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Status of the Black-capped Vireo at Fort Hood, Texas, Volume I: Distribution and Abundance

by
David J. Tazik
John D. Cornelius
Cynthia A. Abrahamson

The black-capped vireo is an endangered species that resides at Fort Hood, TX during the summer breeding season. A 3-year ecological status survey of the black-capped vireo was conducted on Fort Hood from 1987 through 1989 as part of the effort to fully comply with the Endangered Species Act. Part II in this series focuses on habitat and Part III on population and nesting ecology.

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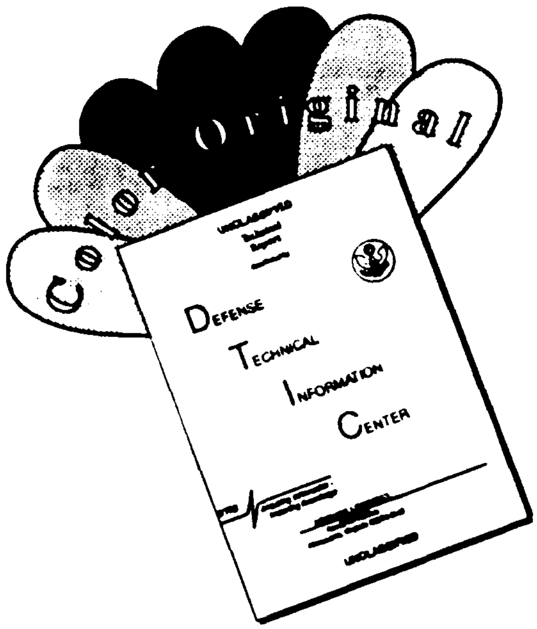

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FOREWORD

This study was conducted for Headquarters (HQ) III Corps and Fort Hood under Intra-Army Orders (IAOs) 348-87, 66-88, and 268-88, for the Assistant Chief of Staff for Installation Management (ACSIM) under Funding Acquisition Document (FAD) 89-080046, and for HQ, Forces Command (FORSCOM) 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), of the U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Dr. David Tazik. Special appreciation is owed to the following individuals for their assistance in this study. Dennis Herbert and B.R. Jones, of the Fish and Wildlife Branch, Fort Hood, were most helpful in identifying potential vireo colony sites, coordinating research activities, assisting researchers in gaining access to various areas of the Fort, and assisting in various aspect of the field work. Valerie Morrill, of Yuma Proving Ground, AZ, also assisted in the location of several vireo colony sites. Daniel Salzer and Geralyn Larkin, Hillsboro, OR located and mapped vireo territories during 1988 and 1989. A helicopter overflight of Fort Hood was made possible by the 6th Calvary Brigade of Fort Hood with flight time provided by CW2 Buddy C. Colley, CW2 Kenneth L. Shirley, and SP4 Scott W. Gray. Rus Allen, of the Scheduling Branch, Range Division, Fort Hood, and personnel of the Fort Hood Range Control Office coordinated researcher access to colony sites within the live fire training area. Dr. Joseph Grzybowski, Norman, OK, provided guidance and insight of importance to the initiation and conduct of the study. Dr. Denice Shaw, Denton, TX, provided several ideas and insight regarding development of the potential vireo habitat model. Jeff Courson, USACERL, summarized the climate data for Fort Hood and vicinity and assisted by aging tree samples. Emmett Gray, Chief, Fort Hood Environmental Division, provided the training intensity map. Robin Musson assisted in the compilation of this final report. Dr. William D. Severinghaus is Acting Chief, CECER-EN, and William D. Goran is Acting Chief, CECER-EL. The USACERL technical editor was William J. Wolfe, Information Management Office.

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1 INTRODUCTION

Background

The U.S. Army is responsible for managing 12.4 million acres of land on 186 major installations worldwide (U.S. Department of the Army [DA] 1989). Many of these lands are used for military training and testing activities, and many are also managed for nonmilitary uses, including fish and wildlife, forest products, recreation, agriculture, and grazing. Proper land management supports the military mission and multiple use activities, but also presents the Army with a unique challenge as public land steward.

In its effort to promote responsible land stewardship, the Army has initiated the Land Condition-Trend Analysis (LCTA) program, which uses standard methods to collect, analyze, and report natural resources data (Tazik et al. 1992a), and which is the Army's standard for land inventory and monitoring (Technical Note 420-74-3 1990). LCTA is a major component of the Integrated Training Area Management (ITAM) program, both developed at the U.S. Army Construction Engineering Research Laboratories (USACERL). The three other components of ITAM include: (1) Environmental Awareness, (2) Land Rehabilitation and Maintenance, and (3) Training Requirements Integration. LCTA promotes the principles of sustained yield, land stewardship, and multiple use of military land resources. The major objectives of LCTA are to: (1) characterize installation natural resources, (2) implement standards in collection, analysis, and reporting of the acquired data that enable compilation and evaluation of these data Army-wide, (3) monitor changes in land resource condition and evaluate changes in terms of current land uses, (4) evaluate the capability of land to meet the multiple-use demands of the U.S. Army on a sustained basis, (5) delineate the biophysical and regulatory constraints to uses of the land, and (6) develop and refine land management plans to ensure long-term resource availability.

Such programs help the Army comply with a variety of environmental regulations based on such legislation as the National Environmental Policy Act, the Endangered Species Act, and the Clean Water Act (Donnelly and Van Ness 1986). These regulations require land management personnel at Army installations to take measures to evaluate the impacts of military activities on natural resources, including endangered species, on Army land. The black-capped vireo (*Vireo atricapillus*) was placed on the Federal list of endangered species in October 1987 (Ratzlaff 1987).

A 3-year ecological field study of the black-capped vireo (*Vireo atricapillus*) on the lands of Fort Hood, Texas was initiated in 1987 in response to the proposed addition of this species to the federal list of endangered species (51 FR 44808-44812). Listing became effective 5 November 1987 (52 FR 37420-37423) and with it came the full protection of the Endangered Species Act of 1973, as amended. The black-capped vireo is one of five federally endangered species observed on the lands of Fort Hood, TX, of which two (the black-capped vireo and the golden-cheeked warbler) reside on the installation during the summer breeding season. Major threats to the vireo throughout its range identified at the time of listing include loss of habitat due to grazing, excessive range land improvement, natural succession, and urbanization, and reduced reproductive potential due to extensive nest parasitism by the brown-headed cowbird (*Molothrus ater*). To address such concerns, the Fort Hood black-capped vireo study included documentation of distribution and abundance of the vireo and its habitat, habitat preferences, and population and nesting ecology on the Fort. This part of the study focused on the distribution and abundance of the vireo on Fort Hood and created a model delineating potential habitat there.

The black-capped vireo is a small migratory songbird that occupies a distinctive scrub oak habitat throughout its breeding range during late March through August. The historical breeding range of the vireo extended from south-central Kansas through northern Mexico with a few records in southeastern Nebraska (Graber 1961, Marshall et al. 1985). Its range has diminished significantly during the past several decades, with the northern limit now reaching only into south central Oklahoma, and individual colonies have disappeared in a seemingly random fashion throughout (Marshall et al. 1985). The last stronghold for vireos in Oklahoma is a population of about 85 to 90 adults in the Wichita Mountains Wildlife Refuge (Grzybowski et al. 1986, Grzybowski 1988a). However, the heart of the breeding population resides in the hill country of central Texas (Figure 1, p 28).[1] Although there has been little work on populations in Mexico, breeding colonies are known to persist in the state of Choahuila in northern Mexico (Marshall et al. 1985). Wintering populations occur along the western coast of Mexico (Graber 1961).

Impetus for the Fort Hood black-capped vireo status survey came about as a result of sightings made by one of the authors (J.D. Cornelius) during 1985 and 1986. At least two singing males were observed in one area during 1985, and several again in 1986. An extensive survey of the installation by Marshal and coworkers in 1985 revealed no additional birds (Marshall et al. 1985; Marshall, personal communication). These authors suggested that the Fort might once have supported a large vireo population that subsequently was eliminated due to cowbird parasitism. Other sightings include one each during late summer 1978 and spring 1979 (Severinghaus et al. 1980).

The black-capped vireo also has been observed on Fort Sill, OK (Grzybowski and Tazik 1993), and the Camp Bullis Training Site of Fort Sam Houston, TX (Shaw et al. 1989). The number of vireos on Fort Sill is small (four to nine territories) and has been inconsistent from year to year. Camp Bullis supports about 36 adults (Rust and Tazik 1990). Conclusions drawn based on analyses of Fort Hood data should have some application to these installations as well.

Objectives

The objectives of this study were to (1) document the recent distribution and abundance of the black-capped vireo on Fort Hood, (2) characterize colony sites with respect to habitat age and associations with major landscape features, (3) characterize territory size requirements, and (4) use information from objectives (1) and (2) to delineate potential habitat throughout the Fort. The data gathered are also intended to serve as a basis for compliance with the requirements of the Endangered Species Act.

Approach

Distribution and abundance were documented through extensive on-site survey work done from 1987 through 1989. Potential habitat on Fort Hood was delineated by using analysis tools in the Geographic Resources Analysis Support System (GRASS), a geographic information system (GIS) developed at the U.S. Army Construction Engineering Research Laboratories (USACERL). This analysis was based on an expected association between known vireo habitat locations and various landscape features such as geology, soils, elevation, slope, and aspect. These features were expected to affect potential vegetation of a site and thus define the site's potential to support the specific vegetation type preferred by the vireo.

[1] All figures and tables are included in Appendix A.

Scope

This report is one of a three-part series documenting the ecology of the black-capped vireo on Fort Hood. Evaluation of the distribution and abundance of the vireo on Fort Hood serves as a basis for subsequent reports dealing with habitat preferences (Tazik et al. 1992a), and population and nesting ecology (Tazik and Cornelius 1993). Data presented here have been used in the development of a biological assessment required by regulations implementing section 7 of the Endangered Species Act (Tazik et al. 1992b). Results are expected to apply to Fort Sill, and the Camp Bullis Training Site.

Mode of Technology Transfer

This research contributes to a fundamental understanding of the ecology of the endangered black-capped vireo, and serves as an example of a proactive approach to endangered species management on Army lands. This and other related reports are being transmitted to military, land, and wildlife managers at Fort Hood, Headquarters (HQ), U.S. Army Forces Command, and HQ, Department of the Army in conjunction with the LCTA program.

2 SITE DESCRIPTION

Fort Hood occupies 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 (Figure 1, p 28). It lies on the eastern fringe of the Edward's Plateau between the cities of Waco, 40 miles to the northeast, and Austin, 60 miles to the south. The installations Master Plan Report (Nakata 1987) contains details on the Fort Hood environment, which is summarized below.

Fort Hood's 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. 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, p 29). (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, Diersing et al. 1990). The temperature line shows a steady increase from a low in January to a high in July and a steady decline thereafter. Precipitation has two 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 (Raisz 1952). 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 have 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, p 30).

Soil cover generally is shallow to moderately deep and clayey, and underlain by limestone bedrock. The major soil associations in the area (Figure 4, p 31) are:

1. 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.

2. 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.

3. 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.

4. 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.

5. 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.

6. 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, p 34). The landscape exhibits a stairstep 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 (Gould 1975), 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 (*Juniperus ashei*), live oak (*Quercus fusifornis*) and Texas oak (*Q. texana*). The grasses are derived from the Blackland Prairie area to the east. Under climax condition, these would consist of little bluestem (*Schizachyrium scoparium*) and indiangrass (*Sorghastrum nutans*).

Unpublished data obtained from the U.S. Army's Land Condition-Trend Analysis (LCTA) program* at Fort Hood show that the Fort is divided mainly into perennial grassland (65 percent) and woodland (31 percent) community types (Figure 6, p 34, 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 winter grass (*Stipa leucotrichia*) (29 percent) and prairie dropseed (*Sporobolus asper*) (18 percent), with little bluestem grasslands comprising only 9 percent of grassland sites.

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.

No federally endangered plant species are known to occur on the Fort. However, three federally endangered wildlife species in addition to the black-capped vireo have been observed (Diersing et al. 1985). The bald eagle has been recorded during winters at Belton Lake on or adjacent to Fort Hood. Aircraft overflights are restricted during winter to avoid bald eagle roosting sites. The peregrine falcon and whooping crane are rare migrants in the area. The golden-cheeked warbler is resident during the summer breeding season from March to July, and inhabits mature oak-juniper woodland. The warbler is abundant as suitable habitat may constitute as much as 15 percent of the Fort.

* Further information on LCTA may be found in Tazik et al. (1992).

3 METHODS AND DATA ANALYSIS

Distribution and Abundance

Vireo colony sites were located by extensive on-the-ground searching aided by the use of aerial photographs, a helicopter overflight, and valuable information from installation personnel. Presence or absence of vireos was determined by entering a potential area and listening for the males' song and other characteristic vocalizations. In many instances, males were heard within a few minutes of arrival at a site. Also, a tape recording of the song was played to induce a response from any nearby males. At least 10 minutes was spent at a site before it was assumed that no vireos were present. Because males sing actively throughout the day, negative evidence is considered acceptable as an indication that the species is indeed absent from a particular locality (Grzybowski 1985a). Sites that appeared suitable but unoccupied typically were visited on several occasions.

Population size of vireo colonies was determined by mapping individual vireo territories. Males were followed or "driven" to the boundaries of their territory, and turning points and dispute points with neighbors were conspicuously marked with flagging (Graber 1961, Grzybowski 1985b). Mapping was facilitated by color banding individual birds to positively identify territory occupants. In areas where territories were not mapped, population size was estimated based on the number of different singing males detected.

Territory Size

Territory maps for each year were plotted by hand on mylar overlays of 1:4800 aerial photographs and digitized into separate GRASS vector files. These data formed the basis of GIS data analysis as described in the following section. Size of individual territories was estimated using the GRASS program *report.*

Territory size data were analyzed using 1-way analysis of variance (ANOVA) (Sokal and Rohlf 1969). Comparisons were made among years by site and overall.

Colony Site Age

Age of woody vegetation at vireo colony sites was estimated based on tree growth ring analysis. At each site, cross sections were obtained during 1990 from several of the largest hardwood trees that were presumed to have developed since the last major disturbance. Samples included primarily oaks (*Quercus spp.*), redbud (*Cercis canadensis*), and Texas ash (*Fraxinus texensis*). Very large trees that obviously had escaped fire destruction were not sampled. Reference was also made to aerial photographs of Fort Hood from 1976, 1981, and 1982.

Potential Habitat

Potential habitat was delineated based on the vireo's apparent preference for certain physical features of the Fort Hood landscape. Several features thought to be important in discriminating such habitat and that were available as data layers within GRASS included geology (Figure 3, p 30), soils (Figure 4, p 31), elevation (Figure 5, p 33), slope (Figure 7, p 35), and aspect (Figure 8, p 36). Preferences were quantified by comparing the frequency of map layer categories in vireo occupied areas to the frequency of categories on Fort Hood as a whole. A map layer was developed for each year of data that delineated vireo and nonvireo areas by converting each vireo vector file of digitized territory data into a cell file. Composite vector and cell maps for 1987, 1988, and 1989 combined were created using the GRASS programs *Gmapcalc*, *Greclass*, and *Gpoly*.

Each map layer was sampled at 20-m resolution to obtain an accurate estimate of the percent of area within vireo and nonvireo areas that coincided with each map layer category. Coincidence tabulations were performed using the GRASS program *coin*. A chisquare (X^2) goodness of fit analysis (Conover 1980) was then performed for each map layer to determine if the distribution of map layer categories in vireo occupied areas differed significantly from that available on the installation as a whole. Frequency distributions for both vireo areas and the installation as a whole were standardized to equal sample sizes of 100 for analysis.

Weights were assigned to each map layer category based on the extent of the difference between observed and expected cell frequencies (Agee et al. 1989), where "observed" refers to vireo occupied areas and "expected" to the installation overall. Row X^2 values were used as a measure of that difference, and significance was judged based on the probability of each row X^2 at 1 degree of freedom. For example, when the row X^2 value for category 1 of geology is 61.974, it is associated with a probability value $p<<0.001$. Weights were assigned as follows:

0 - category not represented in vireo territories and $p \leq 0.10$
1 - category represented less than expected ($p \leq 0.05$), or category not represented but $p>0.10$
2 - category represented in proportion to availability ($p>0.05$)
4 - category represented more than expected ($p \leq 0.05$).

The GRASS analysis tool *weight* was applied, using the 5 map layers, the assigned category weights, and the *weight* multiplier option. In essence, the 5 map layers were multiplied together to yield a map layer classified as to potential vireo habitat. A map layer with 11 categories could be generated in this way with the following values: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024. The expectation was that this would represent a scale of increasing vireo habitat potential. Areas with 0 values and no data areas were considered unsuitable habitat.

The model was initially developed based on the 1988 vireo territory data, and was validated in two ways. First, the distribution of 1989 vireo territory data among the 11 map layer categories derived from the 1988 data was plotted against the expected distribution, and analyzed by X^2 goodness of fit. Second, the composite vireo map layer containing all 1987, 1988, and 1989 vireo data was masked to exclude data areas that contributed to the 1988 model. This map layer was then analyzed as above.

After validation based on 1988 data, the model was redeveloped using the composite of 1987, 1988, and 1989 data following the procedures outlined above. Simplification of the final map layer was achieved by reclassifying the map into one of the following categories:

- Very Low Potential: observed occurrence significantly less than expected at $p \leq 0.001$
- Low Potential: observed occurrence significantly less than expected at $0.001<p \leq 0.05$
- Moderate Potential: observed occurrence not significantly different from expected ($p>0.05$)
- High Potential: observed occurrence significantly greater than expected at $0.001<p \leq 0.05$
- Very High Potential: observed occurrence significantly greater than expected at $p \leq 0.001$.

Training Intensity

Data on installation training intensity by training area was provided as a GRASS map layer by the Fort Hood Environmental Division (Figure 9, p 37). The map was generated by the program Maneuver Activity Damage Assessment Model (MADAM) based on 1 full year of training data. MADAM incorporates information regarding both the frequency of scheduled events and the expected amount of vehicular use associated with those events. Output is in dry tracked vehicle equivalents per day-square mile* (dtve/day-sq mi) for each training area. Distribution of the vireo occupied area and potential vireo habitat was examined with respect to training categories using the GRASS programs *report* and *coin* respectively.

*1 sq mi = 2.590 km^2.

4 RESULTS

Black-capped vireo sightings and search points for all years are shown in Figure 10 (p 38). Much of the area without search points was examined on the ground and from the air and found not to support suitable habitat—e.g., grasslands, tall oak woodlands, and juniper stands without a hardwood understory.

Fort Hood areas occupied by the vireo during 1 or more years of the study are shown in Figure 11 (p 39), which is a composite of vireo territories and site records. Colony sites were situated primarily on the more elevated areas of the Fort, the mesa-like hilltops and their side slopes. More detailed analyses of the relationships between vireo occupied areas and various landscape features are presented below in **Potential Habitat**.

Table 1 lists vireo numbers by colony site and year. Eighty-five males and 33 females were observed in 1987; 132 males and 93 females in 1988; and 143 males and 108 females in 1989. The substantial increase in numbers observed between 1987 and 1988 was due to more extensive coverage of the Fort and detailed territory mapping during 1988. The increase between 1988 and 1989 was due to an increase in numbers at Area 2, Manning Mountain, Red Bluff, and Robinette Point, and a first-ever survey of Pilot Knob Range and Lone Mountain. Declines occurred on several areas, notably at Area 6 between 1987 and 1989, and at West Fort Hood and Jack Mountain between 1988 and 1989. A substantial number of the vireos observed occurred within the live fire training area (56 percent during 1989), especially at Robinette Point, Jack Mountain, Area 75, and Pilot Knob Range (Figure 11, p 39).

Colony Site Age

All major colony sites where vegetation age was documented were in the range of about 5 to 20 years of age (Table 1, p 46). The notable exception is Area 6 at 28 to 29 years. Tree samples were not obtained at the other areas. Site specific information is as follows:

Area 2 Top (AR2T)

The western portion of this area, comprised of four to six territories each year, burned in 1978 or 1979. Plants exhibited seven to nine tree rings, corresponding to the number of growing seasons on the site. Although there may be an occasional double ring in some years due to the bimodal precipitation pattern during the growing season (Figure 2, p 29), the data do indicate the approximate age of the site. The eastern portion was in or adjoining a large area that had been scraped of vegetation during the fall and winter prior to the 1985 growing season (B.R. Jones, personal communication). The regrowth in this area had four to five rings.

Area 2 Slope (AR2S)

This area burned in 1982 or 1983. Plants had five to seven tree rings.

Area 6 (AR 6)

The oldest trees collected in 1990 had 29 to 30 tree rings.

Area 12 (AR 12)

A fire occurred during the summer of 1984. However, the site also is visible in 1981 aerial photographs but not 1976 photographs indicating another fire 3 to 7 years earlier. Tree samples were not available at the time of this writing.

Red Bluff (REBL)

This area was at least 13 years old in 1989. Disturbance due to fire or bulldozing occurred prior to 1976, based on aerial photographs. Trees had 9 to 16 tree rings.

Manning Mountain (MAMT)

This colony site consists of several disjunct areas of various ages. The southern most site has been disturbed primarily by troop activity with many trails and bivouac sites. The next site north burned on several occasions, perhaps as recently as 1983 or 1984. Regrowth showed five to six tree rings. However, other trees had 13 to 21 tree rings, indicating earlier periodic fires. The site is visible in the 1976 aerial photographs. The next site north, Clabber Point, burned sometime between 1976 and 1981, and plants exhibited 10 to 11 tree rings. Other areas supported regrowth with 4 to 6 tree rings.

West Fort Hood (WEFH)

Fires appear to have occurred here periodically. One fire occurred before the 1989 breeding season resulting in the loss of habitat in four territories that were occupied in 1988. Other regrowth in the area indicates another fire 5 to 6 years previously, and one tree had 19 tree rings. There is also much older vegetation present that has escaped these fires, making for a rather heterogeneous habitat.

Area 75 (AR 75)

The most recent fire in the main portion of the site occurred just prior to the 1988 breeding season. Much of the unaffected regrowth had six to eight tree rings. However, the area is also visible in the 1976 aerials. Adjoining this area to the north is a long and narrow scraped area established as a helicopter gunnery range between 1976 and 1981 with regrowth exhibiting up to 12 tree rings. Vegetation at another small area had five to eight tree rings.

Robinette Point (ROPT)

The main portion of this site burned between 1976 and 1981. Plants had 8 to 10 tree rings.

Brown's Creek (BRCR)

This area burned in 1981 or 1982. Regrowth exhibited six to eight tree rings.

Jack Mountain (JAMT)

Older growth at the western end indicates a fire just over 20 years ago. Vegetation in a more recent burn to the east had 9 to 13 tree rings. Vegetation at the southeastern end had 17 to 18 tree rings. All or part of each of these areas is visible in the 1976 aerial photographs.

Territory Size

Overall, mean territory size was similar during 1987 and 1988, but during 1989 was significantly larger than during both 1987 and 1988 (Table 2, p 47). Territory size also was significantly larger during 1989 at four of the nine colony sites with data. It decreased significantly between 1988 and 1989 only at Robinette Point.

Of interest is a possible relationship between territory size and population density. At Robinette Point, vireo territories increased in number from 19 in 1988 to 30 in 1989, while territory size decreased from 2.34 to 1.88 ha. At Area 6, numbers decreased from 14 in 1987 to 3 in 1989, while territory size increased from 2.74 to 7.04 ha. The pattern also holds at Jack Mountain (Table 2, p 47). In contrast, at West Fort Hood, territory size was similar between years while numbers decreased from 18 to 14. But the latter was due to habitat loss from a fire. Population density did not change on the unaffected area. Another contrary pattern occurred at Area 2 Top. Both territory number and size increased between 1987 and 1989. However, the increase in number was due to the addition of several large territories during 1988 and 1989 in an area east of the main 1987 study site rather than to an increase in density. And at Manning Mountain, the concurrent increase in both number and size of territories accompanied the addition of territories in 1989 outside of areas occupied during 1988. Numbers actually decreased within the 1988 occupied area from seven in 1988 to five in 1989.

Potential Habitat

1988 Vireo Data

Evaluation of the relationships between the 1988 vireo occupied area and the five landscape features is presented in Table 3 (p 48). Asterisks indicate the level of significance of each row X^2 value at 1 degree of freedom. The last column lists weights assigned to each category that were used in the GRASS program *weight*. For each map layer, the overall X^2 was very highly significant ($p < 0.001$).

The model resulted in 11 categories with values ranging from 1 to 1024. Validation of the model is illustrated in Figures 12 and 13 (pp 40 and 41). The distribution of the 1989 vireo occupied area clearly shows a preference for categories 7 through 11, and avoidance of categories 1 through 5 (Figure 12). Since category 7 had a value of 64, at least 1 of the 5 map layers had to have a weight of four within these preferred areas. Validation of the model using the composite of 1987, 1988, and 1989 territory data with a mask eliminating 1988 data (i.e., that data on which the model was based) yielded a nearly identical result (Figure 13). Categories 7 through 11 clearly were preferred, and categories 1 through 5 avoided.

Composite Vireo Data

Table 4 gives the results of the analysis using the composite of vireo occupied area. Model weights were the same as those based on the 1988 data with a few exceptions: soil category 4 (Brackett-Topsey) changed from 2 to 1, elevation category 3 (236-253 m) from 2 to 1, aspect category 3 (east) from 1 to 2, and aspect category 6 (southwest) from 4 to 2. Again the overall X^2 was significant for each map layer. However, while overall X^2 was larger using the composite data than the 1988 data for geology, soil, and elevation, it was substantially smaller for slope and aspect (compare Tables 3 and 4, pp 48 and 50).

Results of this model are similar to those based on the 1988 data. Vireos were overrepresented in categories 7 through 11, and underrepresented in categories 1 through 5 (Figure 14, p 42). The resulting map layer was reclassified into only 3 categories using the criteria outlined above: very low, moderate, and very high habitat potential. Figure 15 (p 43) shows the final map along with a composite of vireo occupied area and sightings.

Only 31 percent of the installation falls within the moderate and very high potential categories but these categories account for 98 percent of the composite vireo area (Table 5, p 51). About 89 percent of the composite vireo area occurred within the very high category. Sixty-nine percent of the Fort is unsuitable habitat (white or no data areas), or habitat of very low potential.

Training Intensity

Figure 9 (p 37) shows training intensity by training area. Noteworthy is the extensive nonmaneuver area within the live fire training area, and the location of large areas of the lowest use intensity category (category 1) in the southwestern (West Fort Hood) and eastern areas (East Range) of the Fort. The largest portion of the maneuver area lies within category 3 (19.4 percent) which is most extensive on the west (West Range). Category 4 accounts for 8.3 percent and is about equally divided between West Range and East Range. Categories 5 and 6 comprise only 2.2 and 1.0 percent respectively.

Table 6 (p 52) shows distribution of potential vireo habitat among the training intensity categories. Areas within habitat of very high potential were distributed in proportion to the availability of the training intensity categories (**Total** column in Table 6) with one major exception—overrepresentation of category 4. About 26 percent of very high potential habitat fell in nonmaneuver areas within the live fire training area, with 46 percent in categories 1 through 3, and 21 percent in category 4. Very little was associated with the highest training intensity categories (5 and 6), and just over 5 percent was within cantonment and other low maneuver use areas.

The composite vireo occupied area was overrepresented in the live fire training area and training intensity categories 1 and 3 relative to the percentage of both the total installation area and the very high potential category (Table 6, p 52). The remaining training intensity categories were underrepresented to varying degrees in vireo occupied areas.

5 DISCUSSION

Distribution and Abundance

Fort Hood supports a substantial number of black-capped vireos. Given observations of 143 males in 1989 and a 93.8 percent mating success (Tazik and Cornelius 1993), the Fort Hood population amounts to approximately 277 adult vireos. This represents about 18 percent of the known vireo population of about 1500 adults in the U.S. (Marshall et al. 1985, Grzybowski 1988b and 1989, Dr. David Diamond, Texas Natural Heritage Program, personal communication). It is also the largest population under one land management authority. With approximately 36 adult vireos at Camp Bullis, Texas (Shaw et al. 1989, Rust and Tazik 1990), and 4 to 18 at Fort Sill, Oklahoma (Grzybowski and Tazik 1993), the U.S. Army can contribute significantly to the management and recovery of this species. However, this will require coordination with and the cooperation of both state and other federal wildlife management authorities.

Although all major colony sites on Fort Hood have been located, several isolated individuals or small groups may have been overlooked particularly in the live fire training area, which has not been as intensively studied as other areas. Thus the total number may be somewhat higher.

The overall increase in vireo numbers in 1988 and 1989 over 1987 (Table 1, p 46) was due to expanded survey work and more detailed territory mapping. In particular, this was true for the increases observed at Area 2, Manning Mountain, Red Bluff, and Pilot Knob Range. However, the increase at Robinette Point was a true population increase.

The loss of four pairs at West Fort Hood between 1988 and 1989 was due to an accidental fire that destroyed habitat within four territories that were occupied during 1988. More recently, a fire was responsible for the loss of habitat at Lone Mountain. Each of these areas has since been recolonized.

Reasons for the declines at Area 6 and Jack Mountain are unknown, but appear to be unrelated to habitat disturbance. At Area 6, the decline may be related to habitat succession. Although most of the area appeared to be suitable for the vireo, it was by far the oldest colony site at about 30 years of age. (No vireos were observed there in 1990 [Hunt 1990].) In areas that were adequately censused in 1990, numbers were similar to those reported in 1989. Thus, overall, the population appears to be relatively stable despite concerns expressed elsewhere regarding a possible regional population decline (Tazik and Cornelius 1993).

Colony Age and Habitat Management

Fire clearly is important in the development and maintenance of vireo habitat. On Fort Hood, vireo habitat develops within 3 to 5 years after fire or other such disturbance, and remains suitable for up to 20 to 30 years. This agrees with Graber (1961), as well as with Marshall and co-workers (1985), who noted that the largest and most dense populations were located in habitats that burned in hot fires 10 to 15 years previously. Note that a large portion of the Robinette Point colony site burned about 10 years ago and had the largest and most dense population in 1989 (Tables 1 and 2, pp 46 and 47).

Keeping track of existing habitat of known age allows one to predict future habitat supply and potential vireo numbers. This is an important consideration for both short- and long-term management planning. For example, Kirtland's warbler habitat develops after fire in mature pine stands and exhibits a similar life cycle to that of vireo habitat. Probst (1986) reported that the stock of young regenerating pine was less than that needed to replace currently occupied maturing stands in the short term, but that a recent large burn held the potential for a substantial population increase in the long term.

Much of the existing black-capped vireo habitat on Fort Hood will become unsuitable within the next 10 to 15 years. However, there is some existing potential habitat. There is, for example, an area of 160 ha in Training Area 2 that was scraped of vegetation by bulldozers during the fall and winter of 1984-85. Woody vegetation in this area now is regenerating in a manner similar to that observed subsequent to fire. Vireos have already begun colonizing this area, and more will likely do so in the future. At about 4 hectares per territory, this area could support as many as 40 territories. Also, the continuation of military activity on Fort Hood will help to create new habitats or maintain existing ones through fire and other disturbances.

However, even in the absence of military activity, habitat can be developed and maintained indefinitely using fire. For example, five colony sites burned on a 5-year cycle would maintain an equal amount of habitat in 5-year age groups (0 to 25) indefinitely. This is illustrated in Table 7 (p 52), where 0 indicates the year to burn the stand. After 20 years on this burn rotation, a stable habitat age structure can be maintained with each site burned every 25 years. More frequent burning for most stands during the first 20 years is required to establish the proper cycle while also creating some early successional, but suitable habitat.

Territory Size

Territory size ranged from 2.92 ha in 1987 to 4.08 ha in 1990 (Table 2, p 47). This compares with 1.5 ha reported by Graber (1961) and about 3 ha reported for an area in Austin, TX (J. O'Donnel in Marshall et al. 1985). The overall average of 3.6 ha for Fort Hood vireos is larger than that reported by Mayfield (1960) for several warbler species, a group closely related to the vireos (Welty 1975), except for Kirtland's warbler, which had an average territory size of 3.4 ha. Walkinshaw (1983) reported an average territory size of 8.4 ha for this latter species.

Black-capped vireo territory size appears to vary inversely with population density. The prairie warbler (Nolan 1978) and Kirtland's warbler (Walkinshaw 1983) are known to exhibit a similar relationship.

Large colony sites of several pairs probably will be easier to manage and protect than smaller ones. Also, there is some evidence to suggest that small colony sites with only a few pair are less stable than larger ones (Grzybowski, 1989). As such, a managed colony site should contain enough habitat to support at least three pair. At 4 ha per territory, this requires a minimum of 12 ha. A more reasonable colony size of 10 to 20 territories requires an area of 40 to 80 ha, 50 to 100 ha with buffer areas.

The 1989 population of 143 territories at an average of 4.08 ha per territory yields an area of nearly 600 ha. This amounts to less than 1 percent of the entire installation.

Potential Habitat

This analysis was based on an expected association between known vireo habitat locations and various landscape features such as geology, soils, elevation, slope, and aspect. These features were expected to affect the potential vegetation of a site and thus define the potential of a site to support the specific vegetation type preferred by the vireo. Vireos exhibited distinct preferences with regard to each of these 5 landscape features. Although relationships among these features were anticipated, it was expected that the combination would be more effective in separating potentially suitable and unsuitable habitat areas than any single landscape feature. While the GRASS composite model classified 69.2 percent of the installation as low to no potential, the next best separation was with geology, which classified 65.7 percent of the installation as low or no potential (i.e., index values of 0 or 1). Values for soil, elevation, slope, and aspect were 58.4, 46.9, 48.9, and 0.0 percent. Also, while only 2.09 percent of vireo areas fell within low to no potential habitat areas, 5.8 percent fell within low to no potential geology categories. Values for soil, elevation, slope, and aspect were 8.0, 17.7, 26.0, and 0.0 percent. The following discussion is based on an analysis of the composite of 1987, 1988, and 1989 vireo territories.

Geology

Vireos were most closely associated with the dense and loose limestone geologic formations typical of the high elevation ridge running east-southeasterly across the north half of the installation, and also found in the southwest and southeast portions of the Fort (Table 4, p 50; Figure 3, p 30). The dense limestone category includes Edward's Limestone-Kiamichi Clay complex, and the Denton Clay-Fort Worth Limestone and Duck Creek Limestone complex (Barnes 1970). The loose limestone includes the Comanche Peak Limestone and shale formations. These two categories accounted for 94.2 percent of vireo territories. Geology alone was nearly as effective in separating suitable and unsuitable vireo habitat as the resultant composite model.

Soils

Eight of the 24 soil types were occupied by vireos (Table 4, p 50). However, four of these accounted for over 95 percent of vireo occupied areas: Eckrant (55.1 percent), Real-Rock (26.3 percent), Brackett-Topsey (7.1 percent), and Evant (7.6 percent), of which only the first two were highly favored. Ekrant-Real-Rock is an upland association consisting of very shallow to shallow, gently sloping to steep, cobbly and gravelly, clayey and loamy soils and rock outcrop (McCaleb 1985). The Ekrant series typically lies over Edward's limestone at the higher elevations, with the Real-Rock outcrop complex on the side slopes over Comanche Peak Limestone (Figure 16, p 44). Thus, this association is extensive along the northern mesa-hills and uplands coincident with these geologic formations (Figures 3 and 4, pp 30 and 31). In contrast, the Brackett-Topsey association consists of deep loamy soils on undulating uplands. It typically is situated adjoining and downslope from the Real-Rock complex over the Walnut Clay geologic formation (chalky shale of Figure 3). The Evant series also is a shallow, clayey soil and is found on gently sloping uplands. While present on the north half of the Fort, it is conspicuous in the southeastern and southwestern portions of the Fort (Figure 4), where it is associated with the dense and loose limestone formations (Figure 3).

Elevation

Elevation under 271 m tended to be underrepresented in vireo-occupied areas, while intermediate elevations from 272 to 308 m were represented in proportion to availability (Table 4, p 50). Above 309 m, vireos were significantly more common than expected. Examination of Figures 3, 4, 5, and 16 (pp 30, 31, 33, and 44) reveal an obvious relationship between geology, elevation, and soil.

Slope

Zero to 5 percent slopes were less common in vireo occupied areas than on the Fort as a whole (Table 4, p 50). Slopes of 5 to 10 percent were represented in proportion to availability, while 15 to 25 percent slopes were occupied more commonly than expected. Slopes over 25 percent were uncommon and not clearly favored by the vireo. Slopes over 15 percent occupied by the vireo appear to be associated with the Real-Rock outcrop complex, which typically overlays the Comanche Peak or loose limestone geologic formation and exhibits slopes of 12 to 40 percent (Figures 3, 4, 7, and 16, pp 30, 31, 35, and 44; McCaleb 1985).

Aspect

With respect to aspect, the vireo was found largely according to expectation (Table 4, p 50; Figure 8, p 36). Only western slopes clearly were favored. However, the relationship may be related to the Fort's grounds crew and military activity. For example, at the West Fort Hood, colony site fires frequently are set by grounds crews for juniper control. The site forms a series of draws that, with a westerly breeze, can support a good fire. The western slope of Robinette Point also is prone to fire because artillery is directed at it from the west.

Potential Habitat Model

The final potential habitat map layer delineates areas of the installation with a high potential to support vireos if vegetation structure and composition are correct. It is important to emphasize that the map **does not represent actual existing habitat**, only the potential for that habitat to develop as a result of fire or similar disturbance. Note, for example, that despite the substantial amount of habitat of very high potential in the northwest corner of the Fort and extensive searching in this area (Figure 10, p 38), the number of vireo sightings and colony sites in that area is quite low. In years prior to listing of the vireo as endangered, much of the woody vegetation on the hill tops in this area had been cleared and impacted from training activities (Training Area [TA] 44, 45, 48, 51, 53 Figure 17, p 45). Thus, much of the vegetation currently is unsuited to the vireo. Also, many other areas in the very high habitat potential category throughout the Fort are covered by mature oak-juniper woodland, which also is unsuitable for the vireo at present. In each case, the habitat could develop into vireo habitat; the former through natural succession, the latter through fire or other disturbance.

Training Intensity

Over 25 percent of both the installation as a whole and the very high potential vireo habitat lies within nonmaneuver areas in the live fire training area. A large percentage of existing vireo occupied area also lies within this area (38.5 percent; see also Table 1, p 46). The latter may be the result of a higher probability of fire within the live fire training area due to artillery and flares. Also, the area is protected from vehicle maneuver impacts and other direct human disturbance.

The greatest potential for conflict between training activities and existing vireo colony sites is in 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) (Figure 11 and 17, pp 39 and 45). Red Bluff (TA 3), Area 6 (TA 6), and West Fort Hood (TA 22 and 24) (Figure 11 and 17) fall within the lowest training intensity category and are least likely to be impacted. For sites within the live fire training area, the greatest threat may be from the difficulty in applying necessary management prescriptions (e.g., cowbird control, Tazik and Cornelius 1993) due to restricted access. Also, if fires become overly frequent, existing habitat could be jeopardized. This does not appear to be the case at present as fires have had a net positive impact by creating substantial habitat here.

6 CONCLUSIONS AND RECOMMENDATION

Fort Hood supports a substantial number of the endangered black-capped vireo (about 280 adults) on less than 1 percent of its land. It is an important and perhaps vital population not only because of the large number, but also because it constitutes close to 20 percent of the presently known population within the United States, and resides under a single land management authority.

Vireo colony sites on the Fort are associated primarily with the mesa-hills and side slopes most common along a ridge running east southeasterly from the northwest corner of the post. Similar areas are occupied at West Fort Hood, Pilot Knob Range, and the southeastern portion of the Fort. Colonies typically are located in 5 to 30 year old burns.

Black-capped vireo territories are large for small passerines. Thus, habitat patch size needs to be large to support a manageable colony. For example, 10 vireo pairs may require 40 to 50 hectares of suitable habitat.

Vireo territories are associated with certain landscape features on Fort Hood including geology, soils, elevation, slope, and aspect which are themselves interrelated. Vireo territories were associated with geologic and soil types that co-occur within the mesa-hills and side slopes on the higher elevations of the Fort. The relationship between vireo territory location and aspect may be related to a pattern of military and land management activity that encourages fires along certain west facing slopes.

The potential vireo habitat map developed in GRASS took advantage of the relationship between vireo territory location and the landscape features noted above. It appears to be realistic although it is important to emphasize that it represents only potential habitat, and not existing habitat. In fact, vegetation in much of the very high potential habitat area is currently unsuitable, and could become suitable only through succession in presently disturbed areas and fire in mature oak-juniper woodlands.

The potential vireo habitat map can be used (a) to help avoid conflicts between the vireo and various land use activities, including training, construction, and facility siting, (b) to identify areas of the installation that might be suitable for the development of vireo habitat, (c) to provide direction for future survey work, and (d) as a framework for further delineation of existing suitable habitat through the application of remote sensing tools.

A substantial portion of the vireo population breeds within the live fire training area. This is beneficial since direct contact between vireos and military personnel and vehicles is avoided. However, restricted access to and the potential dangers associated with entering these areas reduces management potential considerably.

It is recommended that these data be updated annually and that a computerized data analysis and reporting program be developed for timely documentation of annual monitoring results, and that this be done as part of the Army's Land Condition-Trend Analysis (LCTA) Program.

REFERENCES

Agee, J.K., S.C.F. Stitt, M. Nyquist, and R. Root, "A Geographic Analysis of Historical Grizzly Bear Sightings in the North Cascades," *Photogrammetric Engineering and Remote Sensing*, Vol 55 (1989), pp 1637-1642.

Barnes, V.E., *Geological Atlas of Texas: Waco Sheet* (Bureau of Ecological Geology, University of Texas at Austin, 1970).

Conover, W.J., *Practical Nonparametric Statistics*, 2d ed. (John Wiley & Sons, New York, 1980).

Donnelly, M., and J.G. Van Ness, "The Warrior and the Druid—DOD and Environmental Law," *Federal Bar News and Journal*, Vol 33, No. 1 (1986), pp 37-43.

Diersing, V.E., W.D. Severinghaus, and E.W. Novak, *Annotated Directory of Endangered Wildlife on Selected U.S. Army Installations West of the Mississippi River*, Technical Report (TR) N-85/08/ADA154623 (U.S. Army Construction Engineering Research Laboratories [USACERL], 1985).

Diersing, V.E., J.A. Courson, S.D. Warren, R.B. Shaw, and E.W. Novak, *Climatic Basis for Planning Military Training Operations and Land Management Activities* TR N-90/13/ADA224174 (USACERL, June 1990).

Gould, F.W., *Texas Plants—A Checklist and Ecological Summary* (Texas A&M University, Texas Agricultural Experiment Station, College Station, MP-585/Rev., 1975).

Graber, J.W., "Distribution, Habitat Requirements, and Life History of the Black-capped Vireo (*Vireo atricapilla*)," *Ecological Monographs*, Vol 31 (1961), pp 313-336.

Grzybowski, J.A., Final Report: *Population and Nesting Ecology of the Black-capped Vireo (Vireo atricapillus). Part I: Population Status of the Black-capped Vireo*, Report submitted to the U.S. Fish and Wildlife Service (USFWS), Office of Endangered Species, Albuquerque, NM (1985a).

Grzybowski, J.A., Final Report: *Population and Nesting Ecology of the Black-capped Vireo (Vireo atricapillus). Part II: Nesting Ecology of the Black-capped Vireo*, Report submitted to USFWS, Office of Endangered Species, Albuquerque, NM (1985b).

Grzybowski, J.A., Performance Report: *Population and Nesting Ecology of the Black-capped Vireo (Vireo atricapillus) in Oklahoma*, Report submitted to Oklahoma Department of Wildlife Conservation, Oklahoma City, OK (1988a).

Grzybowski, J.A., Report: *Black-capped Vireo Investigations—1986-87, Part I: Population and Nesting Ecology*, Report submitted to USFWS, Office of Endangered Species, Albuquerque, NM (1988b).

Grzybowski, J.A., Interim Report: *Black-capped Vireo Investigations: Population and Nesting Ecology*, Report submitted to USFWS, Office of Endangered Species, Albuquerque, NM (1989).

Grzybowski, J.A., and D.J. Tazik, *Status and Management of the Black-capped Vireo at Fort Sill, OK—1988-91*, TR EN-93/06/ADA269217 (USACERL, March 1993).

Gryzbowski, J.A., R.B. Clapp, and J.T. Marshall, Jr., "History and Current Population Status of the Black-capped Vireo in Oklahoma," *American Birds*, Vol 40 (1986), pp 1151-1161.

Hunt, J., *Status of Black-capped Vireos on Fort Hood—1990*, Preliminary Report (USFWS Cooperative Research Unit, University of Arkansas, Fayetteville, March 1991).

Marshall, J.T., R.B. Clapp and J.A. Grzybowski, *Status Report: Vireo atricapillus (Woodhouse), Black-capped Vireo*. Report submitted to the Office of Endangered Species, USFWS, Albuquerque, NM (1985).

Mayfield, H.F., *The Kirtland's Warbler* (Cranebrook Institute of Science, Bloomfield Hills, MI, 1960).

McCaleb, N.L., *Soil Survey of Coryell County, Texas* (U.S. Department of Agriculture, Soil Conservation Service, 1985).

Nakata Planning Group, Inc., *Master Plan Report: Fort Hood, Texas* (U.S. Army Corps of Engineers, Fort Worth, TX, 1987).

REFERENCES (Cont'd)

Nolan, V., Jr., "The Ecology and Behavior of the Prairie Warbler, *Dendroica discolor*," *Ornithological Monographs*, No. 26 (The American Ornithologist's Union, 1978).

Probst, J.R., "A Review of Factors Limiting the Kirtland's Warbler on its Breeding Grounds," *American Midland Naturalist*, Vol 116 (1986), pp 87-100.

Raisz, E., *Land Forms of the United States* (International Geological Congress, Washington, DC, 1952).

Ratzlaff, A., "Endangered and Threatened Wildlife and Plants: Determination of the Black-capped Vireo To Be an Endangered Species," *Federal Register*, Vol 52, No. 193 (1987), pp 37420-37423.

Rust, S.P., and D.J. Tazik, *Field Season Report: Endangered Bird Survey on Camp Bullis Training Reservation, Fort Sam Houston, Texas* (Stewardship Services, Inc., San Antonio, TX, November 1990).

Severinghaus, W.D., R.S. Baran, and R.E. Riggins, *Ecological Baseline--Fort Hood, Texas*, TR N-95/ADA088271 (USACERL, 1980).

Shaw, D.M., D.J. Tazik, J.M. Coffey, and S.F. Atkinson, Status Report: *The Black-capped Vireo on Camp Bullis, Fort Sam Houston, Texas* (Center for Remote Sensing and Landuse Analyses, University of North Texas, Denton, TX, 1989).

Sokal, R.R., and F.J. Rohlf, *Biometry: The Principles and Practice of Statistics in Biological Research* (W.H. Freeman and Company, San Francisco, CA, 1969).

Tazik, D.J., J.A. Grzybowski, and J.D. Cornelius, *The Black-capped Vireo on the Lands of Fort Hood, Texas, Volume II: Habitat*, TR EN-93/01 (USACERL, November 1993).

Tazik, D.J., and J.D. Cornelius, *The Black-capped Vireo on the Lands of Fort Hood, Texas, Volume III: Population and Nesting Ecology*, TR EN-93/01 (USACERL, November 1993).

Tazik, D.J., J.D. Cornelius, D.M Herbert, T.J. Hayden, and B.R. Jones, *Biological Assessment of the Effects of Military Associated Activities on Endangered Species at Fort Hood, Texas*, SR EN-93/01/ADA263489 (USACERL, December 1992b).

Tazik, D.J., Stephen D. Warren, Victor E. Diersing, Robert B. Shaw, Robert J. Brozka, Calvin F. Bagley, and William R. Whitworth, *U.S. Army Land Condition-Trend Analysis (LCTA) Plot Inventory Field Methods*, TR N-92/03/ADA247931 (USACERL, February 1992a).

U.S. Army Engineering and Housing Support Center (USAEHSC), Technical Note 420-74-3, *Army Land Inventory and Monitoring Procedures on Military Installations* (USAEHSC, Fort Belvoir, VA, 1990).

U.S. Department of the Army, *Facilities Engineering and Housing Annual Summary of Operations, Fiscal Year 1987: Volume III--Installations Performance* (Office of the Assistant Chief of Engineers, Washington, DC, 1987).

U.S. Department of the Army (DA), *Facilities Engineering and Housing Annual Summary of Operations, Fiscal Year 1989* (Office of the Assistant Chief of Engineers [OACE], USAEHSC, 1989).

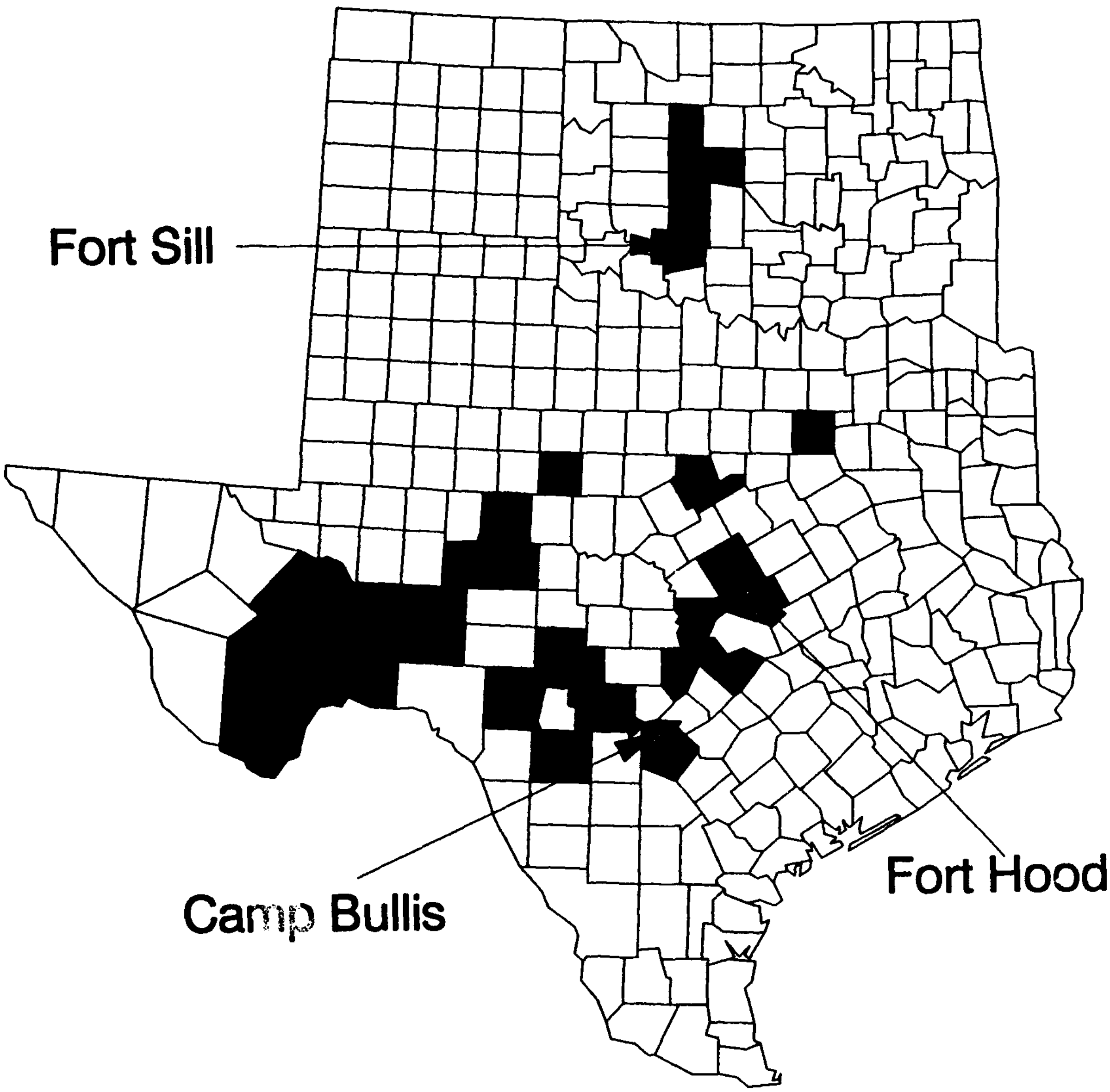
Walkinshaw, L.H., *Kirtland's Warbler: The Natural History of an Endangered Species* (Cranbrook Institute of Science, Bloomfield Hills, MI, 1983).

Walter, H., *Vegetation of the Earth and Ecological Systems of the Geo-biosphere*, 3d ed. (Springer-Verlag, Berlin, Germany, 1985).

Welty, J.C., *The Life of Birds*, 2d ed. (W.B. Saunders Company, Philadelphia, PA, 1975).

APPENDIX A:

Figures and Tables



(Modified from Marshall et al., 1985)

Figure 1. Current Distribution of the Black-capped Vireo in Texas and Oklahoma by County.

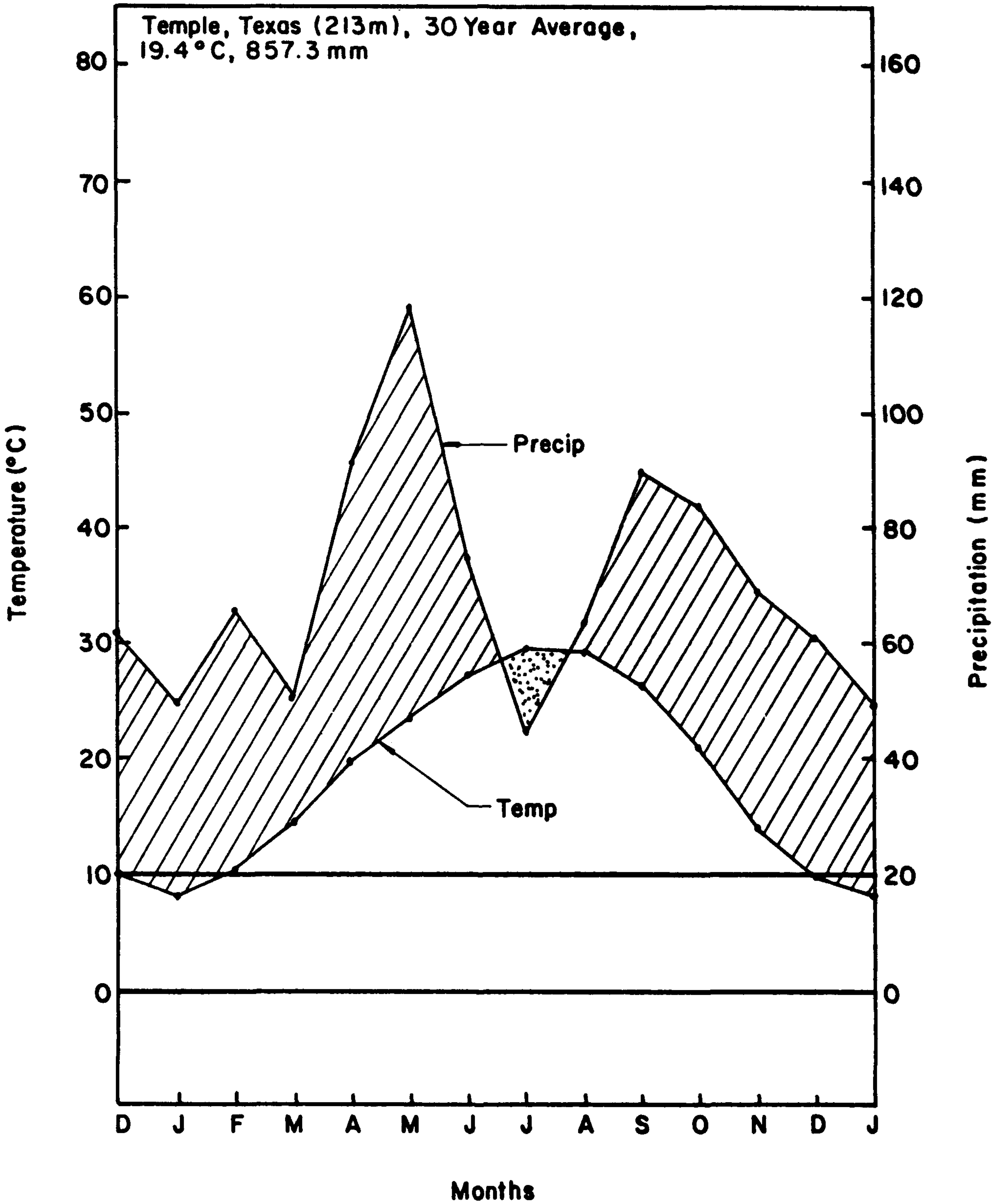
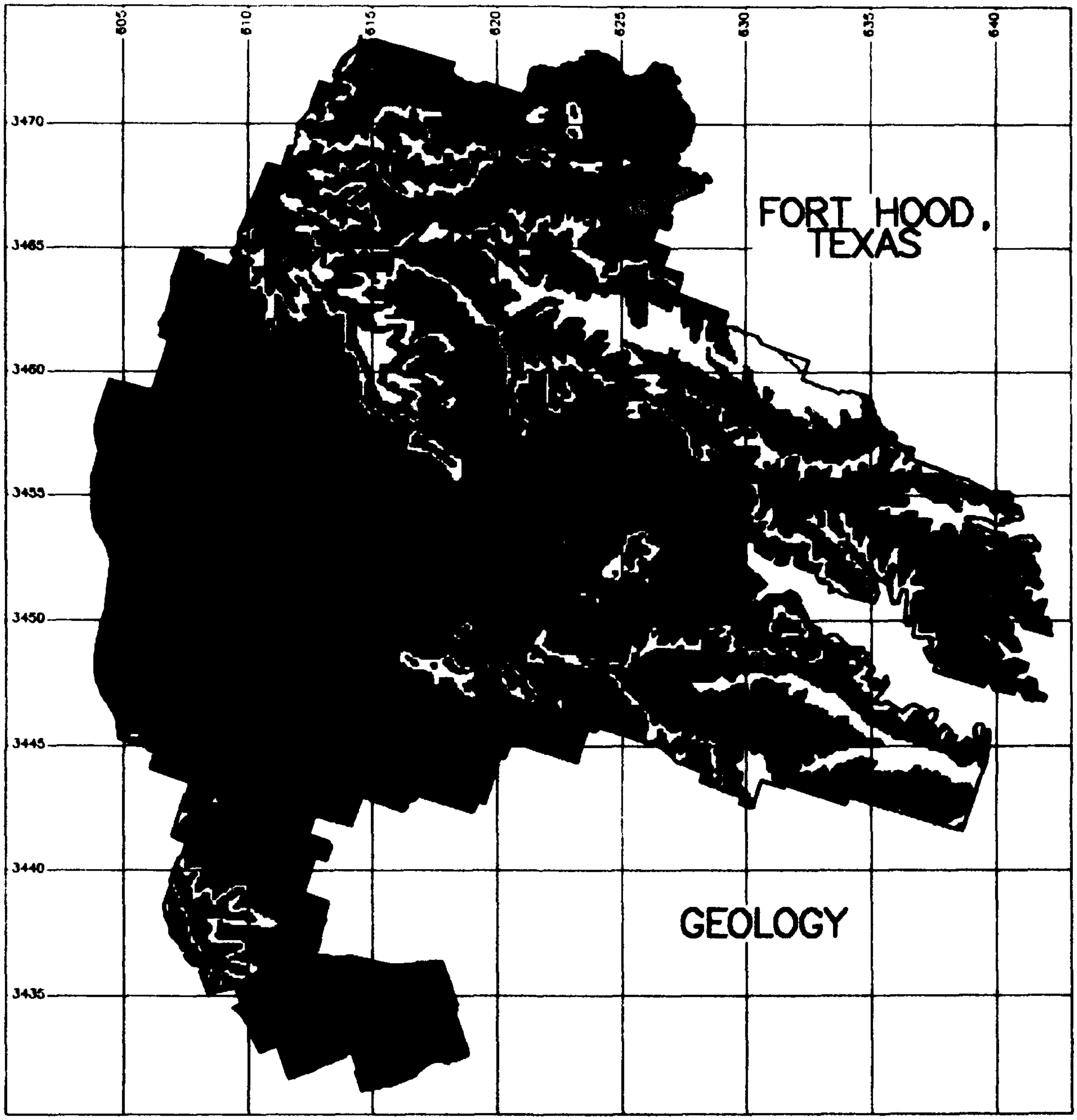


Figure 2. Climate Diagram for Temple, Texas Showing Patterns of Temperature and Precipitation Typical of Fort Hood and Vicinity.



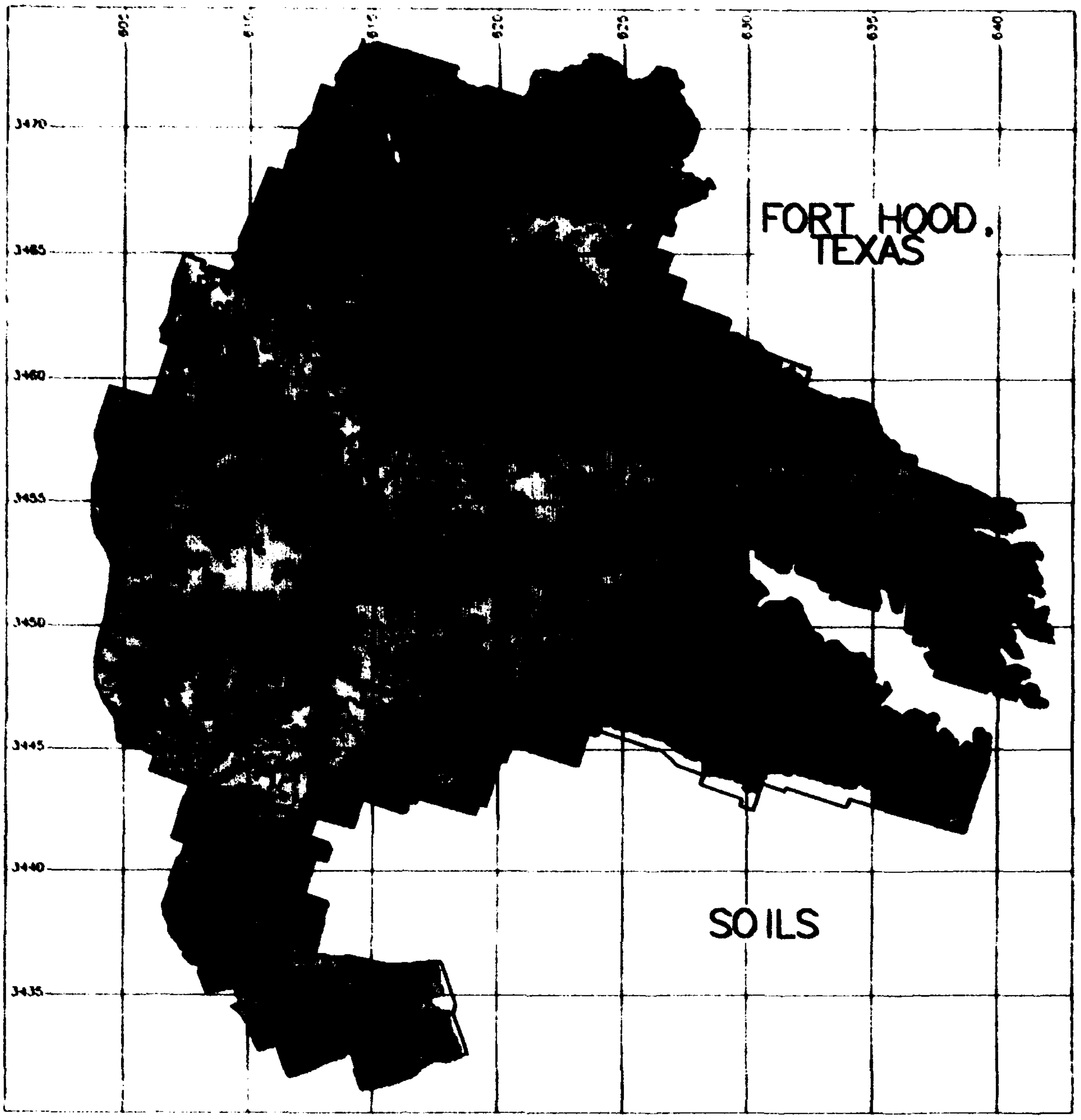
SCALE: 1 : 199034

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

border (PERMANENT)

1 limestn, dense
2 limestn, sandy
3 limestn, chalky
4 limestn, loose
5 shale, chalky
6 unconsolidated

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

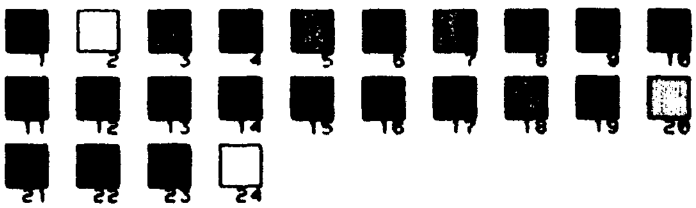


SCALE: 1 : 199034

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

border (PERMANENT)

Figure 4. Fort Hood Soil Map (grid: 5000 m).



1 BaB=Bastsil fine sandy loam, 1-3% slopes
2 BgB=Bolar gravelly clay loam, 1-4% slopes
3 Bo=Bosque clay loam, 0-1% slopes
4 BtC2=Brackett-Topsey assoc., 3-8% slopes
5 ChB=Cho clay loam, 1-3% slopes
6 CoB2=Cisco fine sandy loam, 1-5% slopes
7 CwB=Crawford silty clay, 1-3% slopes
8 DeB=Denton silty clay, 1-3% slopes
9 DrC=Doss-Real complex, 1-8% slopes
10 EcB=Eckrant cobbly silty clay, 1-3% slopes
11 EvB=Evant silty clay, 1-3% slopes
12 Fr=Frio silty clay, 0-2% slopes
13 HoA=Houston Black clay, 0-5% slopes
14 KrB=Krum silty clay, 1-3% slopes
15 LeB=Lewisville clay loam, 1-3% slopes
16 LyB=Lindy clay loam, 0-2% slopes
17 MnB=Minwells fine sandy loam, 1-3% slopes
18 NuC=Nuff stony silty clay loam, 1-2% slopes
19 PrB=Purves silty clay, 1-8% slopes
20 ReF=Real-Rock outcrop complex, 12-40% slopes
21 SeC=Seawillow clay loam, 3-5% slopes
22 SlB=Slidell silty clay, 1-3% slopes
23 TpC=Topsey-Pidcoke assoc., 2-8% slopes
24 WsC2=Wise clay loam, 3-5% slopes

Figure 4. (Cont'd)

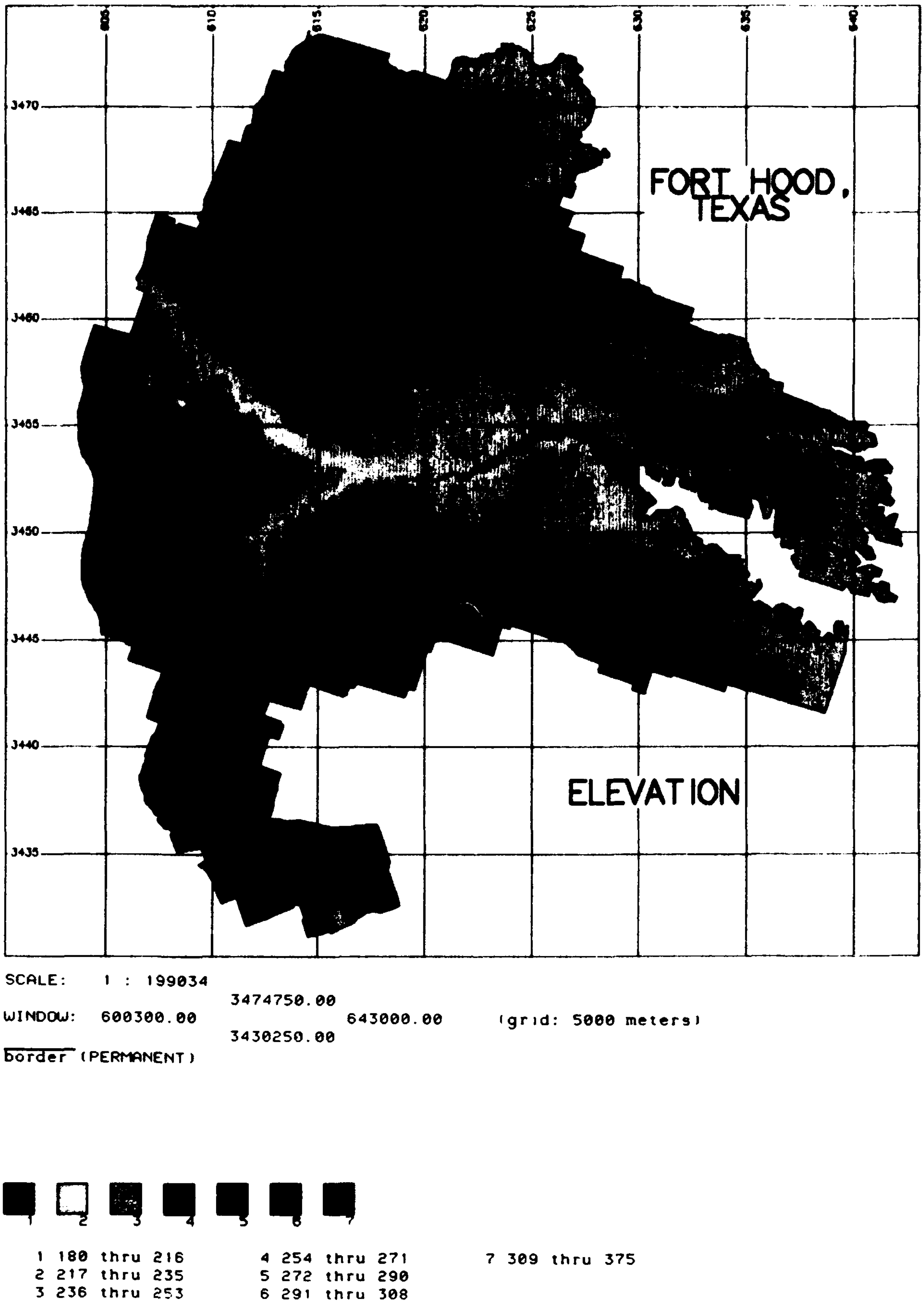
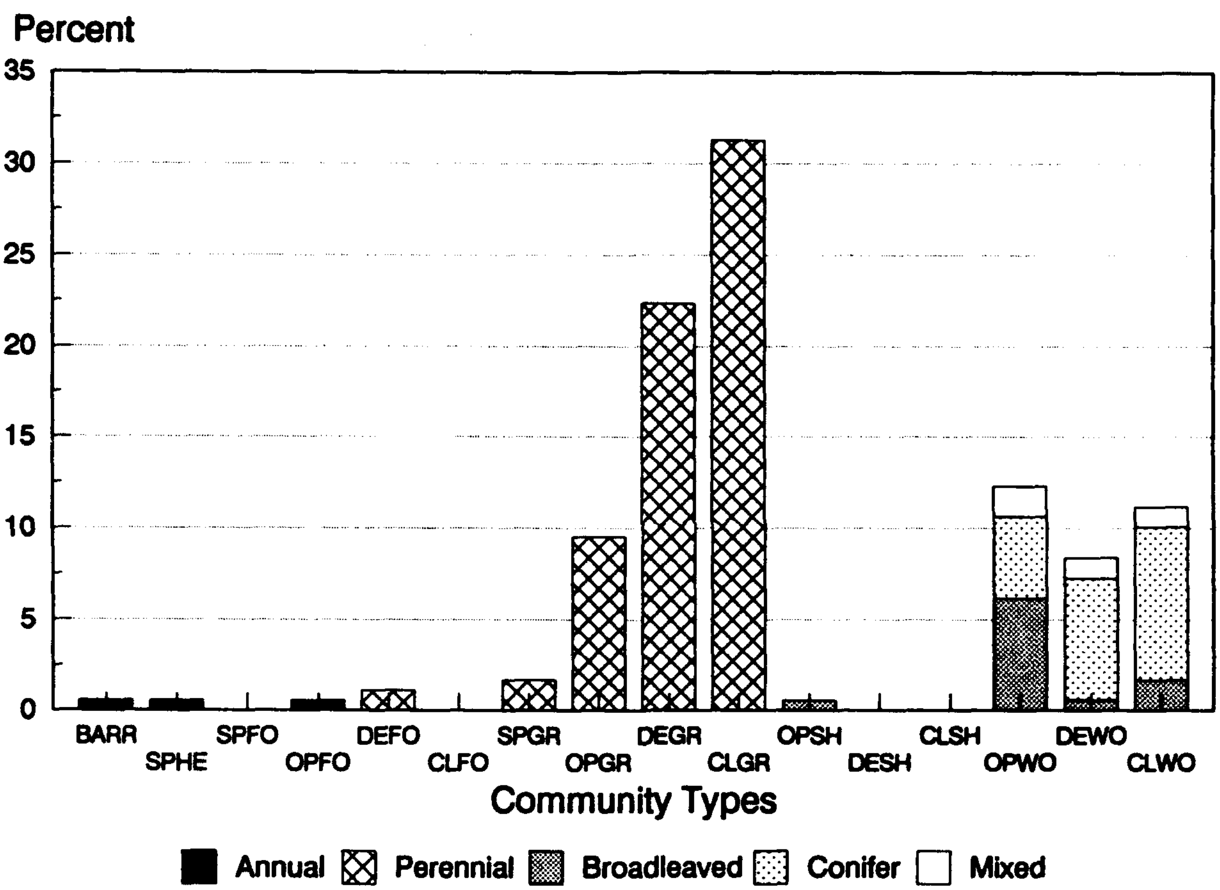


Figure 5. Fort Hood Elevation Map (grid: 5000 m).



(Note: Appendix B lists code descriptions.)

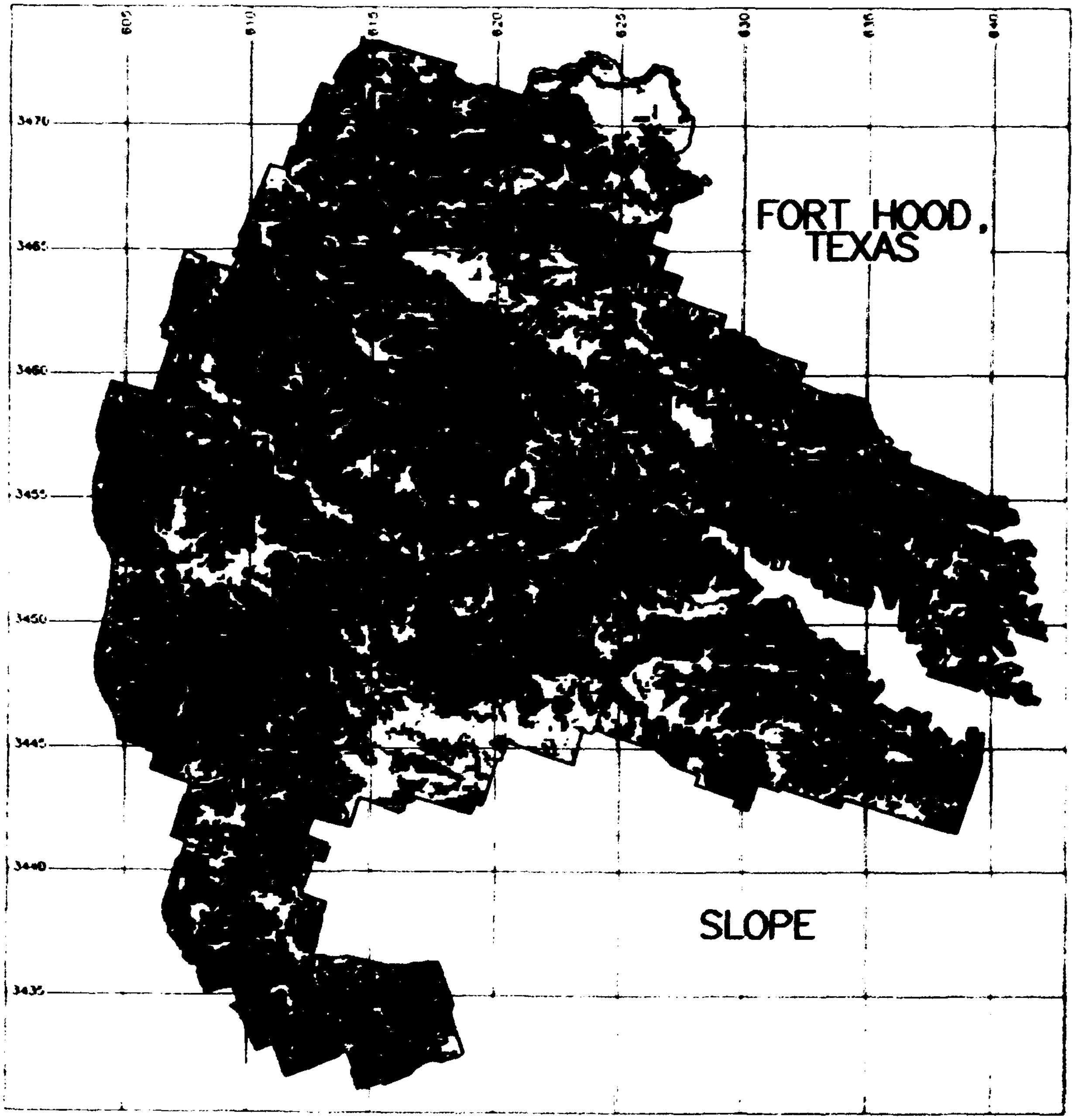
Figure 6. Fort Hood Plant Community Types.

MAPSET: grass USER: grass

CELLFILE: <slope> in mapset <PERMANENT>
MASK: <border> in mapset <PERMANENT>

Produced by: US Army CERL, Champaign Illinois
Software: GRASS

TITLE: Slope
LOCATION: Fort Hood, Texas



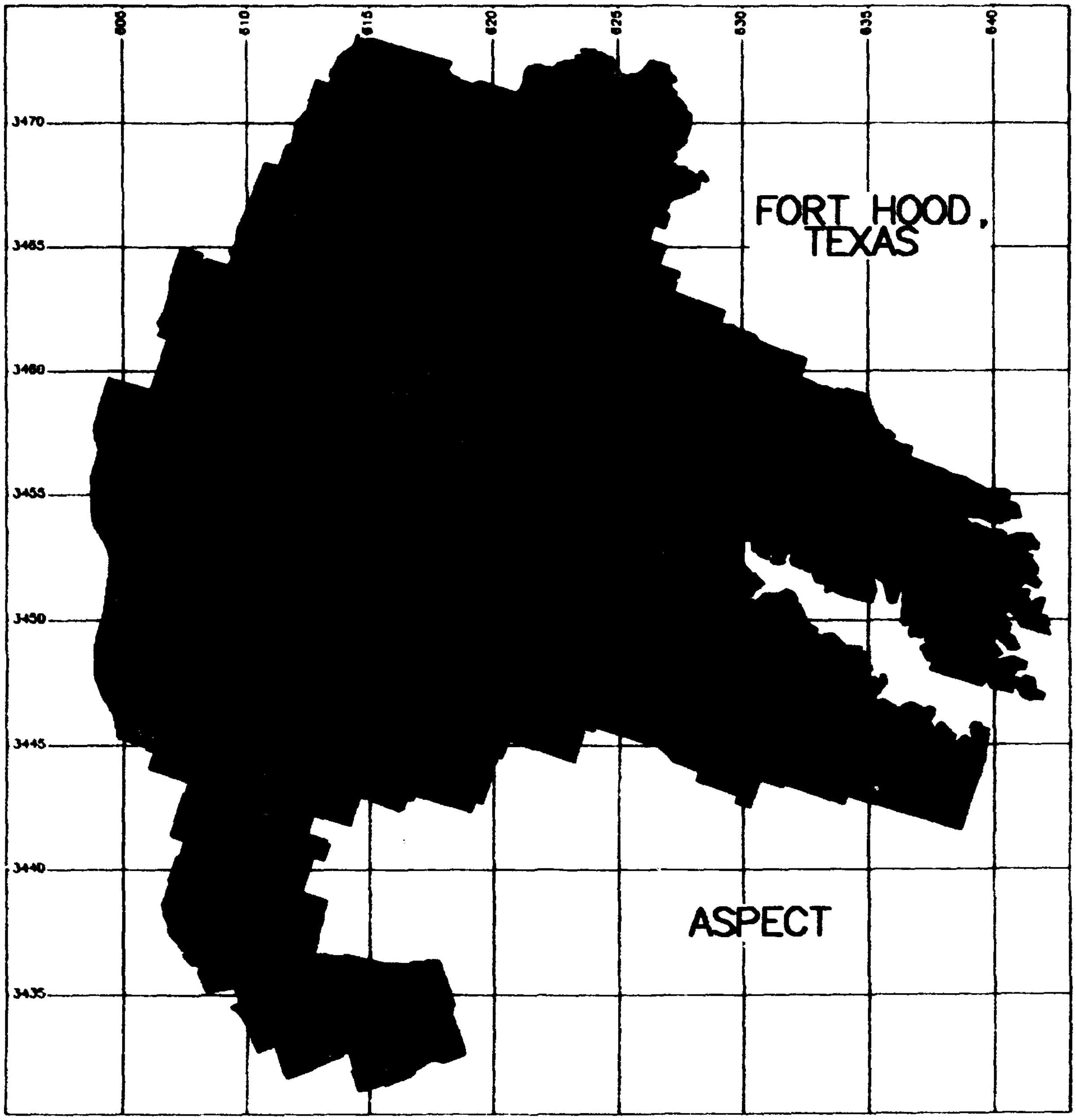
SCALE: 1 : 199034

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

border (PERMANENT)

1 0 to 2%
2 2 to 5%
3 5 to 10%
4 10 to 15%
5 15 to 20%
6 20 to 25%
7 > 25%

Figure 7. Fort Hood Slope Map (grid: 5000 m).



SCALE: 1 : 199034

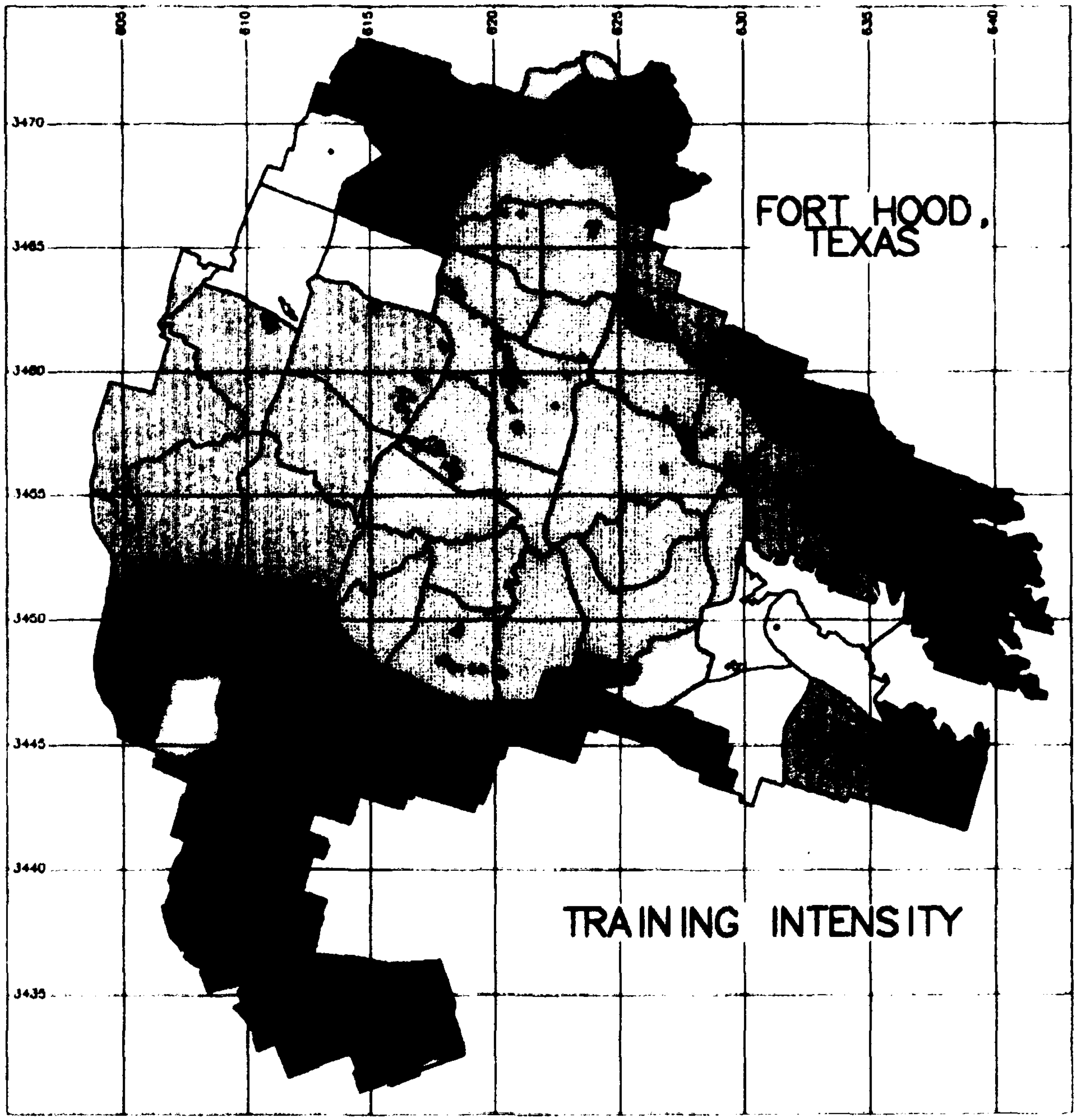
WINDOW: 600300.00 3474750.00 643000.00 3430250.00 (grid: 5000 meters)

border (PERMANENT)

1 2 3 4 5 6 7 8 9

1 north
2 northeast
3 east
4 southeast
5 south
6 southwest
7 west
8 northwest
9 < 2% slope

Figure 8. Fort Hood Aspect Map (grid: 5000 m).



SCALE: 1 : 199034

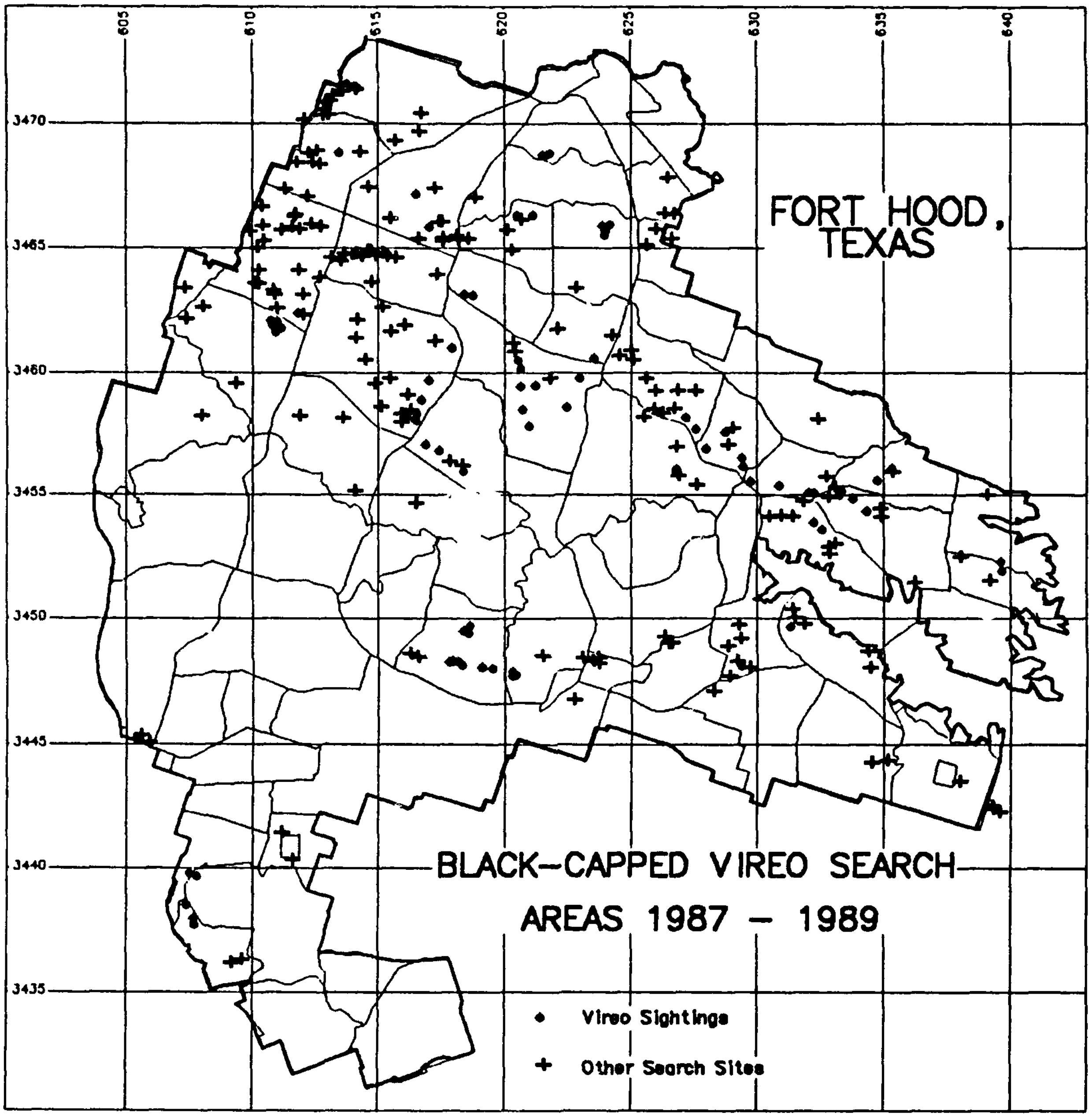
WINDOW: 600300.00 3474750.00 643000.00 3430250.00 (grid: 5000 meters)

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 9. Fort Hood Training Intensity Map (grid: 5000 m).



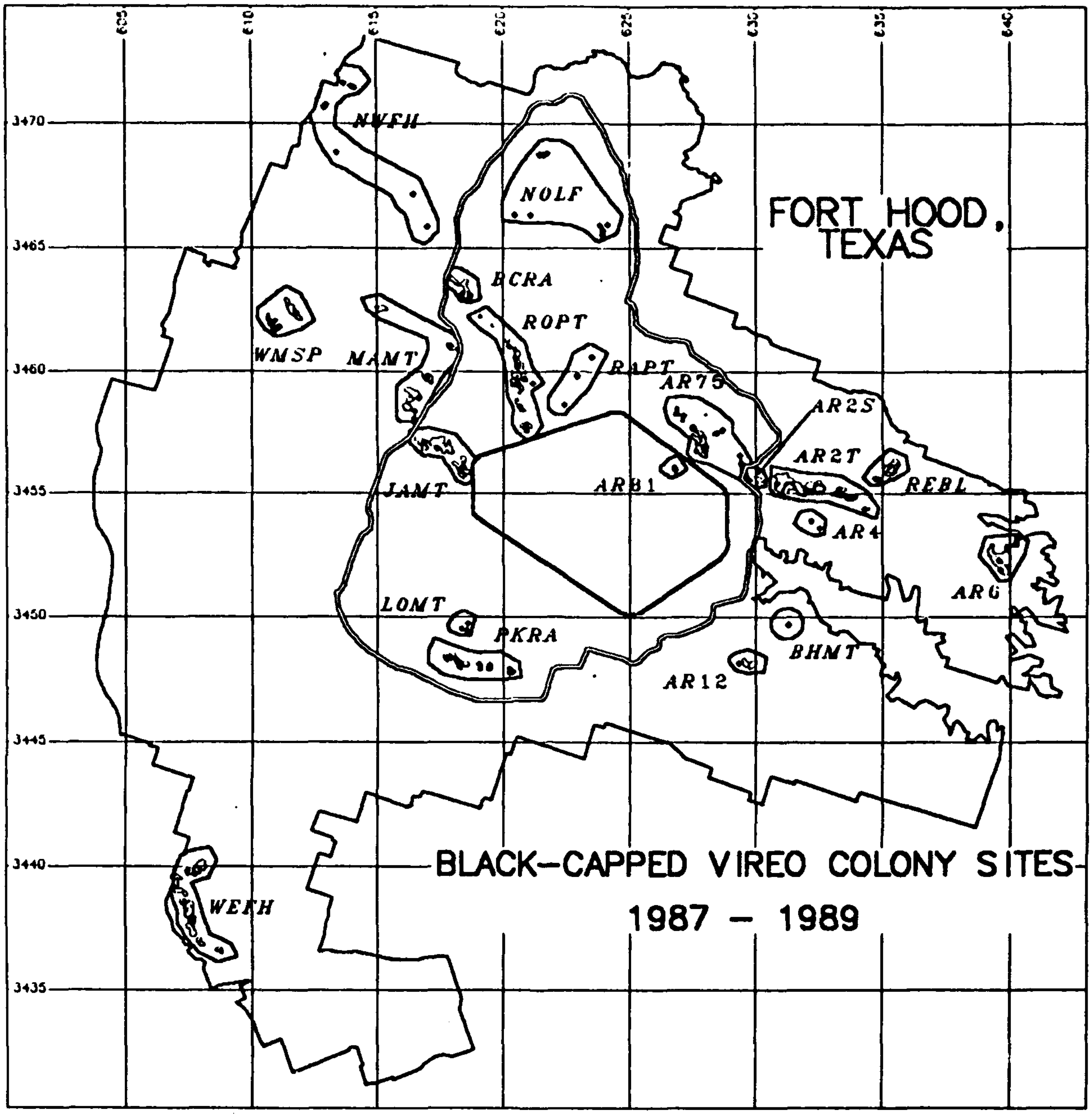
SCALE: 1 : 199034

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

border (PERMANENT)

trn_areas (PERMANENT)

Figure 10. Black-capped Vireo Sightings and Search Points on Fort Hood During 1987 Through 1989 (grid: 5000 m).



SCALE: 1 : 199034

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

border (PERMANENT)

live.fire.zone (grass)

impact (PERMANENT)

vireo.all (grass)

vireo.areas (grass)

(Note: Table 1 lists colony site code descriptions.)

Figure 11. Black-capped Vireo Colony Sites on Fort Hood (grid: 5000 m).

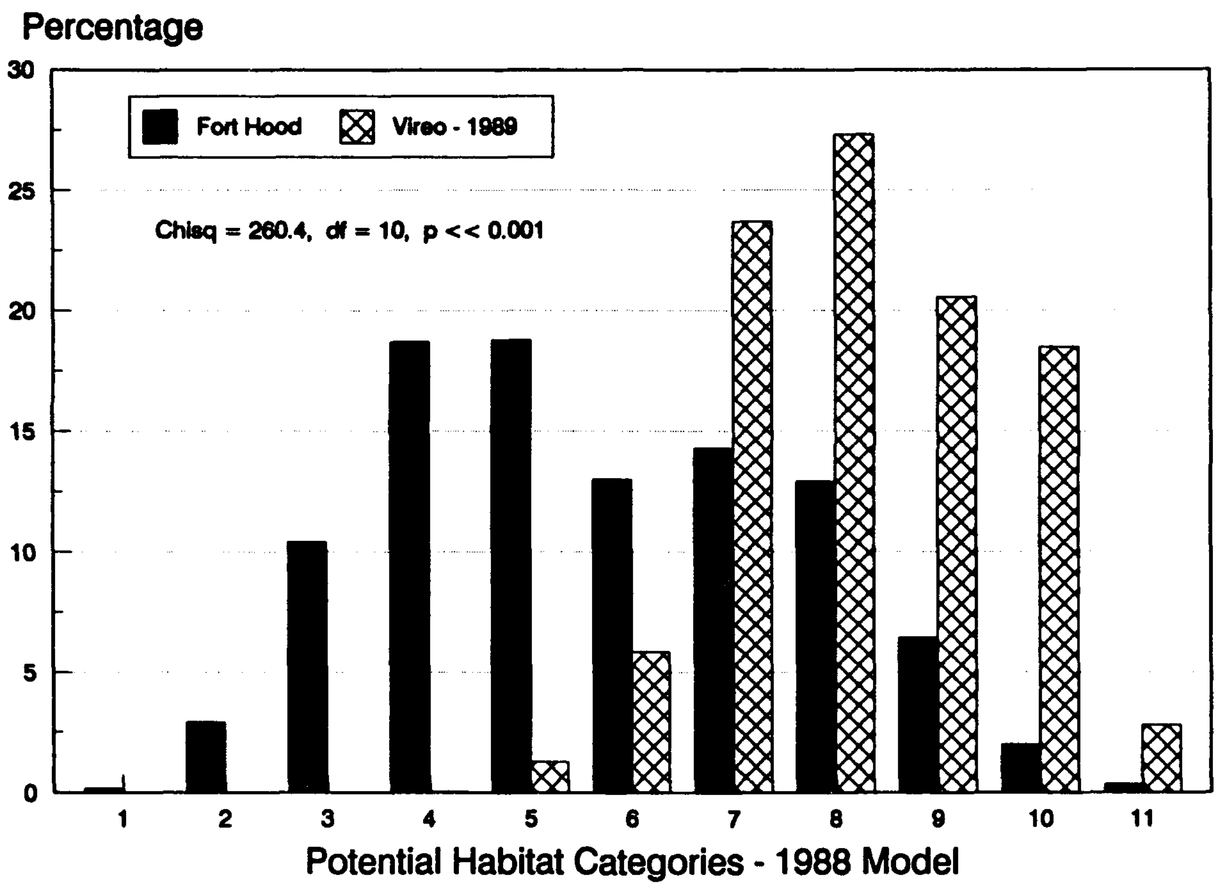


Figure 12. Comparison of 1989 Black-capped Vireo Occupied Area to That Available by Potential Habitat Category Based on the 1988 GRASS Model.

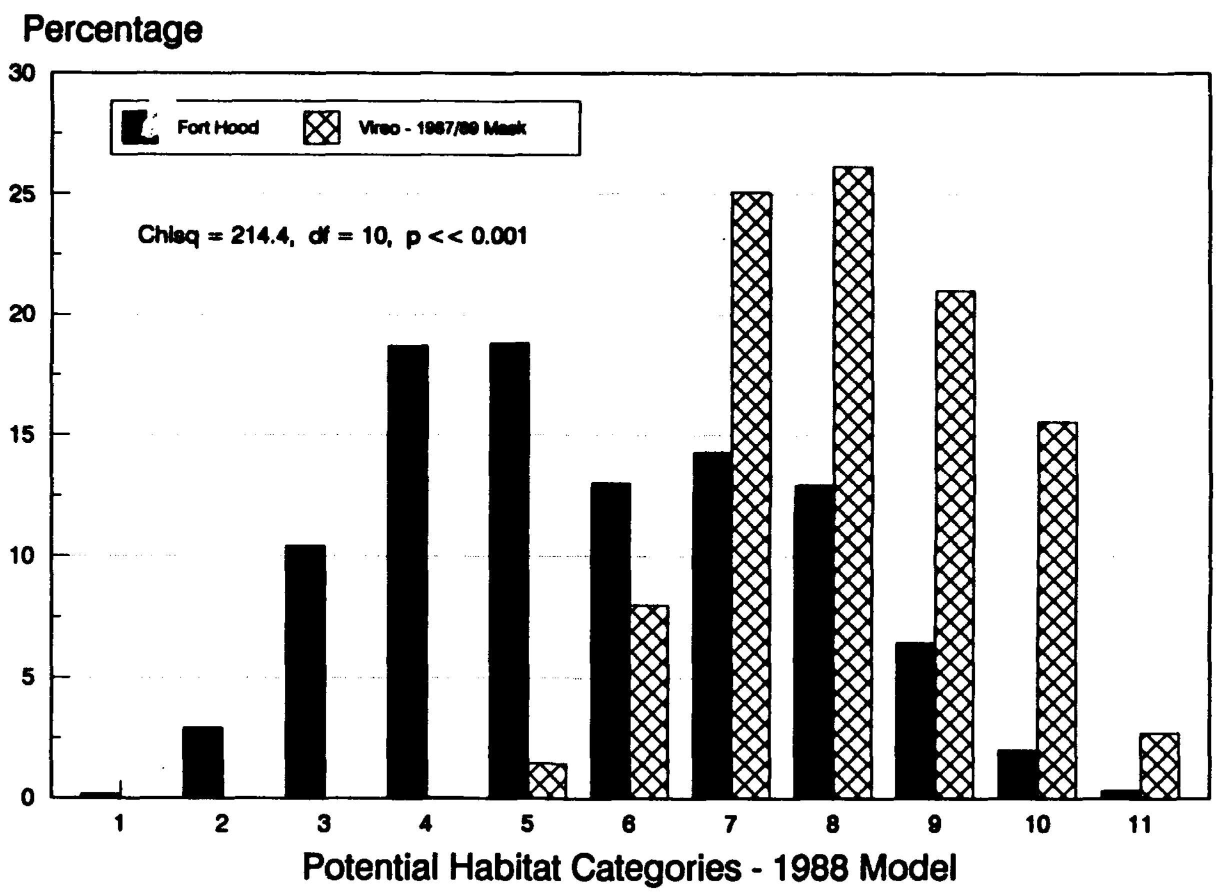


Figure 13. **Comparison of Black-capped Vireo Occupied Area to That Available by Potential Habitat Category Based on the 1988 GRASS Model Using a Mask To Exclude 1988 Occupied Areas.**

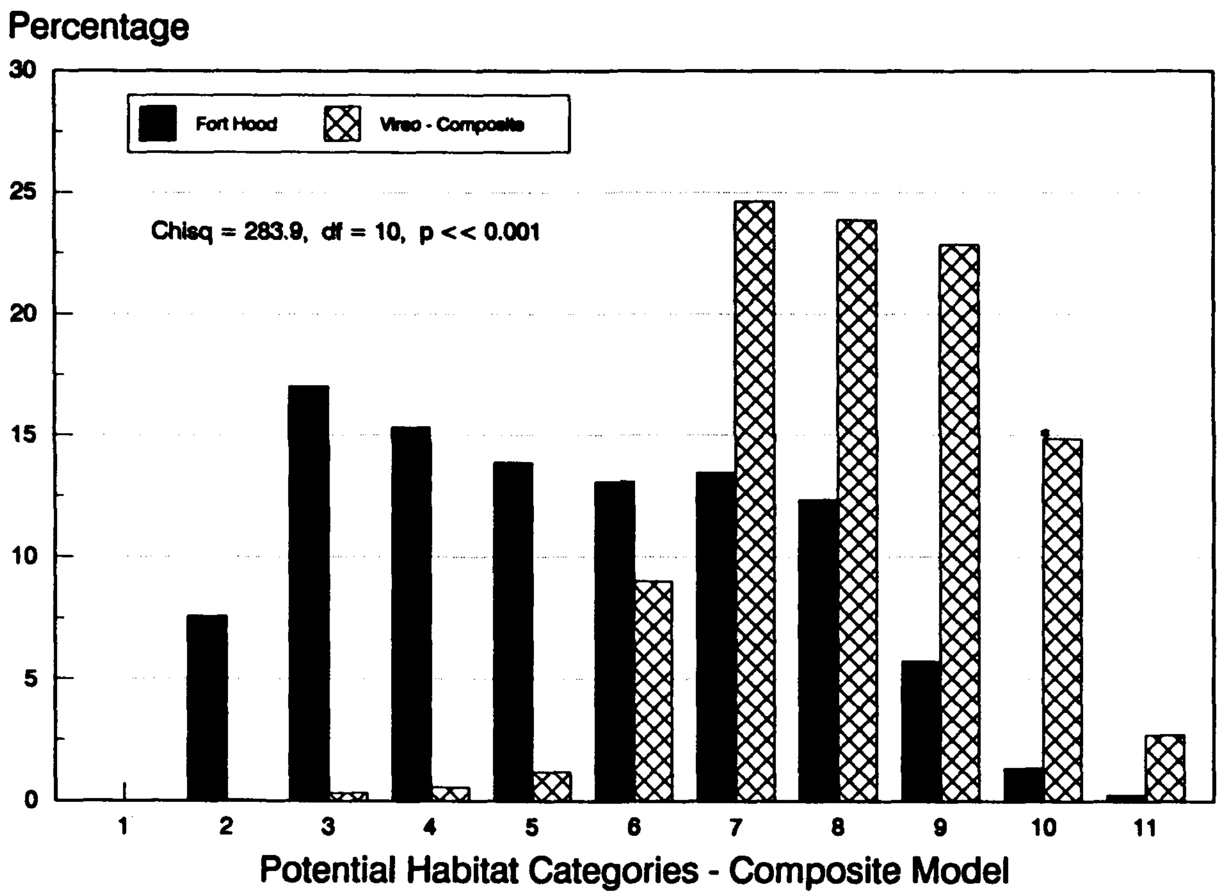


Figure 14. **Comparison of All Black-capped Vireo Occupied Area to That Available by Potential Habitat Category Based on the Composite GRASS Model.**

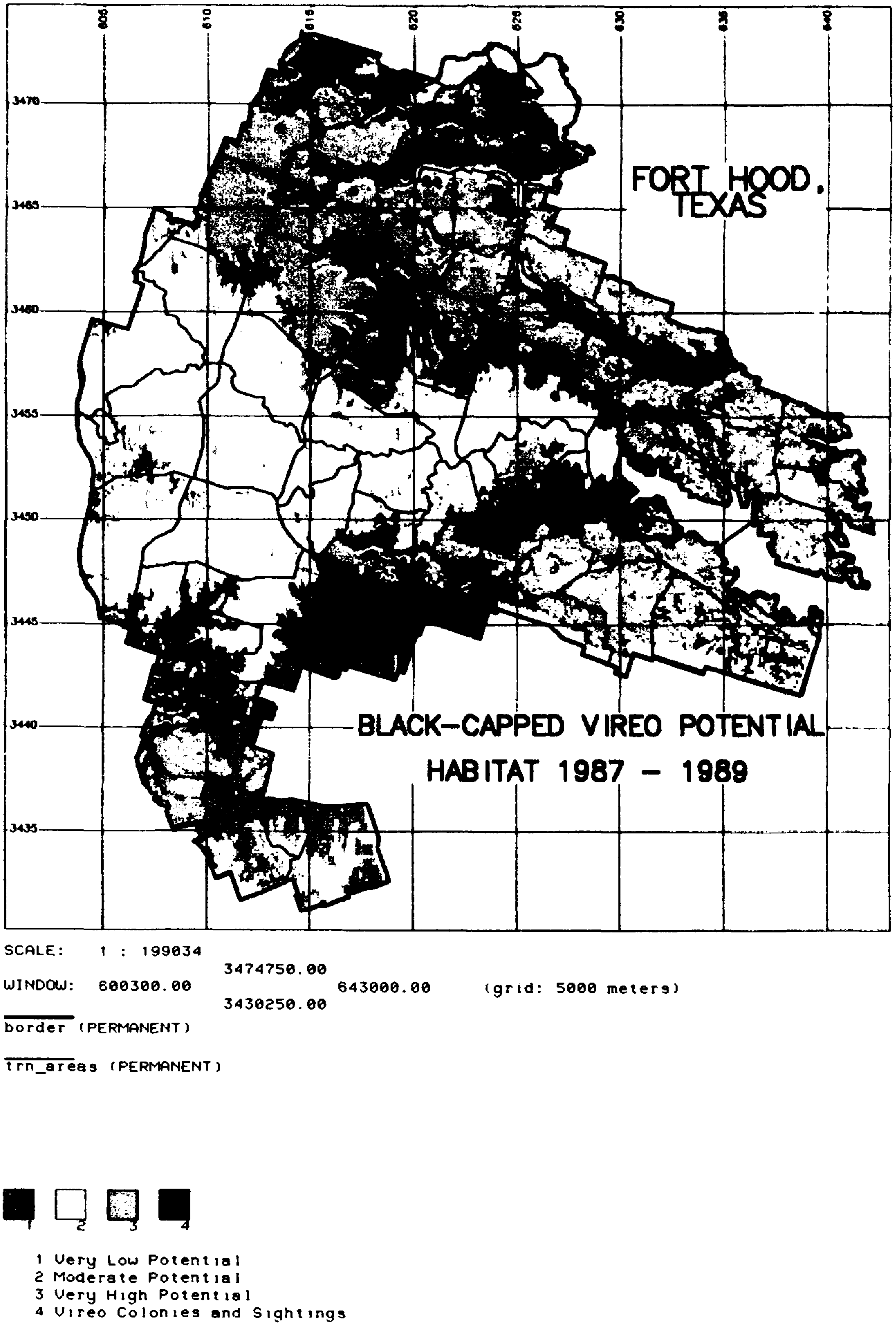
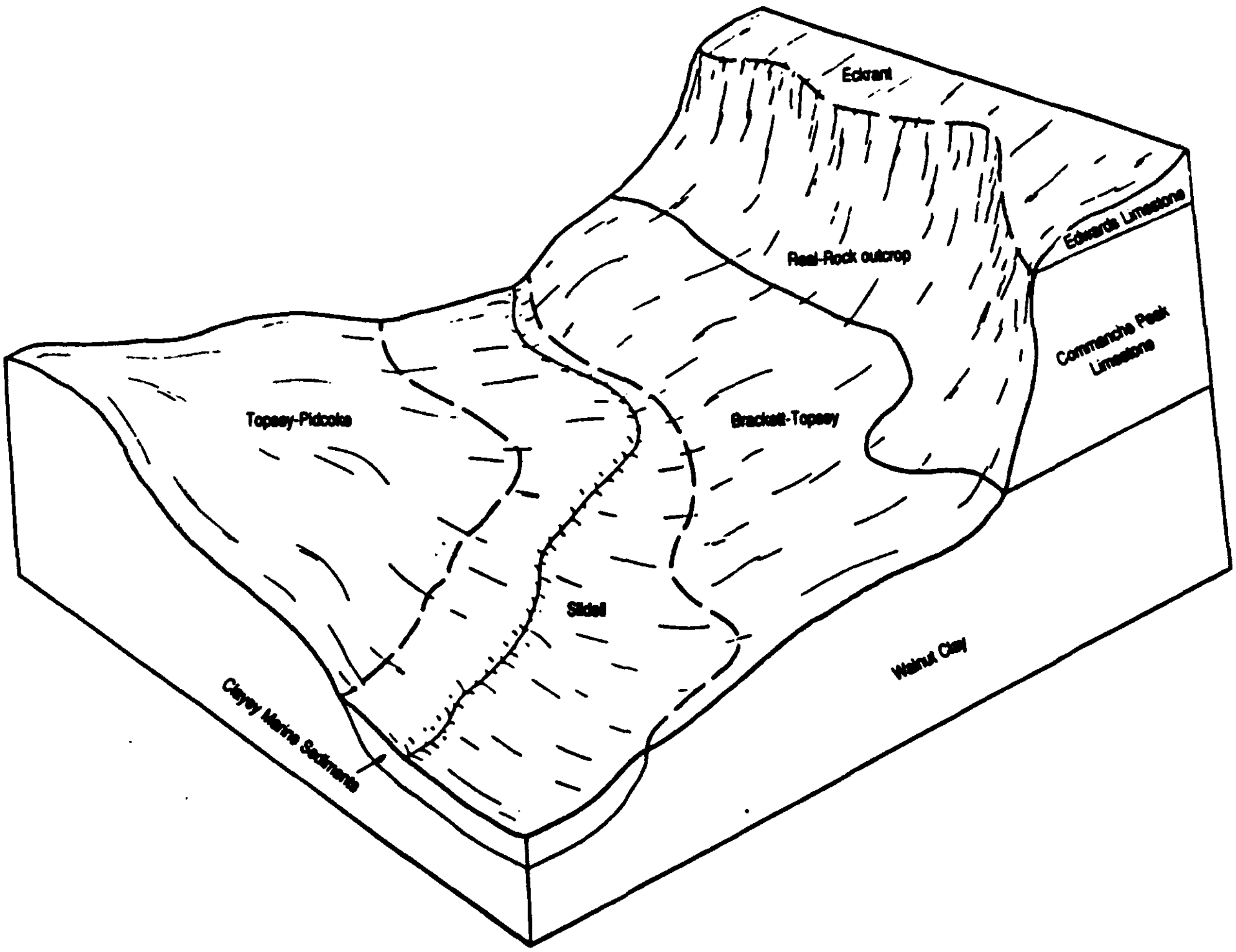
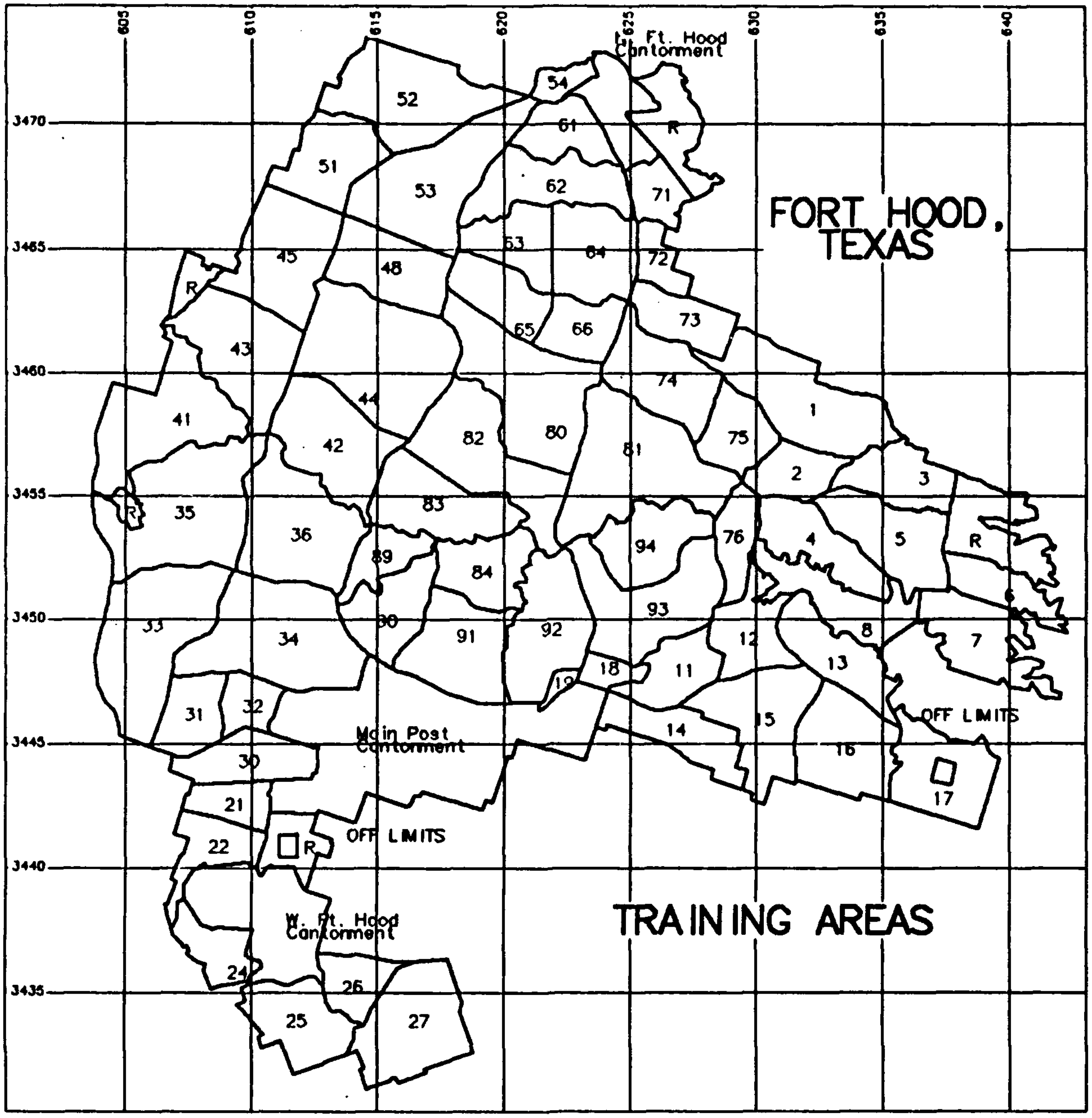


Figure 15. Potential Black-capped Vireo Habitat on Fort Hood Based on Reclassification of the Composite GRASS Model (grid: 5000 m).



(From McCaleb 1985)

Figure 16. Typical Pattern of Soils in the Eckrant-Real-Rock Outcrop Map Unit and the Slidell-Topsy-Brackett Map Unit.



SCALE: 1 : 199034

3474750.00

WINDOW: 600300.00 643000.00 (grid: 5000 meters)

3430250.00

trn_areas (PERMANENT)

Figure 17. Fort Hood Training Areas (grid: 5000 m).

Table 1

Number of Black-capped Vireos Observed or Estimated (e) at Fort Hood Colony Sites, and Approximate Colony Site Age

Colony Sites		Age (yrs)	1987 Male	1987 Female	1988 Male	1988 Female	1989 Male	1989 Female
Maneuver Training Area								
AR2T	Area 2-Top	4-11	6	6	9	7	15	12
AR2S	Area 2-Slope	6-7	4	4	3	3	4	4
AR 6	Area 6	28-29	14	11	11	10	3	3
AR12	Area 12	5			2e		2	2
REBL	Red Bluff	13-16			4	1	6	6
BHMT	Brookhaven Mountain	nd			1			
MAMT	Manning Mountain	5-11	10e	4e	7	6	10	9
WMSP	Williamson Mountain	nd	4e		3	3		
WMSP	Shell Point	nd	1e		3	3	2	2
NWFH	Northwest Fort Hood	nd	3e	1e	2e		3	1
WEFH	West Fort Hood	0-19	11e	2e	18	17	14	13
Subtotal			53	28	63	50	59	52
Live Fire Training Area								
AR75	Area 75	1-12	12e	1e	18	14	18	15
ROPT	Robinette Point	10	9e	2e	19	9	30	18
RAPT	Rambo Point	nd	1e				2	
BRCR	Brown's Creek	7-8	2e	1e	9	7	7	8
JAMT	Jack Mountain	9-22	6e	1e	15	12	11	10
NOLF	Ruth Cemetery	nd			1e	1e	4e	2e
NOLF	Dalton Mountain	nd			2e		1e	
NOLF	Henson Mountain	nd			2e			
LOMT	Lone Mountain	nd					3	
PKRA	Pilot Knob Range	nd	1		2	1	8	3
AR81	Area 81	nd	1		1			
Subtotal			32	5	69	44	84	56
Total			85	33	132	93	143	108

Table 2

Mean, Sample Size (N), and Standard Error (SE) of Black-capped Vireo Territory Size on Fort Hood by Year and Site

Colony Sites	1987[a]	1988	1989
Area 2 Top	3.36 (6/0.6135)a	5.05 (9/0.8757)ab	6.59 (11/0.6525)b
Area 2 Slope	2.72 (4/0.4141)	5.62 (4/1.0344)	4.85 (5/1.0405)
Area 6	2.79 (14/0.1846)a	3.58 (9/0.7034)a	7.04 (3/1.9865)b
Red Bluff			4.45 (6/0.3094)
Area 12			6.64 (2/0.7200)
Manning Mountain		3.61 (7/0.6353)a	6.91 (7/0.5303)b
Williamson Mountain		3.45 (3/0.9953)	
Shell Point		4.57 (3/0.8945)	5.54 (2/2.3000)
West Ford Hood		3.63 (12/0.3522)	3.86 (12/0.6024)
Area 75		2.31 (15/0.2782)	2.66 (13/0.1821)
Robinette Point		2.34 (11/0.1281)a	1.88 (23/0.1259)b
Brown's Creek		1.96 (6/0.3776)	3.18 (7/0.6174)
Jack Mountain		2.76 (15/0.3642)a	5.04 (11/0.4669)b
Pilot Knob Range			3.61 (5/0.5754)
Overall	2.92 (24/0.1956)a	3.26 (94/0.1836)a	4.08 (108/0.2207)b

[a] 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 3

Chisquare Goodness of Fit Analyses of the Relationship Between 1988 Black-capped Vireo-Occupied Area and Five Landscape Features on Fort Hood

Category	Observed	Expected	X²ᵃ	Weight
Geology				
1 Dense Limestone	53.41	19.05	61.974 ***	4
2 Sandy Limestone	0.00	17.45	17.450 ***	0
3 Chalky Limestone	0.00	0.46	0.460	1
4 Loose Limestone	39.17	15.25	37.519 ***	4
5 Chalky Shale	7.41	41.80	28.294 ***	1
6 Unconsolidated	0.00	5.98	5.980 *	0
Total	99.99	99.99	151.677 ***	
Soils				
1 Bastil	0.00	0.49	0.490	1
2 Bolar	0.00	0.17	0.170	1
3 Bosque	0.00	3.54	3.540 +	0
4 Brackett-Topsey	11.30	17.49	2.191	2
5 Cho	0.00	2.48	2.480	1
6 Cisco	0.00	0.71	0.710	1
7 Crawford	0.00	0.12	0.120	1
8 Denton	1.28	4.42	2.231	2
9 Doss-Real	1.09	15.23	13.128 ***	1
10 Eckrant	52.24	15.58	86.262 ***	4
11 Evant	8.57	6.01	1.090	2
12 Frio	0.00	0.58	0.580	1
13 Houston Black	0.00	0.03	0.030	1
14 Krum	0.60	4.27	3.154	2
15 Lewisville	0.00	1.95	1.950	1
16 Lindy	0.00	0.63	0.630	1
17 Minwells	0.00	0.31	0.310	1
18 Nuff	0.00	9.43	9.430 ***	0
19 Purves	0.00	0.21	0.210	1
20 Real-Rock	23.38	8.51	25.983 ***	4
21 Seawillow	0.00	0.48	0.480	1
22 Slidell	0.00	4.43	4.430 *	0
23 Topsey-Pidcoke	1.54	2.78	0.553	2
24 Wise	0.00	0.13	0.130	1
Total	100.00	99.98	160.282 ***	
Elevation				
1 180 to 216	0.00	1.22	1.220	1
2 217 to 235	1.19	8.16	5.954 *	1
3 236 to 253	10.19	15.60	1.876	2
4 254 to 271	9.45	21.91	7.086 *	1
5 272 to 290	30.22	27.72	0.225	2
6 291 to 308	12.85	16.16	0.678	2
7 309 to 375	36.10	9.23	78.223 ***	4
Total	100.00	100.00	95.262	

ᵃ +0.05<p≤0.10, *0.01<p≤0.05, **0.001<p≤0.01, ***p≤0.001

Table 3 (Cont'd)

Category	Observed	Expected	X^{2a}	Weight
Slope				
1 0 to 2%	11.13	19.61	3.667 +	2
2 2 to 5%	21.40	48.89	15.457 ***	1
3 5 to 10%	23.31	23.39	0.00	2
4 10 to 15%	24.51	5.98	57.418 ***	4
5 15 to 20%	17.65	1.85	134.941 ***	4
6 20 to 25%	2.01	0.25	12.390 ***	4
7 >25%	0.00	0.02	0.020	1
Total	100.01	99.99	223.894 ***	
Aspect				
1 North	12.75	11.45	0.148	2
2 Northeast	12.17	9.45	0.783	2
3 East	6.83	14.55	4.096 *	1
4 Southeast	3.30	8.95	3.567 +	2
5 South	7.32	13.32	2.703	2
6 Southwest	14.33	7.75	5.587 *	4
7 West	28.16	9.58	36.035 ***	4
8 Northwest	4.01	5.34	0.331	2
9 <2% Slope	11.13	19.61	3.667 +	2
Total	100.00	100.00	56.916 ***	

[a] $+0.05<p\leq0.10$, $*0.01<p\leq0.05$, $**0.001<p\leq0.01$, $***p\leq0.001$

Table 4

Chisquare Goodness of Fit Analyses of the Relationship Between the 3-year Composite of Black-capped Vireo Occupied Area and Five Landscape Features on Fort Hood

Category	Observed	Expected	X^{2a}	Weight
Geology				
1 Dense Limestone	58.33	19.05	80.993 ***	4
2 Sandy Limestone	0.00	17.45	17.450 ***	0
3 Chalky Limestone	0.00	0.46	0.460	1
4 Loose Limestone	35.87	15.25	27.881 ***	4
5 Chalky Shale	5.80	41.80	31.005 ***	1
6 Unconsolidated	0.00	5.98	5.980 *	0
Total	100.00	99.99	163.769 ***	
Soils				
1 Bastil	0.00	0.49	0.490	1
2 Bolar	0.00	0.17	0.170	1
3 Bosque	0.00	3.54	3.540 +	0
4 Brackett-Topsey	7.12	17.49	6.148 *	1
5 Cho	0.00	2.48	2.480	1
6 Cisco	0.00	0.71	0.710	1
7 Crawford	0.00	0.12	0.120	1
8 Denton	0.68	4.42	3.165 +	2
9 Doss-Real	0.90	15.23	13.483 ***	1
10 Eckrant	55.08	15.58	100.144 ***	4
11 Evant	7.62	6.01	0.431	2
12 Frio	0.00	0.58	0.580	1
13 Houston Black	0.00	0.03	0.030	1
14 Krum	1.51	4.27	1.784	2
15 Lewisville	0.00	1.95	1.950	1
16 Lindy	0.00	0.63	0.630	1
17 Minwells	0.00	0.31	0.310	1
18 Nuff	0.00	9.43	9.430 **	0
19 Purves	0.00	0.21	0.210	1
20 Real-Rock	26.25	8.51	36.981 ***	4
21 Seawillow	0.00	0.48	0.480	1
22 Slidell	0.00	4.43	4.430 *	0
23 Topsey-Pidcoke	0.83	2.78	1.368	2
24 Wise	0.00	0.13	0.130	1
Total	99.99	99.98	189.195 ***	
Elevation				
1 180 to 216	0.00	1.22	1.220	1
2 217 to 235	1.08	8.16	6.143 *	1
3 236 to 253	7.21	15.60	4.512 *	1
4 254 to 271	9.36	21.91	7.189 *	1
5 272 to 290	35.17	27.72	2.002	2
6 291 to 308	15.29	16.16	0.047	2
7 309 to 375	31.89	9.23	55.631 ***	4
Total	100.00	100.00	76.744 ***	

[a] +0.05<p≤0.10, *0.01<p≤0.05, **0.001<p≤0.01, ***p≤0.001

Table 4 (Cont'd)

Category	Observed	Expected	X^{2a}	Weight
Slope				
1 0 to 2%	11.30	19.61	3.521 +	2
2 2 to 5%	25.99	48.89	10.726 **	1
3 5 to 10%	23.50	23.39	0.001	2
4 10 to 15%	23.48	5.98	51.212 ***	4
5 15 to 20%	14.50	1.85	86.499 ***	4
6 20 to 25%	1.24	0.25	3.920 *	4
7 > 25%	0.00	0.02	0.020	1
Total	100.01	99.99	155.900 ***	
Aspect				
1 North	13.43	11.45	0.342	2
2 Northeast	11.57	9.45	0.476	2
3 East	7.24	14.55	3.673 +	2
4 Southeast	5.37	8.95	1.432	2
5 South	12.03	13.32	0.125	2
6 Southwest	11.79	7.75	2.106	2
7 West	21.50	9.58	14.832 ***	4
8 Northwest	5.77	5.34	0.035	2
9 < 2% Slope	11.30	19.61	3.521 +	2
Total	100.00	100.00	26.541 ***	

[a] +0.05<p≤0.10, *0.01<p≤0.05, **0.001<p≤0.01, ***p≤0.001

Table 5

Area (ha) and Percentage of Both Black-capped Vireo Occupied Area and Fort Hood in Each of the Potential Habitat Categories

Category	Habitat Potential	Vireo (ha)	%	Fort (ha)	%
0	None	0.00	0.00	29269	33.30
1	Very Low	0.00	0.00	0	0.00
2	Very Low	0.12	0.02	4447	5.06
3	Very Low	2.12	0.32	9976	11.35
4	Very Low	3.64	0.55	8995	10.23
5	Very Low	7.96	1.20	8141	9.26
6	Moderate	59.68	9.01	7676	8.73
7	Very High	163.00	24.62	7889	8.98
8	Very High	157.96	23.86	7218	8.21
9	Very High	151.40	22.86	3362	3.82
10	Very High	98.36	14.85	790	0.90
11	Very High	17.92	2.71	135	0.15
	None	0.00	0.00	29269	33.30
	Very Low	13.84	2.09	31559	35.90
	Moderate	59.68	9.01	7676	8.73
	Very High	588.64	88.90	19394	22.07
	Total	662.16	100.00	87898	100.00

Table 6

Percentage of Potential Black-capped Vireo Habitat and Vireo Occupied Area by Training Area Intensity

Training Intensity	Habitat Potential: Very Low	Habitat Potential: Moderate	Habitat Potential: Very High	Composite Vireo Occupied	Total
Training Areas:					
Category 1	19.37	29.72	16.62	25.33	15.61
Category 2	12.14	14.73	14.40	3.06	14.26
Category 3	9.04	17.01	15.10	26.57	19.35
Category 4	6.49	14.16	21.35	4.75	8.83
Category 5	1.64	5.06	1.09		2.20
Category 6	1.62	0.84	0.44		1.04
Live Fire Training Area	30.16	13.98	25.76	38.46	27.80
Cantonment & Other Low Training Use	19.54	4.50	5.24	1.83	10.91
Total Percent	100.00	100.00	100.00	100.00	100.00
Total Hectares	31559	7676	19394	662	87890

Table 7

Hypothetical Colony Site Age Structure by 5-Year Interval on a 25-Year Burn Cycle

Site	Year[a] 0	5	10	15	20	25
1	0	5	10	15	20	0
2	0	0	5	10	15	20
3	0	5	0	5	10	15
4	0	5	10	0	5	10
5	0	5	10	15	0	5

[a]0 indicates the year to burn the site.

APPENDIX B: Plant Community Code Descriptions

BARR	Barren; <10 percent 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 percent cover
Open:	25 to 50 percent cover
Dense:	51 to 75 percent cover
Closed:	76 to 100 percent cover

DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CERD-L

US Air Force Command
ATTN: Envr/Natural Res Ofc
Andrews AFB 20031
Wright-Patterson AFB 45433
Randolf AFB 78150
Maxwell AFB 36112
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