Not Available	Helicopter gunnery tables
35	Browns Creek Multi-Use	N/A	37	M2/M3 Bradley firing exercises, tank tables
39	Hensen Mountain Multi-Use	N/A	74	Mech. infantry firing exercises, tank tables

APPENDIX F (Cont'd)

Range Inventory

No.	Range Description	Firing Points/Lanes	Utilization (%)	REMARKS
40b	LORAN Bomb	N/A	8	High performance aircraft practice bombing -- 25 pound bombs
41	Shoal Creek Bomb	N/A	13	High performance aircraft practice bombing -- 25 pound bombs
44a	NFH Rifle Alpha	40	0	M16A1 rifle training
44d	NFH Rifle Delta	40	0	M16A1 rifle training
45	NFH Pistol	25	0	Pistol course, competition firing
46	NFH Submachine Gun	4	0	M3/M3A1 submachine guns
48	NFH Machine Gun Alpha	35	0	M60/M2 machine gun, M16A1 rifle
49	NFH Machine Gun Bravo	35	0	M60/M2 machine gun, M16A1 rifle
50	Lone Star Multi-use	N/A	9	Tank tables
53	Owl Creek Demolition	N/A	0	Explosives and demolition
54	Crittenberger Multi-Purpose	N/A	71	Tank tables, M2/M3 Bradley firing
55	Cold Springs Artillery Direct Fire	N/A	10	105mm, 155mm, 8 inch, 90mm recoilless rifle
56	Dismounted Squad Assault Course (DSAC)			Squad live fire assault course
57	Explosive Ordnance Disposal	N/A	Data Not Available	Emergency EOD
58	Riggs M72	N/A	27	M72/M72A1 LAW live fire
59c	Curry Combat Engineer Vehicle	N/A	10	Combat engineer vehicle tables
59b	Curry Demolition	N/A	19	Explosives and demolition
60a	Curry Mortar North	N/A	Data Not Available	81mm and 4.2 inch mortar training
60b	Curry Mortar Center	N/A	Data Not Available	81mm and 4.2 inch mortar training
60c	Curry Mortar South	N/A	Data Not Available	81mm and 4.2 inch mortar training
61	Brookhaven Multi-Use	N/A	18	Tank tables, mech. infantry platoon attack and defend
61a	Brookhaven Mobile Observe Course	N/A	Data Not Available	Indirect fire support training
62	Trapnell Multi-Use	N/A	52	Tank tables, M2/M3 Bradley firing, M48A2 Chaparral
66	Sugar Loaf Multi-Use	N/A	17	Tank tables, M2/M3 Bradley firing
67	Elm Knob Machine Gun Transition	6	13	M60/M2 machine gun
69	Combat Systems, NBC Chamber	N/A	Data Not Available	Chemical training with vehicle
70a	Black Gap Zero	60	30	M16A1 zeroing
70b	Black Gap Record B	6	41	M16A1/2 record fire -- night
70c	Black Gap Record Fire	13	45	M16A1 record fire -- day

[a] FH Pamphlet 350-18, 23 May 1986, Catalog of Established Live-Fire Ranges, Facilities, and Artillery/Mortar Firing Points.
[b] Utilization From 1 January 1986 - 31 December 1986

APPENDIX F (Cont'd)

Weapons Fired on Fort Hood

Tank	**(Direct Fire)**		**Air Defense**	
25mm	(Bradley)	APDS-T, TP-T	20mm	(Vulcan)
105mm	(M60, M1)	TPDS-T, HEAT-TPT	40mm	(Duster)
120mm	(M1A1)	TPFST		
165mm	(CEV)	HE, TPT		
Aerial	**(Helicopters)**		**Missiles**	
7.62	(Cobra)	BALL, TRACER	Chaparral	
20mm	(Cobra)	HE, TPT	TOW	
30mm	(Apache)	HE, TPT	Dragon	
40mm	Grenade (Cobra)	HE, TPT	Redeye	
HELLFIRE	(Apache)	HE	BATS	
2.75 in.	FFAR Aerial	RKT	Avenger (Stinger)	
Rockets Anti-tank			**Mortar**	
35mm	Practice		107mm (4.2 in.)	
66mm	LAW (M72)		81mm	
AT-4	(84mm)		60mm	
90mm				
Small Arms			**Grenades**	
.50 Cal			40mm	M79/M203
7.62 mm			Hand	
.30 Cal				
.45 Cal			**Explosives**	
9.00 mm			C4	
.22			TNT	
00 Buckshot			Ammonium Nitrate	
5.56 mm			Cratering Charges	
			MCLIC (Mine clearing Line Charge)	

Artillery (Indirect Fire)

8 in.	Howitzer	M100
155mm	Howitzer	M109
M31	Artillery Trainer	
Multiple	Launch Rocket System (MLRS)	

U.S. Air Force Weapons

30mm	HE & TP
BDU-33	(Inert Bomb)
MK 82,	531 Lbs
MK 83,	985 Lbs
MK 84,	1972 Lbs

APPENDIX G: Fort Hood Air Operations

Authorized Aircraft

Designation	Name	Type	Number
Robert Gray AAF			
OH-58	Kiowa	Rotary	43
UH-1	Iroquois	Rotary	24
UH-60	Blackhawk	Rotary	21
AH-1	Cobra	Rotary	8
AH-64	Apache	Rotary	18
U-21	Ute	Fixed	13
C-12	Huron	Fixed	2
OV-1	Mohawk	Fixed	16
			145
Hood AAF			
OH-58	Kiowa	Rotary	105
UH-1	Iroquois	Rotary	11
UH-60	Blackhawk	Rotary	52
AH-1	Cobra	Rotary	4
AH-64	Apache	Rotary	72
CH-47	Chinook	Rotary	16
			260
Total			405

Airfield Traffic Counts[a]

	Year	Traffic Count
Robert Gray AAF	1982	196,758
	1983	184,045
	1984	165,341
	1985	174,620
Hood AAF	1985	153,980
	1986	116,462

[a] Traffic count is defined as radio contact with one aircraft.

APPENDIX G (Cont'd)

USAF and Commercial Aircraft at Robert Gray Army Airfield

Type	Designation
Attack/Fighter	A-10, A-37, F-4, F-16
Cargo	C-5, C-9, C-20, C-130, C-135, C-141
Tanker	KC-10, KC-135
Trainer	T-33, T-38, T-39
Commercial (Contract)	707, 727, 737, 747, DC-8, DC-9, DC-10, L1011

Landing Strips

Strip No.	Composition	Length	Width	Remarks
12	Hard Pack	3,000	60	Used for EDRE and low altitude extraction exercises.
16	Hard Pack	2,300	120	
20	Sod	1,700	100	
31	Sod	1,500	75	
41	Sod	1,800	75	Used by ADA units for launch/recovery of miniature targets.

APPENDIX H: The Cave Biology of Fort Hood, Bell and Coryell Counties, Texas

THE CAVE BIOLOGY OF FORT HOOD, BELL AND CORYELL COUNTIES, TEXAS

by

James R. Reddell
Texas Memorial Museum
2400 Trinity
Austin, Texas 78705

INTRODUCTION

Twenty caves have been visited on Fort Hood, with doubtless many more yet to be located. Of these, only nine have been biologically studied. Only two (Nolan Creek Cave and Tippit Cave) were visited more than once, and no recent trip has been made to Tippit Cave.

Three aquatic and two terrestrial troglobites (cave-restricted species) are known from caves on Fort Hood. The aquatic species are the amphipods Stygobromus bifurcatus (Holsinger) and Stygobromus russelli (Holsinger) and the isopod Caecidotea reddelli Steeves. The terrestrial species are an undetermined (but certainly undescribed) spider, Cicurina (Cicurella) sp. and the millipede Cambala speobia speobia (Chamberlin). The aquatic invertebrates are all known from other localities. Until adults of the spider are collected it cannot be determined if it also ranges in other areas. The millipede ranges widely throughout Texas.

Two species presently considered endangered are known from northern Williamson County: the Bone Cave harvestman Texella new species and the Coffin Cave mold beetle Batrisodes (Excavodes) new species. It is possible that could also be found in caves on Fort Hood. In addition, three other species known only from northern Williamson County and likely to be petitioned for listing in the near future could also possibly be found on the fort. These species are the ground beetle Rhadine noctivaga Barr and the spiders Cicurina (Cicurella) new species and Neoleptoneta anopica (Gertsch). Given the limited amount of study in northern Williamson and southern Bell Counties, other species are likely to be found.

A study of the cave fauna of Fort Hood is of extreme interest, both because of the possibility of finding the endangered species and to determine the distribution of several species occurring in the caves of Williamson County. Virtually nothing is known of the cave fauna of Bell and Coryell Counties nor any area to the north of these counties. It would be highly surprising not to find species occurring in northern Williamson County to occur in this area; nor would it be surprising to find endemic troglobites restricted to the isolated plateau regions of Fort Hood and therefore prime candidates for endangered species listing.

In the following list of species, the following terms are used to designate the ecological classification of the species: troglobite (a species restricted to the cave habitat and usually characterized by loss or reduction of eyes and pigment and elongate appendages), troglophile (a

species which may reproduce in caves, but which may also be found in similar sheltered habitats on the surface), trogloxene (a species such as bats and cave crickets which may roost in caves but which must return to the surface for food), accidental (a species washed, fallen, or carried into caves and not part of the cave ecosystem).

CHECKLIST OF SPECIES

KINGDOM PLANTAE
DIVISION EUMYCOTA
CLASS PLECTOMYCETES
Order Gymnascales

Family Gymnascaceae
Ajellomyces capsulatum (Kwon-Chung) (histoplasmosis)
Record.--CORYELL COUNTY: Shell Mountain Bat Cave.

KINGDOM ANIMALIA
PHYLUM MOLLUSCA
CLASS GASTROPODA (snails)

Undetermined material
Record.--CORYELL COUNTY: Plateau Cave No. 2.

Order Diotocardia

Family Helicinidae (accidental)
Helicina orbiculata tropica (Pfeiffer)
Record.--CORYELL COUNTY: Brokeback Cave.

Order Sigmurethra

Family Helicodiscidae
Helicodiscus eigenmanni Pilsbry (troglophile)
Record.--CORYELL COUNTY: Tippit Cave.
Comment.--This is a common troglophile in Texas caves.

Family Polygyridae
Mesodon roemeri (Pfeiffer) (trogloxene)
Record.--CORYELL COUNTY: Brokeback Cave.
Comment.--This is frequently found in cave entrances.

PHYLUM ANNELIDA
CLASS CLITELLATA
Order Haplotaxida (earthworms)

Family Lumbricidae
Undetermined genus and species
Record.--CORYELL COUNTY: Tippit Cave.

PHYLUM ARTHROPODA
SUPERCLASS CRUSTACEA
CLASS MALACOSTRACA
Order Amphipoda (amphipods)

Family Crangonyctidae

Stygobromus bifurcatus (Holsinger) (troglobite)
Record.--CORYELL COUNTY: Tippit Cave.
Comment.--This troglobite is widespread in Central Texas.
Stygobromus russelli (Holsinger) (troglobite)
Records.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Tippit Cave.
Comment.--This is a widespread troglobite in Central Texas.

Order Isopoda
Suborder Asellota (aquatic isopods)

Family Asellidae
Caecidotea reddelli (Steeves) (troglobite)
Records.--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Tippit Cave
Comment.--This species ranges from Travis to Palo Pinto Counties.

Suborder Oniscoidea (pillbugs and sowbugs)

Undetermined material
Records.--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Brokeback Cave; Viper Den Cave.

CLASS ARACHNIDA
Order Araneae (spiders)

Undetermined material
Records.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Runoff Cave; Sledgehammer Cave; Viper Den Cave.
Family Agelenidae
Cicurina (Cicurella) n.sp. (troglobite)
Record.--CORYELL COUNTY: Tippit Cave.
Comment.--No adults of this troglobite were collected, but it certainly represents an undescribed species.
Cicurina (Cicurusta) varians Gertsch and Mulaik (troglophile)
Records.--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Brokeback Cave; Shell Mountain Bat Cave; Tippit Cave.
Comment.--This is an extremely widespread troglophile.
Family Araneidae
Argiope aurantia Lucas (accidental)
Record.--CORYELL COUNTY: Brokeback Cave.
Comment.--This species was taken from the entrance area.
Family Clubionidae
Undetermined genus and species
Record.--CORYELL COUNTY: Plateau Cave No. 1.
Family Linyphiidae
Meioneta sp. (troglophile)
Record.--CORYELL COUNTY: Oxygen Bottle Cave; Plateau Cave No. 1; Viper Den Cave.
Comment.--This genus is widespread in Central Texas caves.
Family Theridiidae
Achaearanea porteri (Banks) (troglophile)
Record.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Oxygen

Bottle Cave; Plateau Cave No. 2.
Comment.--This is a widespread troglophile.

Order Acarina (mites)

Undetermined material
Records.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Brokeback Cave; Oxygen Bottle Cave; Shell Mountain Bat Cave.

Suborder Prostigmata

Family Trombidiidae
Undetermined genus and species (parasite)
Records.--CORYELL COUNTY: Oxygen Bottle Cave; Viper Den Cave.
Comment.--This is a parasite of Ceuthophilus sp.

CLASS CHILOPODA (centipedes)

Undetermined material
Records.--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Shell Mountain Bat Cave; Tippit Cave.

Order Scolopendromorpha

Family Cryptopidae (?troglophile)
Cryptops aqueus Chamberlin
Record.--BELL COUNTY: Nolan Creek Cave.
Comment.--This species is also known from a few other Texas caves.

Order Geophilomorpha

Undetermined material
Record.--CORYELL COUNTY: Runoff Cave.

Order Lithobiomorpha

Undetermined material
Record.--CORYELL COUNTY: Oxygen Bottle Cave; Plateau Cave No. 1; Runoff Cave.

Family Lithobiidae
Undetermined genus and species
Record.--BELL COUNTY: Nolan Creek Cave.

Order Scutigeromorpha

Family Scutigeridae
Undetermined genus and species (troglophile)
Record.--BELL COUNTY: ?Nolan Creek Cave. CORYELL COUNTY: Oxygen Bottle Cave.

CLASS DIPLOPODA (millipedes)
Order Spirostreptida

Family Cambalidae
Cambala speobia speobia (Chamberlin) (troglobite)
Records.--CORYELL COUNTY: Oxygen Bottle Cave; Shell Mountain Bat

Cave; Tippit Cave.

CLASS INSECTA

Order Collembola (springtails)

Undetermined material

Record.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Brokeback Cave; Plateau Cave No. 1; Plateau Cave No. 2; Runoff Cave.

Family Entomobryidae (slender springtails)

Pseudosinella violenta (Folsom) (troglophile)

Records.--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Shell Mountain Bat Cave; Tippit Cave.

Comment.--This troglophile occurs in virtually ever cave in Texas.

Order Orthoptera

Family Rhaphidophoridae (cave crickets)

Ceuthophilus sp. (trogloxene)

Records.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Oxygen Bottle Cave; Plateau Cave No. 1; Plateau Cave No. 2; Sledgehammer Cave; Viper Den Cave.

Ceuthophilus (Ceuthophilus) secretus Scudder (trogloxene)

Records.--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Brokeback Cave; Shell Mountain Bat Cave.

Ceuthophilus (Geotettix) cunicularis Hubbell (trogloxene)

Records.--CORYELL COUNTY: Shell Mountain Bat Cave.

Order Dictyoptera (roaches)

Undetermined material

Record.--CORYELL COUNTY: Plateau Cave No. 1; Viper Den Cave.

Family Polyphagidae (desert cockroaches)

Arenivaga tonkawa Hebard (trogloxene)

Record.--CORYELL COUNTY: Brokeback Cave.

Comment.--This is a frequent inhabitant of dry entrance areas.

Order Hemiptera

Family Reduviidae (assassin bugs)

Triatoma gerstaeckeri (Stal) (trogloxene)

Records.--CORYELL COUNTY: Brokeback Cave; ?Shell Mountain Bat Cave.

Comment.--This is a frequent inhabitant of dry entrance areas.

Order Coleoptera (beetles)

Undetermined material

Record.--CORYELL COUNTY: Shell Mountain Bat Cave.

Family Carabidae (ground beetles)

Undetermined genus and species

Record.--CORYELL COUNTY: Plateau Cave No. 2.

?Tachys sp. (troglophile)

Records.--CORYELL COUNTY: Plateau Cave No. 1; Plateau Cave No. 2.

Comment.--This genus is common in Texas caves as troglophiles.

Family Elateridae (click beetles)
Cardiophorus sp. (accidental)
Record.--CORYELL COUNTY: Tippit Cave.
Family Leiodidae (round fungus beetles)
Ptomaphagus (Adelops) cavernicola cavernicola Schwarz (troglophile)
Records.--CORYELL COUNTY: Shell Mountain Bat Cave; Tippit Cave.
Comment.--This species is occasionally found in Texas caves.
Family Staphylinidae (rove beetles)
Undetermined genus and species
Record.--CORYELL COUNTY: Oxygen Bottle Cave.
Aleocharinae genus and species
Record.--CORYELL COUNTY: Tippit Cave.
Belonuchus sp. (troglophile)
Records.,--BELL COUNTY: Nolan Creek Cave; CORYELL COUNTY: Plateau Cave No. 1; Plateau Cave No. 2; Tippit Cave.
Eustilicus condei (Jarrige) (troglophile)
Record.--CORYELL COUNTY: Tippit Cave.
Comment.--This species is known only from caves, but does not appear particularly cave-adapted.
Family Tenebrionidae (darkling beetles)
Enbaphion muricatum (Say) (trogloxene)
Records.--CORYELL COUNTY: Brokeback Cave; Shell Mountain Bat Cave.
Comment.--This species is usually found associated with dry bat guano in Texas caves.

Order Hymenoptera

Family Formicidae
Leptogenys elongata (Buckley) (accidental)
Record.--CORYELL COUNTY: Brokeback Cave.
Oligomyrmex longiii (accidental)
Record.--CORYELL COUNTY: Viper Den Cave.

Order Diptera

Family Streblidae (bat flies)
Trichobius major Coquillett (parasite)
Record.--CORYELL COUNTY: Cave at Fort Hood (prob. Shell Mountain Bat Cave).
Comment.--This is a parasite of bats.

Order Siphonaptera (fleas)

Family Pulicidae
Pulex simulans Baker (parasite)
Record.--CORYELL COUNTY: ?Shell Mountain Bat Cave.

PHYLUM CHORDATA
CLASS AMPHIBIA
Order Anura

Family Ranidae
Rana ?berlandieri Baird (leopard frogs) (accidental)
Record.--BELL COUNTY: Nolan Creek Cave.

CLASS REPTILIA
Order Squamata
Suborder Serpentes

Family Crotalidae

Ankistrodon contortrix (Linnaeus) (copperhead) (trogloxene)

Record.--CORYELL COUNTY: Copperhead Cave.

Crotalus atrox Baird and Girard (western diamondback rattlesnake) (trogloxene)

Records.--BELL COUNTY: Nolan Creek Cave. CORYELL COUNTY: Sledgehammer Cave; Viper Den Cave.

CLASS MAMMALIA
Order Chiroptera (bats)

Undetermined material (trogloxene)

Records.--CORYELL COUNTY: Egypt Cave; Shell Mountain Bat Cave.

Order Carnivora

Family Procyonidae

Bassariscus astutus (Lichtenstein) (ringtail cat) (trogloxene)

Record.--CORYELL COUNTY: Copperhead Cave.

APPENDIX I: Habitat Structure Variable Code Descriptions

Variable	Description
WOCVR	Percent woody cover
WOCVR_CV	Coefficient of variation (CV) for WOCVR
WOCVR_HARD	Percent hardwood cover
STEM	Total woody stems < 7.6 cm dbh at 1.5 m height/0.036 ha
STEM_CV	CV for STEM
STEM_JL	Live juniper stems < 7.6 cm dbh at 1.5 m height/0.036 ha
STEM_JD	Dead juniper stems < 7.6 cm dbh at 1.5 m height/0.036 ha
STEM_HL	Live hardwood stems < 7.6 cm dbh at 1.5 m height/0.036 ha
STEM_HD	Dead hardwood stems < 7.6 cm dbh at 1.5 m height/0.036 ha
STEM_DD	Dead stems < 7.6 cm dbh at 1.5 m height/0.036 ha
TREE	Total trees ≥ 7.6cm dbh/0.24 ha
TREE_CV	CV for TREE
TREE_JL	Live juniper trees ≥ 7.6cm dbh/0.24 ha
TREE_JD	Dead juniper trees ≥ 7.6cm dbh/0.24 ha
TREE_HL	Live hardwood trees ≥ 7.6cm dbh/0.24 ha
TREE_HD	Dead hardwood trees ≥ 7.6cm dbh/0.24 ha
TREE_DD	Dead trees ≥ 7.6cm dbh/0.24 ha
TREE_JLA	Live juniper trees 7.6 cm to < 15.2 cm dbh/0.24 ha
TREE_JLB	Live juniper trees 15.2 cm to < 22.9 cm dbh/0.24 ha
TREE_JLC	Live juniper trees ≥ 22.9 cm dbh/0.24 ha
TREE_JDA	Dead juniper trees 7.6 cm to < 15.2 cm dbh/0.24 ha
TREE_JDB	Dead juniper trees 15.2 cm to < 22.9 cm dbh/0.24 ha
TREE_JDC	Dead juniper trees ≥ 22.9 cm dbh/0.24 h
TREE_HLA	Live hardwood trees 7.6 cm to < 15.2 cm dbh/0.24 ha
TREE_HLB	Live hardwood trees 15.2 cm to < 22.9 cm dbh/0.24 ha
TREE_HLC	Live hardwood trees ≥ 22.9 cm dbh/0.24 ha
TREE_HDA	Dead hardwood trees 7.6 cm to < 15.2 cm dbh/0.24 ha
TREE_HDB	Dead hardwood trees 15.2 cm to < 22.9 cm dbh/0.24 ha
TREE_HDC	Dead hardwood trees ≥ 22.9 cm dbh/0.24 h
V5	Woody vegetation hits in decimeter intervals 1 thru 5
V10	Woody vegetation hits in decimeter intervals 6 thru 10
V15	Woody vegetation hits in decimeter intervals 11 thru 15
V20	Woody vegetation hits in decimeter intervals 15 thru 20
V25	Woody vegetation hits in decimeter intervals 20 thru 25
V30	Woody vegetation hits in decimeter intervals 25 thru 30
V40	Woody vegetation hits in decimeter intervals 30 thru 40
V50	Woody vegetation hits in decimeter intervals 40 thru 50
V60	Woody vegetation hits in decimeter intervals 51 thru 60
V70	Woody vegetation hits in decimeter intervals 61 thru 70
V70+	Woody vegetation hits in decimeter intervals over 70
VLT30_CV	CV for woody vegetation hits in decimeter intervals ≤ 30
VGT30_CV	CV for in woody vegetation hits in decimeter intervals > 30
VGRAS	Sum of all grass hits
VFORB	Sum of all forb hits
WOOD	Percent woody ground cover
GRAS	Percent grass ground cover
FORB	Percent forb ground cover
ROCK	Percent rocky ground cover
CACT	Percent cactus ground cover
TRAC	Percent vehicle tracking on ground

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