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Land Condition Trend Analysis Data Summaries

Preliminary Data Applications

by

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The Army's Land Condition Trend Analysis (LCTA) program is the standard for land inventory and monitoring, using standard methods of natural resources data collection, analyses, and reporting designed to meet multiple goals and objectives. This report presents a general overview of LCTA data applications and documentation capabilities for use in natural resource management plans and other environmental compliance documents. Specifically, this report focuses on preliminary summarization of univariate vegetation and wildlife data collected on LCTA core plots. Analyses presented are intended to provide Army land managers a greater degree of flexibility with respect to characterizing the condition of the installation's natural resources, but by no means represents an exhaustive treatment of analysis options. Necessary considerations required to properly interpret each summary are identified in addition to the mathematical calculations behind each analysis.

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Foreword

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The work was performed by the Natural Resource Assessment and Managment Division (LL-N) of the Land Management Laboratory (LL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Dr. David L. Price. Dr. David J. Tazik is Acting Chief, CECER-LL-N; Dr. William D. Severinghaus is Operations Chief, CECER-LL; and William D. Goran is Chief, CECER-LL. The USACERL technical editor was Gloria J. Wienke, Technical Resources Center.

COL James T. Scott is Commander and Acting Director, and Dr. Michael J. O'Connor is Technical Director of USACERL.

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1 Introduction

Background

Inventory and monitoring of land resources is an important fundamental issue in thorough natural resources management. The U.S. Army Land Condition Trend Analysis (LCTA) program was developed at the U.S. Army Construction Engineering Research Laboratories (USACERL) under the sponsorship of the U.S. Army Engineering and Housing Support Center (USAEHSC)* as a means to inventory and monitor natural resources on military installations. LCTA uses standard methods to collect, analyze, and report natural resources data (Diersing, Shaw, and Tazik 1992), and is the Army's standard for land inventory and monitoring (Technical Note 420-74-3 1990). Over 50 military installations and training areas in the United States and Germany have begun or plan to implement LCTA.

The LCTA program was designed to meet the need for natural resources management and land stewardship on military installations (Tazik et al 1992). The LCTA program uses standard methods of natural resources data collection, analysis, and reporting that are designed to meet multiple goals and objectives. LCTA uses information on topographic features, soil characteristics, climatic variables, vegetation, and wildlife resources to characterize an installation's natural resources in a cost- and time-effective manner. The information assists installation managers with making decisions on best use of land, scheduling of military activities, protection of threatened and endangered species, and long-term environmental planning. The information also provides officials at all levels with standard natural resources inventory information for installations across the continental United States and overseas. Specific objectives of LCTA are to: (1) characterize installation natural resources, (2) implement standards for collection, analysis, and reporting of acquired data that enable compilation and reporting 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 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.

* The USAEHSC is now known as the U.S. Army Center for Public Works (CECPW).

Objective

The objective of this research is to describe standard LCTA statistical data analysis procedures and reporting formats that meet the needs of individual installations and the Department of the Army (DA). The data summaries are intended to help in the exploration of LCTA data sets and to highlight patterns in the biotic communities of the installation. Due to the nature of any long-term surveys, LCTA data can be difficult to summarize. LCTA data sets may contain missing data, a mixture of quantitative and qualitative variables, sampling error, sampling variation, observer bias, and other problems that make data difficult to analyze and interpret. It is the intent of this report to describe summaries that are appropriate for analyzing and interpreting LCTA data and to describe how to handle aspects of the data that make analysis confusing and difficult.

Approach

A literature survey was conducted to identify analysis techniques useful for interpreting LCTA data. Information obtained from the survey was then used to analyze and summarize an example installation LCTA database. The importance, limits, and interpretation of each data summary are explained in reference to the literature reviewed. This report emphasizes simple univariate descriptive data summaries. These types of summaries are useful for preliminary analysis of LCTA data that characterizes installation natural resources and documents trends in those resources.

Scope

This report includes summaries developed using data collected by using the documented LCTA data collection techniques or data provided as a part of standard LCTA databases. This report is not intended to be an exhaustive listing of LCTA data summaries. Rather, a partial list of potentially useful simple univariate descriptive data summaries is provided to help installation personnel characterize and monitor changes in their installations' natural resources. This report provides summaries of single installation databases and does not attempt to provide cross-installation data summaries. This report provides only summaries of LCTA core plot data; however, the summaries may be useful when analyzing LCTA special use plots, depending upon the specific objectives for the use of the plots.

Mode of Technology Transfer

It is intended that installation LCTA coordinators incorporate these data summary methods and procedures into LCTA annual installation reports. This report will also assist LCTA coordinators in developing new installation-specific data summaries that meet local needs by identifying and discussing data summary considerations and limits of the LCTA field methods. Data summaries presented in this document can be applied to training land carrying capacity models, integrated natural resource management plans, and National Environmental Policy Act (NEPA) documents required for military installations. Data summaries presented in this document are intended to be incorporated into and automated by future versions of the LCTA computer system.

2 LCTA Study Design, Issues, and Implications

The LCTA program is a general land inventory and monitoring scheme for the Army's natural resources that is based on standard field techniques (Tazik et al 1992). The objective of LCTA is to evaluate the status and trend of training land resources relative to current and planned use so well-informed decisionmakers can help to ensure long-term sustainability of the land and mission. In the first year of use, LCTA is a survey that provides an inventory of the installation. LCTA becomes a monitoring system as the plots are remeasured each year.

A survey is a one-time static inventory. Monitoring consists of surveys that are repeated over time, producing a baseline of information and measures of how something is changing. Monitoring only indicates what is happening, not why the changes are occurring. By correlating the observed patterns with possible cause factors, the most probable causes of the observed patterns can be inferred. Only through rigorous experimentation incorporating proper controls can the causes of the patterns be determined with a reasonable degree of certainty.

Green (1979) generally divided environmental studies into five categories (Table 1). If an impact has not yet occurred, before-impact baseline data can be collected. If the location and time of a predicted impact is known, a control in time exists. If a spatial control can also be obtained, then a type 1 study exists. Type 1 studies can determine cause and effect relationships. If spatial control is missing, the effects of the impact can only be inferred from observed changes over time. In a type 2 study, which lacks spatial controls, it is necessary to assume that the observed changes are associated with the impact. A type 3 study is appropriate when impacts have not yet occurred and the type, time, and location of impacts is unknown. A type 4 study is suitable when the impact has already occurred and the type, time, and location of the impacts are known. A type 5 study is appropriate when the impact has already occurred, but the type, location, and time of the impacts is unknown.

LCTA monitoring system guidelines generally fall into the type 3 study. Most installations lack the proper spatial controls required for a type 1 study because of the inability to control or predict the location and types of impacts. Most installations do not know where and when the impacts will occur that characterize type 2 and 4

Table 1. Classification of environmental study designs.

Has the impact already occurred?	No			Yes	
Is impact where and when known?	Yes		No	Yes	No
Is there a control area?	Yes	No			
Sample type category	1	2	3	4	5
Description	permits an optimal impact study design	impact inferred from temporal change	baseline or monitoring	impact inferred from spatial pattern	when and where is the question

Table modified from *Sampling Design and Statistical Methods for Environmental Biologists* by Roger H. Green, copyright 1979 by John Wiley & Sons, Inc., New York. Reprinted by permission of John Wiley & Sons, Inc.

studies. The objectives of LCTA are to assess condition and then detect and monitor future impacts rather than assess historic impacts as in a type 5 study.

In all but the type 1 study, the sampling and statistical analysis design are suboptimal. However, due to the constraints imposed by the objectives of LCTA, the nature of military impacts, and other factors, type 1 studies are impractical. As a consequence, LCTA data cannot be used to make strong inferences about specific cause and effect relationships using sophisticated statistical analyses because of the lack of controls imposed by the nature of the impacts. LCTA data can be used to document the present condition and trend of soils, vegetation, and wildlife with relatively simple descriptive statistics. Correlation, regression, principal component, and other analyses can be used to make inferences about the effect of the Army's current management practices on soils, vegetation, and wildlife over time. Supplemental, controlled type 1 studies can then be used to test, verify, and quantify suspected cause and effect relationships.

Baseline data as provided by LCTA methods is required for any monitoring program where impacts are detected as departures from the unimpacted state. The magnitude, duration, and complexity in trends and fluctuations of the data, as well as the magnitude and complexity of the impacts, determine the amount of baseline data required. For LCTA or any other monitoring system to be effective, a sufficient amount of baseline data must be accumulated. However without this sufficient baseline data, LCTA data still serves to characterize an installation and detect impacts that exceed annual fluctuations, and begins to define annual fluctuations until a sufficient baseline of data is accumulated.

LCTA surveys involve two types of plots: core and special use. Core plots are used to evaluate the condition of natural resources on the installation and serve as a basis for the national inventory, including Major Command (MACOM) and DA summaries. Core plots are located in an objective, stratified random manner to ensure that the data are representative of the installation as a whole (Warren et al 1990). Core plots provide the type 3 baseline monitoring study design needs of LCTA. Special use plots are used for installation-specific issues that are not sufficiently covered by the core plots. Special use plots are located in any manner deemed appropriate by the installation for their objectives. If special use plots incorporate proper temporal and spacial controls, these studies can identify cause and effect relationships. Special use plot studies supplement the baseline monitoring information provided by LCTA, and can potentially elucidate cause and effect relationships in a cost effective manner.

3 Fort Hood Site Description

Fort Hood, TX, data was used in this report to illustrate potential LCTA data summaries because Fort Hood was one of the first installations to implement LCTA. As a result, 4 years of data were available for use including initial, long-term, and monitoring surveys. Fort Hood surveys consisted of both core and special use plots. In addition, the authors were familiar with the area, the LCTA data sets, and were directly involved in the collection of both the wildlife and vegetation data.

Fort Hood occupies an 87,890-hectare (ha) area (U.S. Department of the Army 1987) in central Texas in Bell and Coryell Counties. The installation Master Plan Report (Nakata Planning Group 1987), which contains detailed information on the Fort Hood environment, is summarized in the following paragraphs.

Fort Hood's climate is characterized by long, hot summers and short, mild winters. Average temperatures range from a low of about 8 °C in January to a high of 29 °C in July. Average annual precipitation is 81 cm.

Elevation at Fort Hood ranges from 180 to 375 m above sea level with 90 percent below 260 m. Most slopes are in the 2 to 5 percent range with slopes in excess of 45 percent occurring as bluffs along the flood plain and as the sides of slopes of the mesa-hills. Soil cover is generally shallow to moderately deep and clayey, underlain by limestone bedrock.

Fort Hood lies in the Cross Timbers and Prairies vegetation area (Gould 1975). The area is normally composed of oak woodlands with grass undergrowth. Traditionally the predominant woody vegetation consisted of ashe juniper (*Juniperus ashei*), live oak (*Quercus fusiformis*) and Texas oak (*Quercus texana*). Under climax conditions the predominant grasses consisted of little bluestem (*Schizachyrium scoparium*) and indian grass (*Sorghastrum nutans*).

No Federally endangered plant species are known to occur on the installation. Four Federally endangered wildlife species and several state listed species have been observed on Fort Hood (Diersing, Severinghaus, and Novak 1985; Tazik, Cornelius, and Abrahamson 1993). The bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), and osprey (*Pandion haliaetus*) are occasionally seen on the installation for portions of the year. The golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo articapillus*) nest on the installation.

The primary mission of Fort Hood is the training, housing, and support of the III Corps and its two divisions (1st Calvary Division and 2nd Armored Division). Support is also provided to other assigned and tenant organizations, the U.S. Army Reserve, the National Guard, the Reserve Officer Training Corps, and the reservists from other services.

Of the 22,700 ha live-fire and impact areas, 8,700 ha are multi-purpose maneuver live-fire areas. The range areas serve as familiarization and qualification firing ranges for all individual weapons, crew-served weapons, and the major weapons systems of active units assigned or attached to the III Corps and Fort Hood. Maneuver areas comprise 52,400 ha (not including the multi-purpose live-fire area). Maneuver areas are used for armored and mechanized infantry forces in the conduct of task force and battalion-level operations, and for company and platoon level dismounted training, along with engineer, amphibious, combat support, and combat services support training.

Approximately 69,500 ha of Fort Hood are outleased for cattle grazing. Present stocking rates range from 19 ha per animal unit year on the more intensively used training areas to 14 ha per animal unit year on the less intensively used training areas.

4 Vegetation Data Summaries

LCTA vegetation surveys consist of three main components; line transect aerial cover surveys, line transect ground cover surveys, and belt transect surveys. The line transect aerial cover survey characterizes canopy cover species composition and distribution. The line transect ground cover survey characterizes ground cover composition and distribution and surface disturbance. Data from the line transect surveys are recorded using a modified point intercept method. The point intercept method has been shown to be more efficient than other sampling methods and is applicable to a wide range of habitat types (Heady, Gibbens, and Powell 1959). The belt transect characterizes species composition, density, and height distribution of woody and succulent vegetation.

Although the three sampling components involve measuring similar parameters, there are several important differences. With the line transect aerial and ground surveys, all vegetation is measured; on the belt transect survey, only woody and succulent vegetation is measured. Line transect ground cover surveys involve recording only vegetation at ground level; aerial cover surveys involve recording vegetation at any height. Only the belt transect survey characterizes the frequency of individual woody plants since the line transect survey is based on a modified point intercept method. Only on the belt transect survey is mortality recorded. Only the ground survey records ground cover and disturbance data.

To document changes in vegetation over time, the LCTA plots usually are remeasured annually. LCTA vegetation surveys have two options: initial/long-term surveys and short-term monitoring surveys. Short-term monitoring surveys are scaled-down versions of the initial/long-term surveys that minimize staffing demands while allowing the gathering of sufficient information to detect annual changes in vegetation. Generally initial/long-term surveys are conducted every 3 to 5 years with short-term monitoring surveys conducted in the interim years. Because of the more limited sampling conducted during short-term monitoring surveys, some data summaries can only use initial/long-term survey data. Short-term monitoring surveys do not identify plant cover at the species level and only record the presence or absence of data at each transect location.

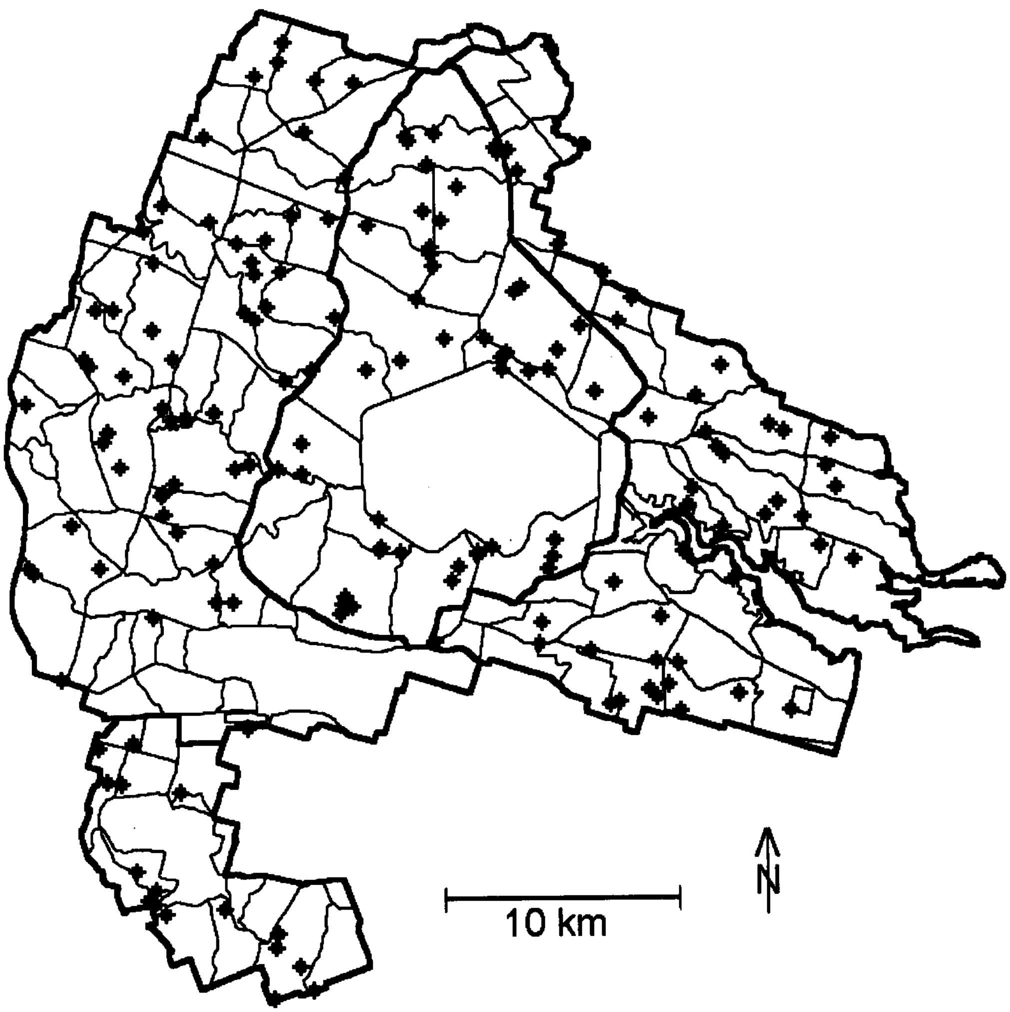
Core plots located in east, central, west, and south Fort Hood were grouped together by region and analyzed separately based on substantial differences in military training activities, general vegetation types, and topography (Figure 1). The intent was to isolate patterns of general land use combined with general topography and vegetation type while maintaining sample sizes that were statistically sound. The intent was not to make comparisons among the different regions. Installation summaries consisted of the plots used in each regional group. Although predominant land use, vegetation types, and topography were used as an example to group Fort Hood LCTA data in this report, other grouping criteria can be used. The sampling design and plot allocation method were not intended for use in a controlled experiment with a specific treatment design.

East Fort Hood is dominated by oak-juniper woodlands, on high mesa-like hills with geologic cuts and slopes up to 45 percent. West and south Fort Hood is a savannah type and dominated by mid-grasses, little bluestem, tall dropseed, and Texas wintergrass with scattered motts of live oak on rolling topography, and oak-juniper on hills and steep slopes along the major drainages. Central Fort Hood has a mixture of the savannah type on rolling topography and oak-juniper woodlands on mesa tops and along steep slopes of drainages (Nataka Planning Group, Inc. 1987).

Central Fort Hood contains a 22,700 ha live-fire and artillery impact area and an additional 8,700 ha multi-purpose maneuver live-fire range on the north end. West and south Fort Hood are used primarily for tracked and wheeled maneuver exercises at the Battalion level on west Fort Hood and at the smaller Platoon level on south Fort Hood. East Fort Hood is used primarily for small unit exercises, bivouac, and foot soldier training because the terrain and dominant oak-juniper woodlands prevent large cross country exercises.

Historically, 69,050 ha of Fort Hood have been leased to a local livestock association for grazing. The installation is open to free-range grazing except for the cantonment areas and along Highway 190 that divides the west and south portions of Fort Hood (Nakata Planning Group, Inc 1987). The lease for the south portion of Fort Hood has not been renewed since 1992 in an effort to reduce the number of cow birds. Cowbirds are nest parasites and have a negative effect on two Federally endangered song-bird species: the golden-cheeked warbler and the black-capped vireo.

Discussions for each of the following vegetation summaries emphasize the utility of each data summary for characterizing installation vegetation and documenting changes over time. These and similar summaries may also be useful summaries of the data for ground-truthing remotely sensed data (Bouman and Shapiro 1994; Ribanszky DRAFT; Wu and Westervelt 1994).



Thick lines delineate habitat/management regions. Thin lines delineate training areas.

Figure 1. LCTA vegetation plots, Fort Hood, TX.

The tabular display format used for each of the vegetation summaries was used to emphasize the detailed information that can be derived from LCTA data. Several of the summaries and similar summaries could also be displayed as maps that emphasize the information in geographic context (Warren and Bagley 1992).

Line Transect Aerial Cover Summaries

A standard LCTA plot is a 100-m by 6-m quadrant with a 100-m line transect forming the central, longitudinal axis of the LCTA plot (Tazik et al. 1992). The central axis or line transect is used to quantify aerial vegetation cover. One hundred points are sampled along the line transect beginning at the 0.5-m point and continuing at 1-m intervals to the 99.5-m point. Using a measuring tape as a guide, a measuring rod is positioned vertically over each point. At each point, canopy cover is recorded for each height increment.

Only initial/long-term survey data were used in the line transect aerial cover summaries presented in this section. The field procedures used in short-term monitoring yield much the same information as those in initial/long-term monitoring, but in lesser detail, particularly with regard to species composition. Since most of the summaries in this section make use of species composition, only 1989 and 1992 Fort Hood data were used. Where monitoring data could be used in a summary, it is noted in the discussion section of the data application.

Only core plot data were used in these summaries because the results are intended to be extrapolated to the habitat/management and installation level. In addition, only plots that were measured in both years were included in the summaries. Several plots were not measured in both years due to access difficulties. Including and excluding these plots in the summaries indicated these plots had a significant impact on several of the summaries. Plots that were not surveyed in all years did not appear to be a random occurrence. Certain plots were more likely to be excluded from sampling because of their location and the land use associated with those plots. The plots under evaluation were located in a buffer area surrounding an impact area. The plots that were not inventoried each year were located nearest the impact area and, as a result, were burned more frequently. The vegetation on these more frequently burned plots was considerably different than the rest of the plots in the buffer area. To avoid introducing a bias into the analyses, these plots were not included in the summaries. For this and several other statistical reasons, only plots measured both years were included in the summaries contained in this report. With any long-term monitoring program such as LCTA, missing data points is a common problem. Choosing to exclude data for which there are not observations for every year may eventually result in an insufficient number of plots to analyze. However the impact of missing observations and the cause of the missing observations should be evaluated to understand their effect on the summary results.

Four statistics were computed when summarizing the line transect aerial cover data; number of plots with occurrence, presence/absence intercepts, total intercepts, and number of species present. Number of plots with occurrence is the number of plots on which the vegetation class occurred. Presence/absence intercepts is the percentage of transect locations that had one or more intercepts for the vegetation class. Total intercepts is the total number of intercepts for all transect locations and heights for the vegetation class. Number of species present is a tally of the number of distinct species measured on all plots within the area. Number of plots is a measure of the distribution of the vegetation class across the site being characterized. Presence/absence measures are used to indicate the horizontal distribution or coverage of the vegetation class along the length of the transect. Total intercepts is a measure of the abundance of the vegetation class. Number of species or species richness is an simple indicator of vegetative complexity and one aspect of diversity.

None of the four statistics is a direct measure of the number of individual plants found on a plot. A single plant with a large canopy could potentially be measured more than once on successive or nonsuccessive transect points. Intercepts are interpreted as an index of frequency of vegetation rather than the absolute frequency of individual plants.

Presence/absence and total intercepts could have been calculated in two different ways. The average values could represent an average of all plots in the grouping or the average value could represent the average of only those plots where the vegetation type occurred. Neither measure is correct nor incorrect. The two measures have slightly different interpretations. When calculated to include all plots in the grouping, the value represents an average for the whole area. When calculated to include only plots where the vegetation type occurred, the value represents the average amount of vegetation where the vegetation occurs. When one of these values is combined in a table with the percent of plots where the vegetation class was found, the other value can be calculated directly from the table. The choice of measure for inclusion in a summary depends on the objectives of your report and the type of plot groupings used. When each plot grouping includes only one general habitat type that is expected to be fairly uniform, presenting averages based on all plots in the area may be more meaningful. When each plot grouping includes a wide range of habitat types as in an installation summary, presenting averages based only on plots where the vegetation type occurred may be more meaningful. Presence/absence and total intercept averages presented in this report are averages based on all plots in the plot grouping.

Diversity and richness indices have been popular among ecologists for years. Species richness is the number of species in the community. A number of species richness indicies have historically been used. Many of these indices make assumptions that are often not met by the data or sampling methodologies. Assumptions often not met include indicies being independent of sample size and that a functional relationship between sample size and the number of species in the community exists and is constant. An alternative to species richness indices is to use the direct count of species number in samples of equal size (Ludwig and Reynolds 1988). Since the number of LCTA plots measured generally is the same every year, the requirement of equal sample sizes is frequently met. In addition, if the objective of summarizing the data is to detect trends over time within the same sampling area rather than estimating the absolute number of individuals in the community, then the assumption of the relationship between the number of species observed and the total number of species in the community is more likely to be a constant function. However, differences in field crews or time of field sampling from year to year could potentially affect the use of number of species as a richness index.

Annotated Species Installation Checklist

Table 2 contains an annotated species checklist of plants used in the line transect summaries discussed in this report. The annotated species checklist identifies all species codes used in the report and contains descriptive information about each species. If a complete annotated species checklist is to be provided, use all plots.

Genus and species are taxonomic descriptions, growth form is a structural description, life-span denotes length of life, and historic origin refers to whether or not the species is native to the United States. Vegetation codes used in the LCTA database and this report are from the National List of Scientific Plant Names (USDA 1982).

If only species specifically listed in the rest of the report are included, the table is simply a reference table for the report. However, if a complete species list is provided, the table can be compared with the LCTA herbarium list (see Tazik et al. 1992) to determine what percentage of total species that exist at the installation were recorded during LCTA vegetation surveys. Since only habitats 5 acres or larger are eligible to receive LCTA core plots and many species are relatively rare, the species checklist from LCTA core plot surveys is likely to be considerably less than the LCTA herbarium survey checklist. Identifying which species are not being sampled by LCTA core plots may help identify habitats that need additional monitoring with special use plots or other survey methods.

Table 2. Annotated plant species checklist for Fort Hood, TX, line transect summaries.

VegID	Genus	Species	Growth Form	Life-Span	Historic Origin
AMDR	Amphiachyris	dracunculoides	Forb	Annual	Native
ARPU9	Aristida	purpurea	Grass	Perennial	Native
BOBA2	Bouteloua	barbata	Grass	Annual	Native
BOCU	Bouteloua	curtipendula	Grass	Perennial	Native
BOIS	Bothriochloa	ischaemum	Grass	Perennial	Introduced
BORI	Bouteloua	rigidiseta	Grass	Perennial	Native
BOSA	Bothriochloa	saccharoides	Grass	Perennial	Native
BRJA	Bromus	japonicus	Grass	Annual	Introduced
BUDA	Buchloe	dactyloides	Grass	Perennial	Native
FRTE	Fraxinus	texensis	Tree	Perennial	Native
IVAN	Iva	angustifolia	Forb	Annual	Native
JUAS	Juniperus	ashei	Tree	Perennial	Native
QUSHT	Quercus	shumardii	Tree	Perennial	Native
QUSIB	Quercus	sinuata	Tree	Perennial	Native
QUST	Quercus	stellata	Tree	Perennial	Native
QUVIF	Quercus	virginiana	Shrub	Perennial	Native
SCSC	Schizachyrium	scoparium	Grass	Perennial	Native
SPAS	Sporobolus	asper	Grass	Perennial	Native
STLE5	Stipa	leucotricha	Grass	Perennial	Native

Vegetation Summarized by Structural Growth Form

This summary characterizes installation vegetation by structural growth form and documents changes in the distribution, abundance, and species richness over time by structural growth form class. Summarizing the data by growth form is important because different growth forms are likely to respond differently to environmental fluctuations and military impacts, and are preferentially used by different types of wildlife.

This data summary uses only core plot and initial/long-term survey data. All species data were included in the summary. Data associated with unknown species were used to calculate vegetation total statistics but were not used to calculate the individual vegetation form grouping statistics because structural growth form types could not be determined for unknown vegetation codes. Unknown species data were not used to calculate any species counts. Unknown data were assumed to be valid vegetation data observations that could not be properly identified or had erroneous vegetation codes that could not be corrected.

The number of species is calculated as the total number of valid vegetation codes for all plots in the specified category. Means and standard errors were calculated using individual plot presence/absence and total intercept totals for each category. Structural growth form classes for individuals species were obtained from the *National List of Scientific Plant Names* (USDA 1982).

Table 3 summarizes trends in total vegetation by structural growth form. If a change in total vegetation is evident from the data, vegetation form class summaries can be used to identify which components accounted for most of the change. If no change in total vegetation is evident, vegetation form classes can be examined to determine if there was a shift in vegetation cover between structural form classes (Figure 2). (The figures are presented in various formats to show some of the different ways to visually emphasize distinct data.) Changes in total vegetation cover or in the proportion of individual growth form classes over time may be the result of military impacts, natural plant succession, or other factors.

Table 3. Line transect aerial vegetation cover for Fort Hood, TX, summarized by structural growth form.

Region*	Year	Growth Form	Plots	Presence/Absence		Total Hits		Species
			%	M**	SE***	M	SE	#
Central	1989	Total	100	81.2	2.84	231.1	19.66	137
		Forb	92	16.2	2.00	20.8	2.78	65
		Grass	100	56.2	4.59	102.2	10.02	35
		Half Shrub	36	0.9	0.24	1.1	0.33	4
		Shrub	40	5.9	1.81	17.6	5.55	11
		Tree	57	19.5	4.42	88.9	20.86	18
		Woody Vine	19	0.3	0.09	0.4	0.19	4
	1992	Total	100	77.2	2.83	197.1	16.51	122
		Forb	87	18.2	2.21	26.9	4.00	60
		Grass	94	47.3	4.17	83.2	7.98	30
		Half Shrub	15	0.1	0.05	0.2	0.06	2
		Shrub	34	5.6	1.75	15.2	5.04	10
		Tree	55	18.4	4.18	65.5	16.37	17
		Woody Vine	15	0.3	0.13	0.6	0.33	3
East	1989	Total	100	86.9	1.54	338.5	23.22	169
		Forb	100	11.2	1.58	15.6	2.32	62
		Grass	98	43.0	4.81	78.0	10.92	45
		Half Shrub	32	1.8	0.64	3.2	1.12	6
		Shrub	75	17.6	3.01	59.0	11.07	18
		Tree	80	37.7	4.82	176.8	23.58	32
		Woody Vine	52	3.2	0.68	5.8	1.35	6
	1992	Total	100	75.6	3.75	258.9	21.60	126
		Forb	89	11.0	1.71	16.2	3.77	47
		Grass	93	28.0	4.12	45.8	7.31	31
		Half Shrub	9	0.2	12.00	0.3	0.19	3
		Shrub	68	17.3	2.91	49.1	8.90	14
		Tree	82	36.1	4.72	131.6	18.87	26
		Woody Vine	50	3.0	0.86	5.8	1.96	5

Region*	Year	Growth Form	Plots %	Presence/Absence M**	Presence/Absence SE***	Total Hits M	Total Hits SE	Species #
South	1989	Total	100	82.7	2.93	229.0	23.12	117
		Forb	100	19.4	2.76	26.4	4.63	59
		Grass	100	66.0	4.98	130.1	16.53	37
		Half Shrub	38	1.0	0.48	1.1	0.51	3
		Shrub	69	6.8	2.89	18.5	8.86	7
		Tree	69	9.6	3.41	52.0	20.81	9
		Woody Vine	25	0.6	0.29	0.9	0.54	2
	1992	Total	100	76.5	3.85	186.3	16.22	86
		Forb	100	15.4	2.86	20.3	4.66	40
		Grass	100	55.5	6.45	99.4	14.50	26
		Half Shrub	25	0.5	0.22	0.6	0.26	2
		Shrub	63	6.3	2.48	15.9	7.17	9
		Tree	88	11.4	3.51	42.9	12.92	6
		Woody Vine	19	0.4	0.27	0.6	0.32	1
West	1989	Total	100	74.6	2.59	192.8	16.56	169
		Forb	98	15.6	1.30	21.1	2.10	76
		Grass	100	53.7	3.25	89.4	7.10	41
		Half Shrub	20	0.3	0.08	0.4	0.14	3
		Shrub	57	8.1	1.56	25.5	5.04	15
		Tree	59	12.3	2.83	53.3	13.56	27
		Woody Vine	27	1.7	0.55	3.2	1.05	7
	1992	Total	100	73.8	2.61	183.8	12.50	151
		Forb	98	21.7	1.86	31.4	3.01	60
		Grass	100	37.7	3.00	62.2	6.09	44
		Half Shrub	13	0.2	0.08	0.3	0.11	3
		Shrub	55	8.4	1.64	24.2	5.15	15
		Tree	59	13.9	2.89	47.9	9.41	25
		Woody Vine	23	1.1	0.40	2.0	0.78	4
Combined	1989	Total	100	80.6	1.35	246.7	11.31	265
		Forb	97	15.0	0.90	20.0	1.34	126
		Grass	99	52.7	2.26	94.0	5.15	63
		Half Shrub	29	0.9	0.20	1.4	0.33	6
		Shrub	58	9.9	1.19	31.6	4.09	24
		Tree	65	21.3	2.25	96.8	10.81	37
		Woody Vine	31	1.6	0.28	2.9	0.54	9
	1992	Total	100	75.6	1.61	208.1	9.08	211
		Forb	93	17.2	1.09	25.5	1.94	95
		Grass	96	39.6	2.13	67.5	4.15	55
		Half Shrub	14	0.2	0.05	0.3	0.07	4
		Shrub	53	9.8	1.17	27.5	3.53	19
		Tree	67	21.0	2.16	75.5	8.18	32
		Woody Vine	28	1.3	0.28	2.5	0.62	6

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.
**M = Mean
***SE = Standard Error

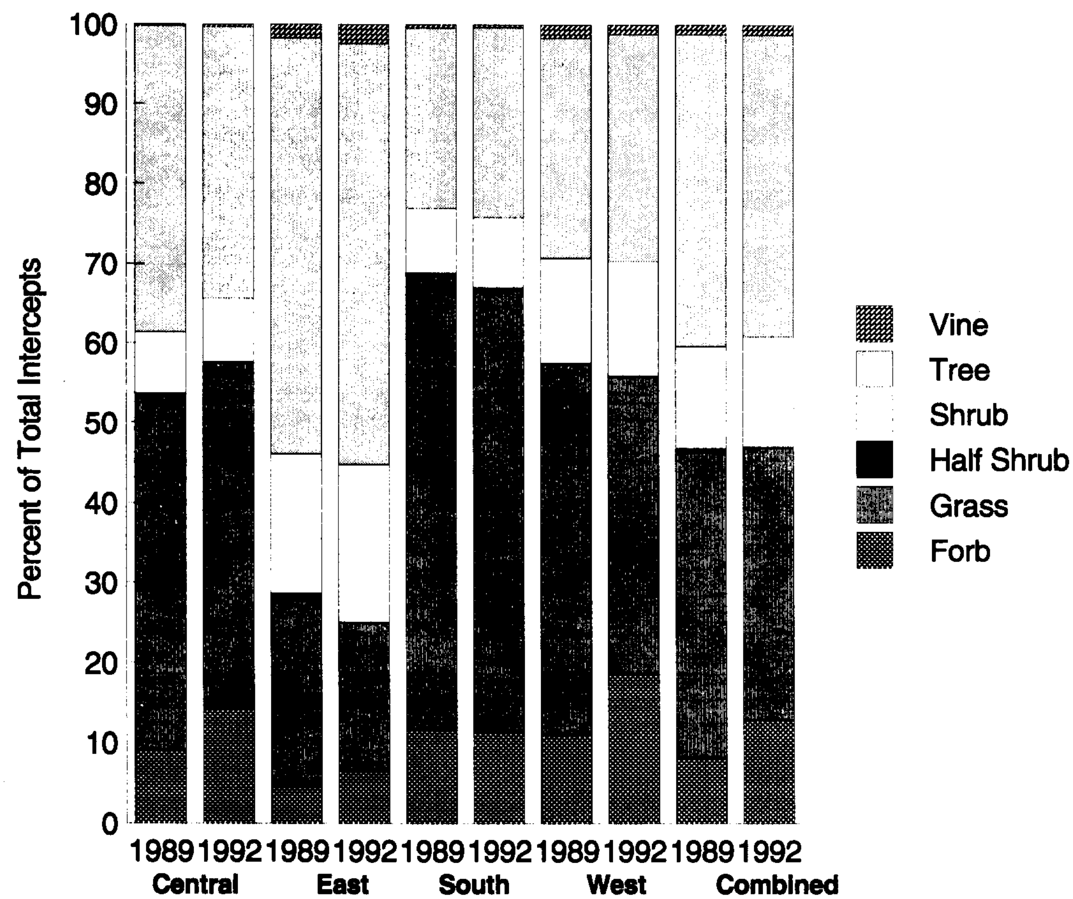


Figure 2. Percent of total vegetation intercepts by region, year, and growth form class for Fort Hood, TX.

The morphological structure of plants has been shown to be strongly associated with resistance to trampling (Bates 1935; Liddle 1975; Kuss 1986; Cole 1987). Sun and Liddle (1993a) suggest that plants with the same morphological structure growing in drastically different ecosystems will respond to trampling in the same way. Numerous studies suggest that woody growth forms are disadvantaged in resistance to trampling (Naito 1969; Cole 1987; Sun and Liddle 1993b). Grasses are generally resistant to trampling while dwarf shrubs are fragile (Crowder 1983).

In a series of studies that compared lightly and heavily impacted tracked vehicle sites on several U.S. military installations, plant populations were drastically reduced on more heavily impacted sites (Goran, Radke, and Severinghaus 1983). Changes in specific growth forms were also evident with grasses being replaced by forbs and a reduction in the proportion of trees.

Changes in the total number of species can be a useful indicator of disturbance. Several studies have shown decreases in the total number of species associated with trampling (Sun and Liddle 1993a; Kuss and Hall 1991; Liddle and Greig-Smith 1975). Kuss and Hall (1991) found the largest decreases in the number of species to occur with only moderate levels of trampling.

Changes in vegetation associated with military activity may also affect mammal and bird populations. Reductions in mammal and bird populations associated with tracked vehicle activity have been attributed to reductions and changes in habitat (Severinghaus, Riggins, and Goran 1980; Severinghaus and Severinghaus 1982).

Changes in total vegetative cover are important for soil stabilization and runoff management (Vachta and Riggins 1988). By intercepting raindrops, vegetation absorbs rainfall energy and reduces the chance for soil particle detachment caused by raindrop impact and splashing. Percent vegetative cover is used in the Universal Soil Loss Equation (USLE) to predict soil erosion losses (Wischmeier and Smith 1978).

By summing up the total intercepts for individual vegetation form classes and comparing to the total vegetation intercepts, the proportion of unidentified vegetation intercepts can be determined. Considerably more unknown data existed in the database for 1992 than 1989. If unknowns represent a large proportion of the data and the proportion varies considerably from year to year, long-term trends may be masked by this source of sampling variation. Recording unknowns by form class can be used in the field to help alleviate this problem.

Vegetation Summarized by Life-Span Growth Form

This summary characterizes installation vegetation by region, year, and vegetative life-span growth form. Vegetative life-span growth forms are likely to respond differently to military, nonmilitary, and other land use activities. The summary contains all species data from core plots. Core plots are used because the data is intended to characterize the study area. Life-span growth form classes were obtained from the *National List of Scientific Plant Names* (USDA 1982).

Only initial/long-term inventory data are used since total intercepts data are not available in short-term monitoring inventories. Presence/absence statistics for annuals and perennials can be calculated using short-term monitoring data.

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes. Unknown codes were not used in species counts for total vegetation of the individual form groupings. Means and standard errors were calculated using individual plot presence/absence and total intercept totals for each category.

Table 4 characterizes installation vegetation by life-span growth form. Trends in total vegetation and by life-span are also summarized in Figure 3. Changes in total vegetation may be an indicator of military or other land use impacts. An increase in the proportion of annuals may also be an indicator of disturbance as early seral stages are frequently dominated by annual plants. Shifts in species composition from perennials to undesirable annuals associated with vehicle use have been reported (Shaw and Diersing 1990; Thurow, Warren, and Carlson 1993; Goran, Radke, and Severinghaus 1983). Separating out the biennial plants could be a useful modification for some installations since biennials typically occupy sites that are disturbed periodically but not every year.

Table 4. Line transect aerial vegetation cover for Fort Hood, TX, summarized by life-span growth form.

Region*	Year	Growth Form	Plots	Presence/Absence		Total Hits		Species
			%	M	SE	M	SE	#
Central	1989	Total	100	81.2	2.84	231.1	19.66	137
		Annual	83	5.9	1.26	8.0	2.05	21
		Perennial	100	79.0	3.07	223.0	20.17	116
	1992	Total	100	77.2	2.83	197.1	16.51	122
		Annual	79	6.7	1.15	9.0	1.59	15
		Perennial	100	71.4	2.97	182.6	16.84	107
East	1989	Total	100	86.9	1.54	338.5	23.22	169
		Annual	86	12.3	1.84	18.4	3.04	26
		Perennial	100	81.9	2.18	320.1	24.22	143
	1992	Total	100	75.6	3.75	258.9	21.60	126
		Annual	73	10.4	2.16	17.6	4.77	20
		Perennial	100	68.6	3.88	233.2	21.96	106
South	1989	Total	100	82.7	2.93	229.0	23.12	117
		Annual	94	8.6	1.53	10.5	1.91	25
		Perennial	100	79.3	3.35	218.5	23.25	92
	1992	Total	100	76.5	3.85	186.3	16.22	86
		Annual	88	11.5	3.20	15.4	5.31	21
		Perennial	100	67.8	4.43	164.2	15.22	63
West	1989	Total	100	74.6	2.59	192.8	16.56	169
		Annual	96	11.4	1.44	15.7	2.25	30
		Perennial	100	70.5	2.62	177.1	16.39	139
	1992	Total	100	73.8	2.61	183.8	12.50	151
		Annual	93	16.3	1.52	23.1	2.42	23
		Perennial	100	57.8	3.14	144.9	12.82	128
Combined	1989	Total	100	80.6	1.35	246.7	11.31	265
		Annual	90	9.8	0.82	13.7	1.32	47
		Perennial	100	76.9	1.47	233.0	11.45	218
	1992	Total	100	75.6	1.61	208.1	9.08	211
		Annual	83	11.5	0.95	16.8	1.72	39
		Perennial	100	65.6	1.83	181.5	9.30	172

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

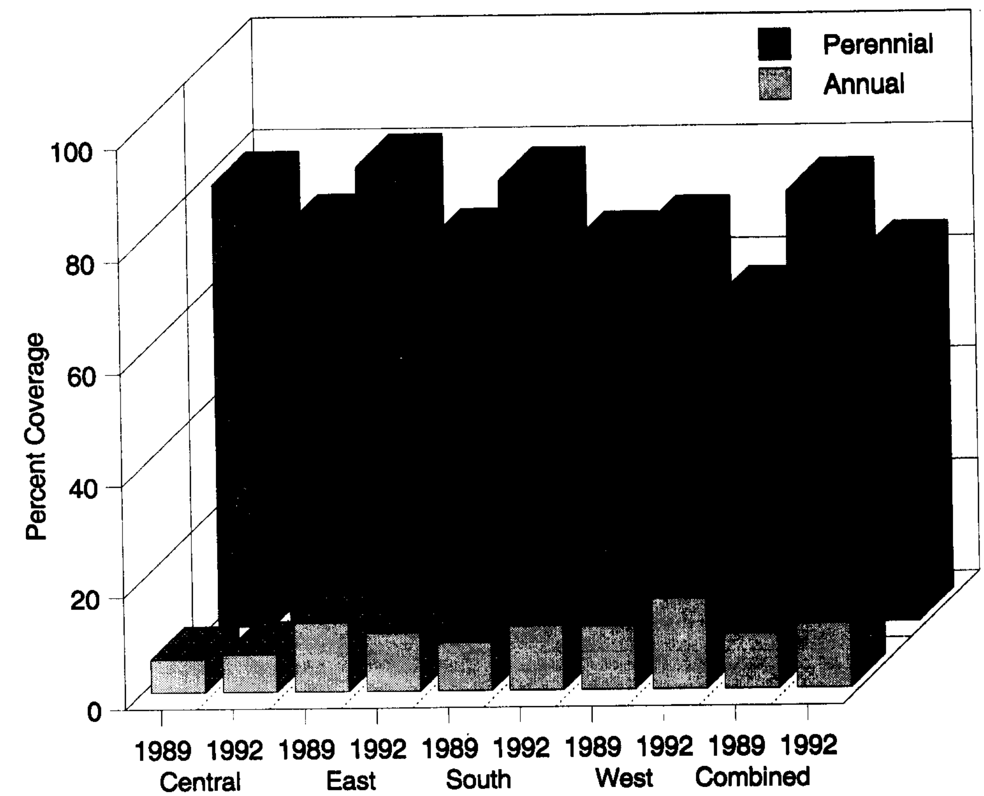


Figure 3. Percent vegetation cover by region, year, and life-span for Fort Hood, TX.

Vegetation Summarized by Historical Origin

This summary characterizes installation vegetation by region, year, and historical origin. For installations with management objectives to maintain and promote native habitat, this summary is useful in identifying the proportion of native vegetation on the installation.

The summary includes all species data. Core plots are used because the data is intended to characterize the study area. Only initial/long-term inventory data are used since species-level data is available in short-term monitoring inventories. Historical origins were obtained from the *National List of Scientific Plant Names* (USDA 1982).

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes. Unknown codes were not used in species counts for total vegetation of the individual form groupings. Means and standard errors were calculated using individual plot presence/absence and total intercept totals for each category.

Table 5 characterizes installation vegetation by historical origin. Trends in total vegetation and by origin are also summarized in Figure 4. If the natural resources management objective is to maintain the native historic vegetation, this summary can help detect improvements or degradation in installation vegetation. Introduced species threaten biodiversity by replacing native vegetation. In controlled experiments that evaluated the impact of various frequencies and seasons of tracked vehicle traffic on a native mixed grass prairie, Wilson (1988) found that introduced species invaded plots subjected to traffic. In a series of studies that compared lightly and heavily impacted tracked vehicle sites on several U.S. military installations, higher densities

Table 5. Line transect aerial vegetation cover for Fort Hood, TX, summarized by historical origin.

Region*	Year	Origin	Plots	Presence/Absence		Total Hits		Species
			%	M	SE	M	SE	#
Central	1989	Total	100	81.2	2.84	231.1	19.66	137
		Introduced	52	3.1	0.96	7.3	3.00	8
		Native	100	79.7	2.85	226.0	19.67	128
	1992	Total	100	77.2	2.83	197.1	16.51	122
		Introduced	30	1.8	0.65	5.0	2.23	6
		Native	100	73.3	2.91	188.1	16.45	116
East	1989	Total	100	86.9	1.54	338.5	23.22	169
		Introduced	61	9.2	1.74	18.0	4.13	10
		Native	100	82.5	1.84	323.6	23.84	156
	1992	Total	100	75.6	3.75	258.9	21.60	126
		Introduced	51	6.6	1.48	12.7	3.33	7
		Native	95	69.9	3.98	241.2	21.61	118
South	1989	Total	100	82.7	2.93	229.0	23.12	117
		Introduced	63	3.8	1.50	7.9	3.46	7
		Native	100	81.1	2.83	222.3	22.16	108
	1992	Total	100	76.5	3.85	186.3	16.22	86
		Introduced	69	5.3	1.78	8.6	2.75	6
		Native	100	70.3	4.38	171.4	16.73	76
West	1989	Total	100	74.6	2.59	192.8	16.56	169
		Introduced	70	7.3	1.55	13.1	3.12	10
		Native	100	71.2	2.70	182.8	16.38	158
	1992	Total	100	73.8	2.61	183.8	12.50	151
		Introduced	77	6.4	1.38	13.4	3.81	7
		Native	100	62.7	2.95	158.3	12.49	143
Combined	1989	Total	100	80.6	1.35	246.7	11.31	265
		Annual	61	6.2	0.79	12.2	1.82	15
		Perennial	100	77.7	1.41	237.1	11.28	247
	1992	Total	100	75.6	1.61	208.1	9.08	211
		Annual	57	5.0	0.69	10.3	1.74	13
		Perennial	99	68.4	1.77	190.6	9.12	199

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

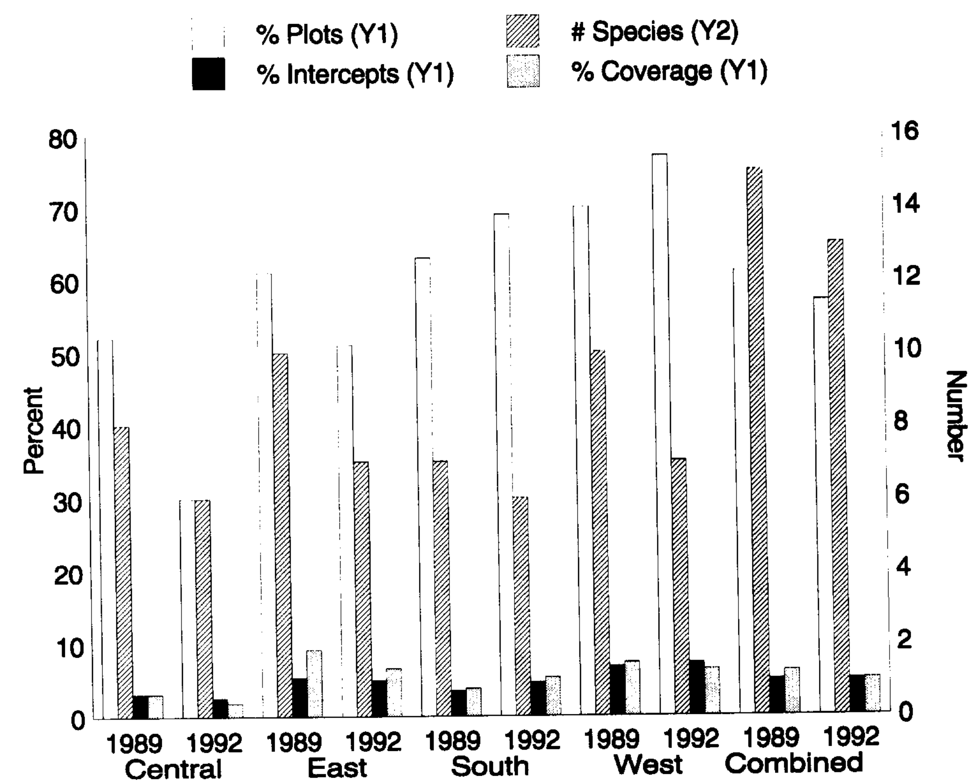


Figure 4. Percent of plots, number of species, percent of vegetation intercepts, and percent coverage of introduced species by region and year at Fort Hood, TX.

of introduced species were associated with more intense impacts (Goran, Radke, and Severinghaus 1983). When studying the impacts of trampling on vegetation, Crowder (1983) found that the most useful index of impact was the frequency of occurrence of introduced weeds.

Native species are defined as species native to the continental U.S. As an alternative, an installation may want to reclassify some species based on the historic occurrence of the species on the installation.

As an alternative data summary, an installation may want to identify weed and/or noxious weed species rather than just introduced species. A weed is generally any undesirable vegetation. The Federal Noxious Weed Act of 1975 says weeds are "plants that directly or indirectly injure . . . public health and roads, crops, livestock, property, and . . . other useful plants." Noxious weeds have become so thoroughly established and are spreading so rapidly that they have also been declared by some state laws to be a menace to the public welfare. Landowners have the responsibility for eradication and/or control of noxious weeds. Weeds designated as noxious are listed by most states.

Vegetation Summarized by Taxonomic Classification

Table 6 summarizes line transect aerial cover vegetation by region, year, and taxonomic classification. Changes in the amount or proportion of individual species may be an indicator of land use activities. "Indicator species" can be used to indirectly monitor changes in rarer species. All species data is used. Core plots are used because the data is intended to be used to characterize the study area. Only initial/long-term inventory data are used since species-level data is available in short-term monitoring inventories. Species codes were obtained from the *National List of Scientific Plant Names* (USDA 1982).

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes. Unknown codes were not used in species counts for total vegetation of the individual form groupings. Means and standard errors were calculated using individual plot presence/absence and total intercept totals for each category.

The species listed in Table 6 are those that represented at least 2 percent of the combined presence/absence intercept data for both 1989 and 1992. For Fort Hood this included the major and "important" species of interest.

The data from Table 6 can be used to identify which species accounted for most of the change in total vegetation or for a vegetation class. Even if there are no changes in total vegetation or in any vegetation grouping, there may be changes at the species level. Species composition changes can be an indicator of military impacts. In controlled experiments that evaluated the impact of various frequencies and seasons of tracked vehicle traffic on a native mixed grass prairie, Wilson (1988) found species composition to vary significantly with traffic frequency.

The health of communities can be discerned by examining the species composition within major plant community types and comparing against known associations of healthy communities. Species composition for comparison can be obtained from journal publications, USDA range site descriptions, or other sources.

Table 6. Line transect aerial vegetation cover for Fort Hood, TX, summarized by taxonomic classification.

Region*	Year	Species**	Plots	Presence/Absence		Total Hits	
			#	M	SE	M	SE
Central	1989	Total	47	81.2	2.84	231.1	19.66
		BOCU	14	3.6	1.65	4.5	2.05
		BORI	23	2.2	0.57	2.6	0.68
		BOSA	27	3.4	0.65	5.0	0.93
		BUDA	27	5.1	1.25	6.0	1.49
		JUAS	16	16.3	4.03	73.1	18.40
		QUSIB	10	3.0	1.31	9.6	4.00
		SCSC	20	11.2	2.81	18.7	4.55
		SPAS	45	21.3	2.77	37.2	5.66
		STLE5	32	11.3	2.28	15.1	3.19
	1992	Total	47	77.2	2.83	197.1	16.51
		BOCU	11	2.6	1.14	3.8	1.73
		BORI	25	2.6	0.76	3.1	0.86
		BOSA	26	3.5	0.86	5.4	1.50
		BUDA	19	2.8	0.80	3.2	0.93
		JUAS	16	14.6	3.62	47.7	12.30
		QUSIB	7	3.1	1.39	9.1	4.18
		SCSC	22	11.6	2.90	19.6	4.89
		SPAS	38	14.1	2.13	26.1	4.06
		STLE5	27	8.7	1.94	12.1	2.83
East	1989	Total	45	86.6	1.53	333.6	23.21
		AMDR	22	2.2	0.50	3.4	0.86
		BOIS	13	2.8	1.09	4.1	1.56
		BRJA	21	5.5	1.35	8.5	2.39
		BUDA	24	9.3	1.98	12.0	2.60
		FRTE	19	4.6	1.10	11.0	2.97
		JUAS	33	24.2	3.97	106.1	18.48
		QUSHT	12	3.9	1.44	13.0	5.11
		QUSIB	12	8.1	2.46	29.3	9.34
		QUST	8	3.2	1.45	13.1	6.46
		QUVIF	15	5.5	1.69	17.6	5.37
		SPAS	35	8.8	1.48	15.9	3.73
		STLE5	29	11.9	2.28	17.7	3.55
	1992	Total	45	76.1	3.69	259.3	21.12
		AMDR	23	4.5	1.16	8.7	2.86
		BOIS	12	2.5	1.01	3.7	1.50
		BRJA	14	3.3	1.10	4.1	1.42
		BUDA	19	5.6	1.56	7.0	1.97
		FRTE	21	5.2	1.28	12.2	3.10
		JUAS	31	24.6	3.83	84.1	14.44
		QUSHT	11	3.7	1.40	11.6	4.78
		QUSIB	15	8.0	2.31	24.7	7.11
		QUST	6	2.0	1.02	5.2	2.83
		QUVIF	15	5.2	1.69	14.2	4.87
		SPAS	28	5.0	1.16	8.3	1.95
		STLE5	23	7.0	1.72	9.2	2.39

Region*	Year	Species**	Plots	Presence/Absence		Total Hits	
			#	M	SE	M	SE
South	1989	Total	17	81.1	3.17	226.1	21.91
		ARPU9	13	4.1	1.04	5.9	1.53
		BORI	11	4.3	1.58	5.2	1.92
		IVAN	7	1.0	0.36	1.1	0.40
		JUAS	10	7.9	3.18	44.1	19.46
		QUVIF	10	9.3	4.01	26.5	11.93
		SCSC	13	21.1	6.91	45.4	16.01
		SPAS	15	11.2	2.14	19.7	4.26
		STLE5	12	13.2	4.35	20.7	6.89
	1992	Total	17	75.5	3.76	185.1	15.29
		ARPU9	9	1.6	0.62	2.0	0.75
		BORI	11	3.4	1.32	3.8	1.50
		IVAN	8	3.7	1.28	4.2	1.39
		JUAS	11	10.0	3.39	38.5	12.48
		QUVIF	10	8.1	3.47	18.8	8.41
		SCSC	11	20.1	6.32	34.6	11.13
		SPAS	15	12.2	2.97	17.4	4.61
		STLE5	10	12.6	4.71	20.6	8.24
West	1989	Total	56	74.6	2.59	192.8	16.56
		AMDR	44	4.1	0.69	6.0	1.19
		BOBA2	0	0.0	0.00	0.0	0.00
		BOIS	21	3.1	1.04	3.7	1.36
		BORI	36	3.4	0.66	3.8	0.75
		BOSA	33	2.4	0.64	3.3	0.88
		BRJA	16	3.2	1.13	4.5	1.67
		BUDA	44	7.9	1.30	8.5	1.42
		IVAN	30	1.4	0.28	1.6	0.35
		JUAS	20	5.3	1.87	23.4	9.06
		QUSHT	9	2.9	1.35	11.8	5.46
		QUVIF	22	3.9	0.85	12.3	2.81
		SPAS	50	11.9	1.71	18.6	3.16
		STLE5	49	19.9	2.51	28.7	4.09
	1992	Total	56	73.8	2.61	183.8	12.50
		AMDR	43	4.1	0.63	6.8	1.18
		BOBA2	33	7.2	1.29	7.6	1.40
		BOIS	26	4.0	1.35	5.2	1.90
		BORI	36	3.1	0.65	3.7	0.80
		BOSA	35	2.2	0.40	3.1	0.60
		BRJA	21	1.5	0.45	1.7	0.51
		BUDA	32	3.4	0.85	4.0	0.98
		IVAN	38	8.4	1.35	11.1	1.90
		JUAS	23	6.9	2.00	23.0	6.14
		QUSHT	10	2.1	1.10	7.0	3.35
		QUVIF	18	2.7	0.72	7.1	1.97
		SPAS	47	9.7	1.36	16.0	2.39
		STLE5	46	12.0	1.86	17.0	2.96

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.
**Species codes were obtained from the *National List of Scientific Plant Names* (USDA 1982). See Table 2 for scientific names.

A few species may carry most of the information about the structure of a community in space and time. Additionally the large number of species encountered on LCTA surveys may hide the important information in a large table. Reducing the number of species data presented can highlight the important changes.

Sampling intensity, while sufficient for major species, may be insufficient for minor species. Large sample size requirements for minor species are due to the statistical distribution of the data, variation within and among plots, and the relative rarity of many species. This is especially true for smaller installations with fewer plots or when creating subsets of the data for regional groupings. Minor species often are not normally distributed, which makes inferences from the data even more difficult. Displaying only the major species not only reduces the quantity of the data displayed but also displays only those species that are sufficiently sampled.

Instead of listing species that account for most of the vegetation, the table could include the "important" species as defined by the installation, species that account for most of the change in total vegetation, the major species from each form class, local indicator species that are used to track TES species or are sensitive to habitat changes, or major food or habitat species for wildlife.

Misidentification of measurements is especially a problem when summarizing data at the species level. In Table 6, note in the west region that the annual *Bouteloua barbata* (BOBA2) does not occur in 1989 but is very common in 1992. It is difficult to determine if this trend can be attributed to land use impacts, annual fluctuation, or misidentification.

Line Transect Ground Cover Summaries

A 100-m line transect forming the central, longitudinal axis of the LCTA plot is used to quantify ground cover and surface disturbance (Tazik et al. 1992). The ground cover transect is at the same location as the aerial cover transect. One hundred points are sampled along the line transect beginning at the 0.5-m point and continuing at 1-m intervals to the 99.5-m point. Using a measuring tape as a guide, a measuring rod is positioned vertically over each point and lowered to the ground. At the point where the rod contacts the ground, the kind of ground cover and disturbance are recorded.

Both initial/long-term and short-term monitoring survey data were used in the line transect ground cover summaries presented in this section. The field procedures used in short-term monitoring yield much the same information as those in initial/long-term monitoring, but in lesser detail, particularly with regard to species composition. Since most of the summaries in this section did not make use of species composition, all Fort Hood data were used.

Only core plot data were used in these summaries because the results are intended to be extrapolated to the habitat/management region and installation level. Core plots used for the ground cover summaries are the same plots used in the line transect aerial cover summaries. Only plots that were measured in all years were included in the summaries for the same reasons discussed in the section on line transect aerial cover.

Three statistics were computed when summarizing the line transect ground cover data: percent of plots with occurrence, average percent ground cover, and number of species present. Percent of plots with occurrence is the percent of plots on which the ground cover category occurred. Average percent ground cover is the average percent coverage and standard error for each ground cover category. Number of species present is a tally of the number of species measured on all plots within the area. Number of plots is a measure of the distribution of the ground cover category across the site being characterized. Average percent ground cover measures are used to indicate the horizontal distribution and coverage of vegetation class along the length of the transect. Number of species or species richness is a simple indicator of vegetative complexity and one aspect of species diversity.

Table 7 summarizes ground cover distribution by region, year, and cover type. Changes in ground cover types can be an indicator of disturbance. All species data is used for vegetation cover. Only core plots are used because the data is intended to be used to characterize the study area. Both initial/long-term and short-term inventory data are used since data was not summarized at the species level. The litter category presented in Table 7 consists of both litter and duff LCTA measurement categories. The rock category consists of both rock and gravel.

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were not used in species counts. Means and standard errors were calculated using individual plot presence/absence and total intercept totals for each category.

Table 7 characterizes installation ground cover and documents changes in ground cover over time. An increase in the percent of bare ground may be an indicator of disturbance and the potential for increased erosion. All other categories help to reduce the potential for erosion. Increases in the percent of rock may indicate an erosion problem as the original soil profile is removed leaving rock fragments on the surface

Table 7. Line transect ground cover for Fort Hood, TX, summarized by ground cover category.

Region*	Year	Species #	Bare Ground % Plots	Bare Ground M	Bare Ground SE	Litter % Plots	Litter M	Litter SE	Rock % Plots	Rock M	Rock SE	Vegetation % Plots	Vegetation M	Vegetation SE
Central	1989	57	100.0	36.8	3.00	97.9	35.3	3.55	85.1	13.2	2.72	97.9	14.7	1.09
	1990	na	95.7	25.0	2.40	100.0	51.3	3.43	78.7	11.2	2.39	97.9	12.5	1.33
	1991	na	93.6	17.4	2.51	100.0	73.8	3.13	59.6	3.7	0.97	87.2	5.1	1.00
	1992	22	97.9	27.8	3.15	100.0	68.6	3.31	55.3	2.6	0.56	42.6	1.0	0.22
East	1989	53	97.7	23.5	2.51	100.0	56.6	3.29	81.8	8.6	1.69	100.0	11.3	1.44
	1990	na	90.9	16.7	2.04	100.0	65.4	2.88	81.8	7.7	1.48	93.2	10.3	1.34
	1991	na	86.4	7.4	1.11	100.0	83.4	1.62	79.5	5.8	1.16	81.8	3.4	0.55
	1992	27	90.9	11.4	2.20	100.0	81.7	2.34	70.5	5.5	1.20	45.5	1.4	0.34
South	1989	34	100.0	38.3	3.39	100.0	32.1	4.08	87.5	14.6	4.06	100.0	15.1	2.22
	1990	na	100.0	26.7	2.06	100.0	46.4	3.59	75.0	8.9	3.02	100.0	18.0	2.33
	1991	na	100.0	16.3	1.62	100.0	61.7	3.97	75.0	9.0	3.23	100.0	13.1	1.56
	1992	23	93.8	20.1	2.59	100.0	71.5	4.29	56.3	3.9	1.79	93.8	4.5	1.07
West	1989	55	100.0	39.0	2.10	100.0	37.7	2.51	83.9	9.1	1.43	100.0	14.2	1.11
	1990	na	98.2	28.7	2.33	100.0	51.7	3.09	78.6	7.6	1.25	92.9	12.0	1.11
	1991	na	94.6	20.7	2.44	100.0	70.9	2.77	60.7	4.1	0.97	91.1	4.3	0.47
	1992	24	100.0	26.3	2.75	100.0	69.5	2.82	57.1	2.7	0.56	53.6	1.6	0.35
Combined	1989	100	99.4	34.1	1.44	99.4	41.6	1.80	84.0	10.7	1.11	99.4	13.6	0.67
	1990	na	95.7	24.2	1.26	100.0	54.7	1.75	79.1	8.8	0.95	95.1	12.3	0.70
	1991	na	92.6	15.7	1.22	100.0	74.2	1.51	66.9	4.9	0.63	88.3	5.1	0.44
	1992	57	96.3	22.1	1.55	100.0	72.7	1.60	60.1	3.5	0.45	52.1	1.6	0.21

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

(Severinghaus, Riggins, and Goran 1979). Soil loss from erosion tends to expose rocks found in the soil (Trumbull et al. 1994). Bare ground has been shown to be related to introduced weed species establishment (Best et al. 1980; Bultsma and Lynn 1985) and habitat suitability for birds and mammals (Diersing and Severinghaus 1985). The percent of exposed soil caused by tracked vehicle traffic has been shown to be the strongest predictive factor of soil infiltration rate over recovery time (Thurow, Warren, and Carlson 1993).

Changes in amount of litter coverage may also be an indicator of land use impacts (Figure 5). For example, Crowder (1983) found a significant decrease in the amount of litter with increasing intensity of trampling.

Ground cover only represents what is on top of the ground. The categories are mutually exclusive at each measurement point; changes in one category will be reflected in the other categories. At Fort Hood the percent litter cover increased from 41.6 to 72.7 percent over 4 years. The percent bare ground fluctuated but resulted in an overall decrease and percent rock decreased steadily over the same 4 years. The reduction in rock coverage is likely to be caused by the increase in litter rather than actual decreases in the amount of rock.

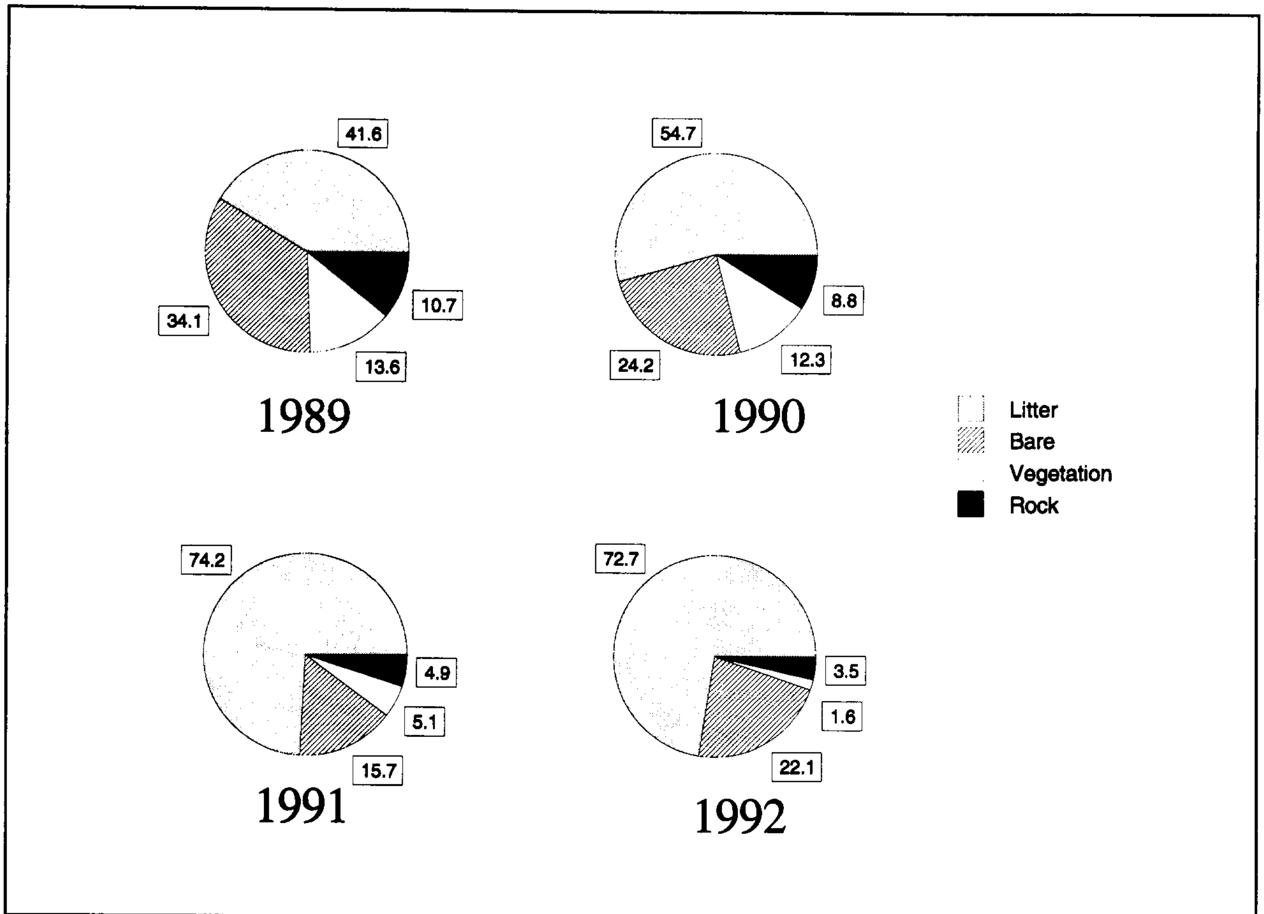


Figure 5. Combined installation percent ground cover by cover category and year for Fort Hood, TX.

Changes in the values of any statistic may be due to natural trends, impacts, or changes in field methods. Ground cover vegetation decreased each year from 13.6 percent in 1989 to 1.6 percent in 1992. A known procedural change in the LCTA ground methods between 1990 and 1991 is likely to account for much of the change between the first 2 years and the last 2 years. However, there was a steady decline each year, suggesting a change in ground cover vegetation occurred as well.

Belt Transect Data Summaries

The belt transect extends the length of the 100-m line transect. The belt transect has a standard width of 6 m that can be reduced for abundant species. During initial/long-term inventory years, the location and height of all woody plants above a predetermined height (0.1 m for Fort Hood) are recorded. All rooted live and dead woody plants are recorded. Short-term monitoring involves only a tally of each species by 1-m height classes up to 4 m and a single class for plants higher than 4 m. Live and dead rooted species are recorded separately.

Both initial/long-term and short-term monitoring survey data were used in the belt transect data summaries in this section. Although short-term monitoring data does not contain location information for each plant, this data was not used in the summaries contained in this report. Initial/long-term survey data contains absolute heights up to 8 m. However, all summaries use the predefined short-term height categories for summarization so that data could be combined from different survey types.

Core plot data were used in these summaries because the results are being extrapolated to the habitat/management and installation levels. Additionally only plots that were measured in all years were included in the summaries. Plots used for the belt transect summaries are the same plots used in the line transect summaries.

Three statistics were computed when summarizing belt transect data: number of plots, number of species, and frequency of occurrence. Number of plots is the number of plots on which the species was present. Number of species is the number of species found on all plots within the sampling area. Frequency of occurrence is the average number of plants found on a plot. Number of plots is a measure of the distribution of the vegetation across the site being characterized. Number of species is a simple indicator of community complexity and one aspect of species diversity. Frequency of occurrence is a measure of abundance per unit area.

Frequency of occurrences could have been calculated in two different manners. The average values could represent an average of all plots in the grouping or the average of only those plots where the vegetation type occurred. Neither measure is correct nor incorrect, but they have slightly different meanings. When calculated to include all plots in the grouping, the value represents an average for the whole area. When calculated to include only plots where the vegetation type occurred, the value represents the average amount of vegetation where the vegetation occurs. When one of these values is combined in a table with the percent of plots where the vegetation class was found, the other value can be directly calculated from the table. The choice of measure for inclusion in a summary depends on the objectives of your report and the type of plot groupings used. When each plot grouping includes only one general habitat type that is expected to be fairly uniform, presenting averages based on all plots in the area may be more meaningful. When each plot grouping includes a wide range of habitat types as in an installation summary, presenting averages based only on plots where the vegetation type occurred may be more meaningful. Frequency of occurrence averages presented in this report are based on all plots in the plot grouping.

The LCTA methods manual (Tazik et al. 1992) requires the installation resource manager to determine all species that should be treated as clonal and define what constitutes a clump. For plants that form dense stands by means of root sprouts, adventitious roots, or rhizomes, the entire clump (motte) is regarded as one individual. The definition of what constitutes a clump will determine how clump data should be incorporated into the data summaries. How clump data is incorporated into a summary may also depend on the intent of the summary. If the definition of a clump is unknown and clump data is not used in the summaries, belt transect data summaries will be biased and potentially misleading.

Fort Hood defined the use of clumps for several woody species. During initial/long-term surveys, clonal groups were defined by the area that the clump occupied. During short-term monitoring surveys, clumps were recorded as single individuals. For the purposes of this report, a clump is treated as a single individual. This definition was used so that initial/long-term and monitoring data would be compatible.

Annotated Species Checklist

Table 8 contains an annotated species checklist of plants found on the belt transect summaries discussed in this report. Vegetation codes used in the LCTA database and this report are from the *National List of Scientific Plant Names* (USDA 1982).

The species checklist includes all species codes listed in the report. If a compete belt transect species checklist is desired, all plots should be included. Genus and species

Table 8. Annotated species checklist for Fort Hood, TX, belt transect summaries.

VegID	Genus	Species	Growth Form	Historic Origin
BULA	Bumelia	lanuginosa	Tree	Native
FOPU2	Forestiera	pubescens	Shrub	Native
FRTE	Fraxinus	texensis	Tree	Native
ILDE	Ilex	decidua	Shrub	Native
JUAS	Juniperus	ashei	Tree	Native
OPLI	Opuntia	lindheimeri	Shrub	Native
PRGL2	Prosopis	glandulosa	Tree	Native
QUSIB	Quercus	sinuata	Shrub	Native
QUVIF	Quercus	virginiana	Shrub	Native
RHLA3	Rhus	lanceolata	Shrub	Native
ULCR	Ulmus	crassifolia	Tree	Native
YURU	Yucca	rupicola	Shrub	Native

are taxonomic descriptions, growth form is a structural description, and historic origin refers to whether or not the species is native to the United States.

If only species specifically listed in the rest of the report are included, the table is simply a reference table for the report. However, if a complete species list is provided, the table can be compared with the LCTA herbarium list (see Tazik et al. 1992) to determine what percentage of the woody species that exist at the installation were recorded during LCTA belt transect vegetation surveys. Identifying which species are not being sampled by LCTA core plots may help identify habitats that need additional monitoring with special use plots or other survey methods.

Woody Vegetation Summarized by Height

Table 9 summarizes belt transect vegetation data by region, year, and height category. Changes in the amount vegetation may be an indicator of land use activities. All species data is used. Only core plots are used because the data is intended to be used to characterize the study area rather than just the plots. Both initial/long-term and short-term inventory data are used since species level data is available with both survey types. All data values were adjusted for differences in plot width.

Table 9. Belt transect woody vegetation for Fort Hood, TX, summarized by height.

Region*	Year	Plots %	Species #	Frequency 0.1-1m M	SE	1-2m M	SE	2-3m M	SE	3-4m M	SE	>4m M	SE	Total M	SE
Central	1989	89	41	51.2	12.83	27.7	8.55	9.9	3.01	6.0	2.17	9.3	2.67	104.1	26.79
	1990	92	39	47.7	12.62	31.6	9.81	10.1	3.34	6.0	2.14	8.7	2.70	104.2	27.60
	1991	81	35	43.8	11.31	24.9	7.83	9.9	3.42	7.4	2.32	9.1	3.08	95.2	25.92
	1992	87	35	34.7	11.17	22.3	6.99	11.0	3.49	8.1	2.78	8.9	2.89	85.0	24.74
East	1989	98	48	84.4	20.89	33.5	5.96	14.6	2.71	8.7	1.73	18.4	3.46	159.7	28.43
	1990	98	44	69.2	14.09	39.9	8.56	14.6	2.81	8.9	1.91	17.5	4.00	150.1	25.41
	1991	98	41	59.4	10.41	35.6	6.40	14.0	2.65	10.0	2.14	15.4	3.64	134.4	20.93
	1992	100	45	81.3	22.50	34.0	5.72	14.0	2.81	7.8	1.51	19.7	3.58	156.8	32.23
South	1989	100	35	33.6	10.85	5.7	1.52	2.1	0.54	1.5	0.55	2.8	1.16	45.6	12.20
	1990	100	28	37.7	13.49	8.6	2.30	2.0	0.72	1.6	0.58	3.1	1.22	52.9	14.45
	1991	100	31	51.5	14.01	11.7	3.25	3.8	2.05	4.3	1.87	1.9	1.39	73.1	17.74
	1992	100	28	31.0	7.94	9.4	3.05	3.1	0.83	1.4	0.50	2.8	0.98	47.8	11.42
West	1989	80	45	28.7	6.32	12.7	4.22	4.2	1.18	2.4	0.73	5.7	2.21	53.7	11.86
	1990	88	38	27.6	5.68	16.4	4.74	4.8	1.17	3.0	1.00	6.0	2.38	57.7	12.34
	1991	88	41	39.8	12.72	20.9	6.42	5.4	1.42	3.6	1.16	5.8	2.12	75.4	18.90
	1992	89	40	31.4	9.33	18.2	5.05	7.8	2.15	3.5	0.86	6.1	1.74	66.9	16.28
Combined	1989	90	63	50.7	7.32	21.9	3.35	8.5	1.25	5.1	0.84	9.9	1.49	96.1	12.11
	1990	93	52	45.6	5.86	26.3	4.07	8.7	1.33	5.3	0.89	9.6	1.60	95.6	11.73
	1991	90	55	47.4	6.27	25.1	3.63	8.9	1.35	6.5	1.00	8.9	1.55	96.8	11.60
	1992	93	55	45.8	7.75	22.8	3.13	9.9	1.48	5.8	0.96	10.2	1.48	94.5	12.89

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes. Unknown codes were not used in species counts for total vegetation of the individual form groupings. Means and standard errors were calculated using individual plot totals.

Table 9 and Figure 6 characterize installation woody vegetation by height category. Changes in total vegetation may be an indicator of military or other land use impacts. In a series of studies that compared lightly and heavily impacted tracked vehicle sites on several U.S. military installations, plant populations were drastically reduced on more heavily impacted sites (Goran, Radke, and Severinghaus 1983). At Fort Hood the greatest effect of training on woody species was a reduction in density without any major shifts in species composition (Goran, Radke, and Severinghaus 1983).

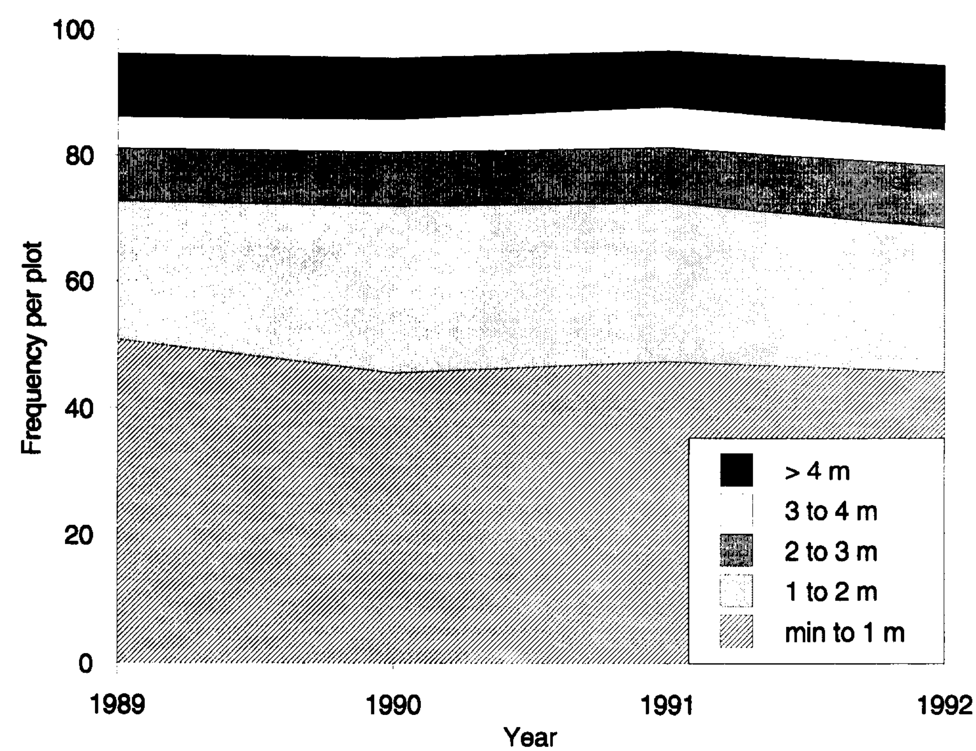


Figure 6. Combined installation frequency of woody vegetation by height class and year for Fort Hood, TX.

Woody Vegetation Summarized by Structural Growth Form

Table 10 summarizes belt transect data by region, year, height categories, and structural growth form. A change in the amount vegetation may be an indicator of disturbance. All species data is used. Only core plots are used because the data is intended to be used to characterize the study area rather than just the plots. Both initial/long-term and short-term inventory data are used since species level data is available with both survey types. All data values were adjusted for differences in plot width. Structural growth form for each species were obtained from the *National List of Scientific Plant Names* (USDA 1982).

Table 10. Belt transect woody vegetation for Fort Hood, TX summarized by region, year, height, and structural growth form.

Region*	Year	Form	Plots	Species	Frequency											
			%	#	min-1m		1m-2m		2m-3m		3m-4m		>4m		total	
					M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
Central	1989	Shrub	77	14	21.1	5.39	9.9	3.66	2.3	1.23	1.4	0.82	0.8	0.38	35.5	10.37
		Tree	81	27	30.0	8.91	17.7	5.87	7.6	2.26	4.6	1.44	8.6	2.38	68.6	18.26
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1990	Shrub	77	13	21.4	5.89	12.3	4.70	1.9	0.89	1.5	0.95	0.7	0.38	37.9	11.43
		Tree	85	26	26.3	8.42	19.2	6.23	8.2	2.61	4.5	1.41	8.0	2.41	66.3	18.29
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1991	Shrub	72	13	19.2	5.16	8.8	3.36	2.1	1.31	1.4	0.81	0.9	0.47	32.3	9.92
		Tree	79	22	24.6	7.45	16.1	5.14	7.8	2.50	6.1	1.70	8.2	2.74	62.9	17.42
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1992	Shrub	70	13	18.8	5.48	9.2	3.60	2.6	1.21	1.8	1.03	1.0	0.48	33.3	10.31
		Tree	79	22	15.9	6.23	13.0	4.33	8.4	2.66	6.3	2.05	8.0	2.58	51.7	15.55
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
East	1989	Shrub	91	16	27.1	5.04	12.4	3.57	4.1	1.11	1.7	0.54	2.4	0.81	47.8	9.15
		Tree	98	32	57.3	18.07	21.1	3.81	10.5	2.03	7.0	1.57	16.0	3.02	111.9	23.14
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1990	Shrub	82	13	25.2	4.67	15.8	5.02	3.8	1.15	2.3	0.73	2.2	0.83	49.4	10.15
		Tree	96	31	44.0	11.16	24.1	5.40	10.8	2.22	6.6	1.45	15.3	3.51	100.7	18.85
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1991	Shrub	84	13	24.2	4.84	12.6	3.14	4.2	1.02	2.4	0.73	2.5	0.90	45.9	8.77
		Tree	98	28	35.2	7.53	23.0	4.82	9.8	2.06	7.6	1.64	12.9	3.12	88.5	14.87
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1992	Shrub	84	12	31.7	6.86	11.0	2.62	4.0	1.05	1.5	0.57	2.3	0.70	50.6	9.69
		Tree	98	32	49.6	17.29	23.0	4.73	10.0	2.42	6.3	1.17	17.3	3.15	106.2	25.31
		Vine	2	1	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.02	0.0	0.02
South	1989	Shrub	94	13	16.1	6.12	1.4	0.52	0.7	0.24	0.5	0.24	1.2	0.53	19.8	6.34
		Tree	88	20	17.4	5.34	4.3	1.25	1.4	0.46	1.0	0.47	1.6	0.74	25.8	6.93
		Vine	6	1	0.1	0.06	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.1	0.06
	1990	Shrub	94	11	19.3	7.81	2.0	0.71	0.2	0.14	0.4	0.22	1.4	0.62	23.4	7.85
		Tree	94	16	18.4	6.05	6.6	1.90	1.8	0.63	1.2	0.54	1.6	0.80	29.6	7.41
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1991	Shrub	88	15	24.0	8.51	2.0	0.87	1.0	0.61	2.1	1.62	0.8	0.51	29.8	9.88
		Tree	88	14	27.4	6.45	9.7	2.79	2.8	1.55	2.2	1.02	1.1	0.94	43.2	9.59
		Vine	6	1	0.1	0.06	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.1	0.06
	1992	Shrub	94	13	13.3	4.33	1.5	0.47	0.7	0.36	0.4	0.22	1.0	0.46	16.9	4.65
		Tree	94	14	17.7	5.20	7.9	2.85	2.4	0.66	1.0	0.42	1.8	0.79	30.9	9.05
		Vine	6	1	0.1	0.06	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.1	0.06

Region*	Year	Form	Plots %	Species #	Frequency min-1m M	SE	1m-2m M	SE	2m-3m M	SE	3m-4m M	SE	>4m M	SE	total M	SE
West	1989	Shrub	66	14	14.0	3.13	5.9	2.50	1.7	0.54	0.9	0.28	1.4	0.39	23.9	5.73
		Tree	77	31	14.7	3.78	6.8	1.83	2.5	0.66	1.6	0.52	4.3	1.92	29.9	6.59
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1990	Shrub	70	11	14.3	3.33	6.6	2.49	1.7	0.49	0.9	0.31	1.4	0.39	24.8	6.18
		Tree	84	27	13.3	3.06	9.8	2.62	3.1	0.76	2.1	0.73	4.6	2.11	33.0	6.88
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1991	Shrub	70	13	22.8	9.84	10.2	4.01	2.0	0.66	1.0	0.34	1.4	0.42	37.3	12.83
		Tree	80	28	17.0	5.50	10.7	2.89	3.4	0.87	2.6	0.92	4.3	1.83	38.1	9.12
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1992	Shrub	64	12	13.3	3.90	7.2	2.55	3.1	0.98	1.5	0.49	1.4	0.40	26.4	7.15
		Tree	82	28	18.1	5.67	11.0	2.91	4.7	1.32	2.0	0.46	4.6	1.50	40.5	9.65
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Combined	1989	Shrub	79	24	19.8	2.42	8.4	1.68	2.4	0.50	1.2	0.29	1.5	0.29	33.3	4.43
		Tree	85	38	30.9	5.80	13.6	2.13	6.0	0.92	3.9	0.64	8.4	1.31	62.8	8.85
		Vine	1	1	0.0	0.01	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01
	1990	Shrub	77	16	19.8	2.52	10.3	2.12	2.2	0.44	1.4	0.36	1.4	0.29	35.1	4.87
		Tree	88	36	25.9	4.13	16.1	2.52	6.5	1.03	3.9	0.63	8.2	1.42	60.5	7.99
		Vine	0	0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
	1991	Shrub	76	21	22.3	3.98	9.6	1.89	2.5	0.53	1.6	0.36	1.5	0.32	37.5	5.82
		Tree	85	33	25.1	3.58	15.5	2.25	6.3	0.99	4.9	0.75	7.5	1.34	59.3	7.33
		Vine	1	1	0.0	0.01	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01
	1992	Shrub	74	18	19.8	2.85	8.2	1.54	3.0	0.56	1.5	0.37	1.5	0.28	34.0	4.73
		Tree	87	36	25.9	5.47	14.5	2.09	7.0	1.12	4.3	0.71	8.7	1.31	60.5	9.07
		Vine	1	1	0.0	0.01	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	0.0	0.01

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes. Unknown codes were not used in species counts for total vegetation of the individual form groupings. Means and standard errors were calculated using individual plot totals.

If a change in total vegetation is evident from the data, vegetation form class summaries can be used to identify which components were most responsible for the change. If no change in total vegetation is evident, the vegetation form class can be examined to determine if there was a shift in vegetation cover between structural form classes. Changes in total vegetation cover or in the proportion of individual growth form class over time may be the result of military impacts, natural plant succession, or other factors.

The morphological structure of plants has been shown to be strongly associated with resistance to trampling (Bates 1935, Liddle 1975, Kuss 1986, Cole 1987). Numerous studies suggest that woody growth forms are disadvantaged in resistance to trampling (Naito 1969; Cole 1987; Sun and Liddle 1993b; Crowder 1983).

Region*	Year	Species	Plots #	Frequency											
				0.1-1m		1-2m		2-3m		3-4m		>4m		total	
				M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
	1992	FRTE	27	9.0	3.73	3.0	1.02	1.7	0.69	0.5	0.23	2.2	0.65	16.3	5.38
		JUAS	36	8.9	3.42	10.1	2.28	5.1	1.42	4.2	0.97	10.8	2.47	39.1	7.48
		OPLI	31	11.7	3.26	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	11.7	3.26
		QUSIB	18	2.1	0.64	4.6	1.92	2.6	0.97	0.7	0.32	0.7	0.42	10.5	3.49
South	1989	BULA	10	5.7	3.37	0.1	0.06	0.1	0.06	0.0	0.00	0.0	0.00	5.8	3.36
		JUAS	13	8.1	2.84	3.2	1.04	0.9	0.34	0.8	0.43	1.2	0.62	14.2	4.40
		QUVIF	9	2.9	0.94	0.3	0.14	0.4	0.19	0.4	0.21	1.4	0.59	5.4	1.56
		RHLA3	5	5.5	3.78	0.0	0.00	0.1	0.12	0.1	0.08	0.0	0.00	5.8	3.87
		YURU	6	2.5	1.28	0.1	0.08	0.0	0.00	0.0	0.00	0.0	0.00	2.6	1.34
	1990	BULA	11	4.6	3.07	0.1	0.06	0.1	0.06	0.0	0.00	0.0	0.00	4.8	3.06
		JUAS	12	7.6	3.14	4.9	1.77	1.1	0.44	0.9	0.52	1.5	0.75	16.1	4.97
		QUVIF	10	5.0	2.16	0.3	0.14	0.0	0.00	0.1	0.08	1.5	0.65	6.9	2.23
		RHLA3	3	5.5	4.38	0.0	0.00	0.0	0.00	0.2	0.18	0.0	0.00	5.7	4.42
		YURU	7	4.1	1.83	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	4.1	1.83
	1991	BULA	8	8.4	5.24	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	8.4	5.24
		JUAS	13	15.3	4.01	7.3	2.41	2.3	1.26	1.9	0.98	0.9	0.77	27.8	7.32
		QUVIF	8	8.9	5.78	0.5	0.27	0.5	0.27	1.9	1.53	1.0	0.56	12.7	7.38
		RHLA3	2	4.9	4.70	0.1	0.06	0.2	0.18	0.0	0.00	0.0	0.00	5.1	4.70
		YURU	6	3.4	1.68	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	3.4	1.68
	1992	BULA	11	4.6	2.62	0.1	0.08	0.1	0.08	0.0	0.00	0.0	0.00	4.8	2.61
		JUAS	13	10.7	4.09	6.6	2.66	2.0	0.61	0.8	0.40	1.5	0.73	21.6	7.53
		QUVIF	10	2.3	1.01	0.3	0.17	0.2	0.18	0.2	0.18	1.2	0.56	4.3	1.39
		RHLA3	3	2.1	1.66	0.2	0.18	0.0	0.00	0.1	0.12	0.0	0.00	2.4	1.85
		YURU	7	2.9	1.16	0.0	0.00	0.0	0.00	0.1	0.06	0.0	0.00	3.0	1.19
West	1989	FOPU2	25	2.0	0.59	1.3	0.44	0.1	0.07	0.1	0.05	0.0	0.00	3.4	0.95
		ILDE	24	2.1	0.63	2.3	1.42	0.5	0.25	0.2	0.21	0.2	0.21	5.3	2.10
		JUAS	35	5.7	2.42	1.9	0.53	0.8	0.29	0.8	0.27	1.3	0.62	10.5	2.98
		OPLI	20	2.8	0.97	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	2.8	0.97
		PRGL2	11	0.6	0.25	0.7	0.45	0.1	0.09	0.0	0.03	0.0	0.00	1.5	0.71
		QUVIF	28	1.3	0.29	0.7	0.20	0.3	0.14	0.3	0.09	0.8	0.22	3.3	0.66
		RHLA3	16	1.6	0.81	0.6	0.25	0.1	0.06	0.1	0.03	0.0	0.00	2.4	0.93
		ULCR	21	1.7	0.62	0.4	0.12	0.1	0.05	0.2	0.12	0.7	0.35	3.0	0.88
	1990	FOPU2	27	2.2	0.76	1.4	0.45	0.2	0.09	0.1	0.06	0.0	0.00	3.9	1.11
		ILDE	21	1.7	0.81	2.5	1.53	0.5	0.25	0.3	0.27	0.2	0.21	5.2	2.46
		JUAS	33	4.8	1.89	2.8	0.91	0.8	0.27	0.7	0.26	1.3	0.68	10.4	2.95
		PRGL2	14	0.7	0.24	2.2	1.53	0.6	0.41	0.2	0.17	0.0	0.00	3.7	2.18
		QUVIF	24	1.3	0.34	0.4	0.12	0.3	0.13	0.3	0.10	0.7	0.23	2.9	0.62
		RHLA3	17	1.6	0.76	0.8	0.31	0.2	0.16	0.0	0.03	0.0	0.02	2.6	0.98
		ULCR	23	2.1	0.83	0.4	0.14	0.1	0.06	0.1	0.06	0.9	0.46	3.8	1.12
	1991	FOPU2	25	1.3	0.56	1.9	0.66	0.2	0.08	0.1	0.06	0.0	0.00	3.4	1.04
		ILDE	22	1.3	0.45	3.0	2.05	0.4	0.17	0.2	0.21	0.2	0.21	5.2	2.27
		JUAS	32	6.9	3.27	2.8	0.74	0.9	0.35	0.9	0.36	1.8	0.90	13.2	4.31
		PRGL2	13	0.6	0.23	2.3	1.58	0.7	0.46	0.2	0.17	0.0	0.00	3.7	2.21
		QUVIF	27	1.8	0.68	0.9	0.37	0.6	0.27	0.4	0.22	0.7	0.22	4.4	1.45
		RHLA3	15	10.9	9.33	2.7	1.66	0.2	0.16	0.0	0.02	0.0	0.02	13.8	10.94
		ULCR	20	1.8	0.86	0.4	0.11	0.1	0.07	0.5	0.24	0.5	0.25	3.3	1.10
	1992	FOPU2	24	1.1	0.34	1.1	0.47	0.2	0.08	0.0	0.02	0.0	0.00	2.4	0.70
		ILDE	25	1.9	0.77	3.0	1.35	0.9	0.45	0.4	0.20	0.1	0.05	6.3	2.39
		JUAS	34	7.5	3.65	4.5	1.71	1.4	0.53	0.7	0.21	2.2	0.94	16.3	5.60
		PRGL2	15	1.9	1.01	2.1	1.78	0.9	0.76	0.3	0.24	0.1	0.06	5.4	3.28
		QUVIF	26	2.1	1.12	0.7	0.26	0.3	0.12	0.6	0.26	0.7	0.22	4.4	1.60
		RHLA3	17	1.3	0.67	0.9	0.39	0.9	0.39	0.2	0.17	0.0	0.02	3.2	1.41
		ULCR	22	2.3	0.93	0.6	0.26	0.2	0.08	0.1	0.06	0.6	0.23	3.8	1.15

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

In a series of studies that compared lightly and heavily impacted tracked vehicle sites on several U.S. military installations, plant populations were drastically reduced on more heavily impacted sites (Goran, Radke, and Severinghaus 1983). Changes in specific growth forms were also evident with a reduction in the proportion of trees.

Changes in vegetation associated with military activity may also affect mammal and bird populations. Reductions in mammal and bird populations associated with tracked vehicle activity were largely attributed to reductions and changes in habitat (Severinghaus, Riggins, and Goran 1980; Severinghaus and Severinghaus 1982).

Woody Vegetation Summarized by Taxonomic Classification

Table 11 summarizes belt transect data by region, year, height categories, and taxonomic classification. A change in the amount vegetation may be an indicator of disturbance. Only species that represented at least 5 percent of the total woody vegetation are reported. Only core plots are used because the data is intended to be used to characterize the study area rather than just the plots. Both initial/long-term and short-term inventory data are used since species level data is available with both survey types. All data values were adjusted for differences in plot width.

Table 11. Belt transect woody vegetation for Fort Hood, TX, summarized by taxonomic classification.

Region*	Year	Species	Plots #	Frequency											
				0.1-1m		1-2m		2-3m		3-4m		>4m		total	
				M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
Central	1989	JUAS	24	12.7	6.65	9.7	3.58	5.6	1.71	3.3	1.01	7.3	2.19	38.6	12.70
		QUSIB	8	2.5	1.46	6.5	3.14	1.9	1.23	1.0	0.79	0.6	0.31	12.4	5.25
		ULCR	20	2.5	0.85	2.3	1.79	0.4	0.38	0.1	0.07	0.2	0.12	5.5	2.64
	1990	JUAS	24	9.5	5.84	9.7	4.03	5.4	1.75	3.5	1.09	6.8	2.24	35.0	12.53
		QUSIB	8	2.3	1.68	7.6	3.82	1.3	0.85	1.0	0.90	0.5	0.31	12.6	5.36
		ULCR	21	2.5	0.95	2.3	1.67	0.6	0.51	0.0	0.04	0.3	0.15	5.7	2.77
	1991	JUAS	22	9.9	5.49	8.7	3.08	5.3	1.82	4.3	1.31	7.3	2.45	35.5	12.24
		QUSIB	7	1.6	1.53	4.7	2.56	1.8	1.31	0.9	0.77	0.4	0.28	9.5	4.59
		ULCR	20	2.2	0.79	2.0	1.31	0.6	0.51	0.2	0.09	0.1	0.09	5.0	2.28
	1992	JUAS	20	5.2	4.46	5.6	2.38	5.9	2.05	4.1	1.30	6.7	2.34	27.4	10.74
		QUSIB	8	2.5	1.94	5.7	3.24	2.3	1.14	1.5	0.97	0.5	0.31	12.6	5.55
		ULCR	20	1.4	0.45	1.4	1.03	0.8	0.77	0.5	0.51	0.2	0.11	4.3	2.33
East	1989	FRTE	27	12.8	5.73	1.5	0.49	1.0	0.49	0.2	0.14	2.1	0.63	17.6	6.35
		JUAS	37	9.4	3.16	10.4	2.56	5.6	1.22	4.9	1.44	9.5	2.30	39.8	7.41
		OPLI	30	7.6	2.35	0.0	0.00	0.1	0.07	0.0	0.00	0.0	0.00	7.6	2.36
		QUSIB	18	4.0	1.22	6.6	2.72	2.6	1.04	0.7	0.34	0.6	0.42	14.5	4.63
	1990	FRTE	27	10.6	5.00	2.8	0.85	1.8	0.91	0.3	0.19	2.0	0.64	17.4	6.70
		JUAS	37	9.3	2.95	11.4	2.89	5.1	1.15	4.4	1.25	9.4	2.66	39.7	7.91
		OPLI	27	8.4	2.67	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	8.4	2.67
		QUSIB	18	3.4	0.96	8.3	3.36	2.4	1.03	1.3	0.56	0.7	0.55	16.0	5.14
	1991	FRTE	23	6.0	2.27	2.6	0.78	1.2	0.60	0.8	0.34	1.8	0.69	12.4	3.40
		JUAS	35	5.5	1.92	10.7	2.94	5.3	1.20	5.2	1.44	8.5	2.51	35.2	6.87
		OPLI	29	9.4	2.58	0.1	0.07	0.0	0.02	0.0	0.00	0.0	0.00	9.5	2.59
		QUSIB	16	2.8	1.08	6.3	2.44	2.3	0.89	1.6	0.61	0.8	0.55	13.8	4.39

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were not used in this summary. Means and standard errors were calculated using individual plot totals.

The data from Table 11 can be used to identify which species accounted for most of the change in total vegetation or for a vegetation class. Even if there are no changes in total vegetation or in any vegetation grouping, there may be changes at the species level.

The health of communities can be discerned by examining the species composition within major plant community types and comparing against known associations of healthy communities. Species composition for comparison can be obtained from journal publications, USDA range site descriptions, or other sources.

Vegetation composition can be useful when evaluating wildlife habitat availability and changes in the habitat over time. A few species may carry most of the information about the structure of a community in space and time. Additionally, the large number of species encountered on LCTA surveys may hide the important information in a large table. Reducing the number of species presented can highlight the important changes.

Sampling intensity, while sufficient for major species, may be insufficient for minor species. The requirement for a large sample size for minor species is due to the statistical distribution of the data, variation within and among plots, and the relative rarity of many species. This is especially true for smaller installations with fewer plots or when creating subsets of the data for regional groupings. Minor species often are not normally distributed, making inferences from the data even more difficult. Displaying only the major species not only reduces the quantity of the data displayed but also displays only those species that are sufficiently sampled.

Instead of listing species that account for most of the vegetation, the table could include the "important" species. The important species could be those that account for most of the change in total vegetation, the major species from each form class, local indicator species that are used to track TES species or are sensitive to habitat changes, and major food or habitat species for wildlife.

Information from Table 11 can be used to evaluate individual species regeneration by examining the distribution of individuals by height category and by changes in the distribution over time.

Total Dead Woody Vegetation Summarized by Height Category

Description. Table 12 summarizes belt transect total dead woody vegetation data by region, year, and height categories. Changes in mortality may be an indicator of disturbance. All species data is used. Only core plots are used because the data is intended to be used to characterize the study area rather than just the plots. Both initial/long-term and short-term inventory data are used since species-level data is available with both survey types. All data values were adjusted for differences in plot width.

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes. Unknown codes were not used in species counts for total vegetation of the individual form groupings. Means and standard errors were calculated using individual plot totals.

Table 12. Belt transect total dead woody vegetation for Fort Hood, TX, summarized by height category.

Region*	Year	Species #	Plots %	Frequency 0.1-1m M	0.1-1m SE	0.1-1m % Live	1-2m M	1-2m SE	1-2m % Live	2-3m M	2-3m SE	2-3m % Live	3-4m M	3-4m SE	3-4m % Live	>4m M	>4m SE	>4m % Live	Total M	Total SE	Total % Live
Central	1989	7	38	1.1	0.60	2.1	1.1	0.55	4.0	0.1	0.07	1.0	0.3	0.19	5.0	0.1	0.07	1.10	2.7	0.94	2.6
	1990	6	28	2.1	1.37	4.4	1.6	0.87	5.1	0.3	0.18	3.0	0.3	0.19	5.0	0.1	0.08	1.10	4.4	2.26	4.2
	1991	7	23	3.2	2.13	7.3	1.6	1.09	6.4	0.3	0.16	3.0	0.1	0.06	1.4	0.1	0.07	1.10	5.2	3.27	5.5
	1992	7	45	0.6	0.21	1.7	0.6	0.22	2.7	0.3	0.16	2.7	0.3	0.18	3.7	0.1	0.05	1.10	1.9	0.44	2.2
East	1989	13	61	1.4	0.54	1.7	3.0	1.23	9.0	0.8	0.27	5.5	0.6	0.24	6.9	0.3	0.14	1.60	6.0	1.95	3.8
	1990	10	43	0.4	0.14	0.6	2.3	1.18	5.8	0.7	0.26	4.8	0.3	0.20	3.4	0.3	0.15	1.70	4.0	1.60	2.7
	1991	9	27	0.3	0.13	0.5	1.1	0.58	3.1	0.3	0.19	2.1	0.3	0.19	3.0	0.1	0.14	0.60	2.1	1.00	1.6
	1992	16	55	1.3	0.50	1.6	2.5	0.79	7.4	0.8	0.34	5.7	0.4	0.18	5.1	0.5	0.22	2.50	5.6	1.61	3.6
South	1989	5	25	0.2	0.14	0.6	0.3	0.25	5.3	0.1	0.06	4.8	0.0	0.00	0.0	0.1	0.06	3.60	0.6	0.29	1.3
	1990	3	31	0.6	0.39	1.6	0.1	0.06	1.2	0.1	0.06	5.0	0.1	0.06	6.3	0.1	0.06	3.20	0.9	0.40	1.7
	1991	3	13	0.2	0.19	0.4	0.5	0.50	4.3	0.2	0.19	5.3	0.1	0.06	2.3	0.0	0.00	0.0	0.9	0.72	1.2
	1992	4	44	0.3	0.17	1.0	0.1	0.06	1.1	0.1	0.09	3.2	0.2	0.14	14.3	0.2	0.14	7.10	0.8	0.33	1.7
West	1989	8	34	0.9	0.60	3.1	0.4	0.17	3.1	0.2	0.13	4.8	0.0	0.00	0.0	0.0	0.03	0.0	1.6	0.74	3.0
	1990	6	23	1.0	0.63	3.6	0.4	0.17	2.4	0.1	0.06	2.1	0.0	0.00	0.0	0.2	0.11	3.30	1.6	0.79	2.8
	1991	7	25	0.8	0.59	2.0	0.3	0.17	1.4	0.1	0.05	1.9	0.0	0.03	0.0	0.2	0.16	3.40	1.4	0.73	1.9
	1992	11	27	0.6	0.34	1.9	0.6	0.35	3.3	0.1	0.06	1.3	0.1	0.07	2.9	0.1	0.05	1.60	1.5	0.58	2.2
Combined	1989	17	42	1.0	0.31	2.0	1.3	0.38	5.9	0.3	0.09	3.5	0.3	0.09	5.9	0.1	0.04	1.00	3.0	0.66	3.1
	1990	14	31	1.1	0.45	2.4	1.2	0.41	4.6	0.3	0.09	3.4	0.2	0.08	3.8	0.2	0.06	2.10	3.0	0.83	3.1
	1991	13	24	1.3	0.65	2.7	0.9	0.36	3.6	0.2	0.07	2.2	0.1	0.06	1.5	0.1	0.07	1.10	2.6	1.02	2.7
	1992	20	41	0.8	0.19	1.7	1.1	0.26	4.8	0.3	0.11	3.0	0.2	0.08	3.4	0.2	0.07	2.00	2.6	0.51	2.8

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

Evaluating both the total number of dead trees and the ratio of dead trees to live trees provides trend information on general ecosystem health over time. Extensive mortality may be an indication of a more serious problem, such as disease, drought stress, insect predation, or physical damage from military training. Dead trees and shrubs provide nesting habitat and food sources for birds and small mammals.

Total dead woody vegetation could be summarized by growth form or species. Identifying the species that account for most of the mortality could be useful in inferring the cause of the mortality and evaluating the impact of continued mortality on wildlife.

Vegetation Disturbance Interaction Summaries

Previously listed data summaries in this report characterized the vegetation of the installation and documented trends in the vegetation over time. Frequently, land managers are interested in whether differences in vegetation could be caused by military or other installation land use practices. Correlation analysis can be used to identify the type and the strength of relationships between observed military impacts and changes in vegetation to infer or identify potential causal relationships for further investigation.

A correlation coefficient (indicated by r) is a measure of the closeness of the relationship between two variables. Specifically, a correlation coefficient is the closeness to a linear relationship. Positive correlations between two categories indicate that the variables change in the same direction. That is, as one variable increases (or decreases) the other variable also increases (or decreases). Negative correlations between two variables indicate that the variables change in different directions. That is, as one variable increases (or decreases) the other variable decreases (or increases). The absolute magnitude of the correlation indicates the strength of the relationship. Correlation coefficients near 0 indicate very little relationship between the variables. Correlation coefficients close to 1 or -1 indicate very strong relationships between the variables.

Correlation analysis only measures the linear relationship between two variables. Other types of relationships may exist. The lack of a large (positive or negative) correlation coefficient does not necessarily mean that no relationship exists, only that a linear relationship does not exist.

Spearman rank correlation analysis, a nonparametric procedure that does not require normal distributions, was used to test the relationships between variables (Hollander and Wolfe 1973). Spearman rank correlation is also useful if the data contains outliers. Care should be used when interpreting correlation coefficients. Just because two variables are correlated does not mean that a change in one variable causes a change in the other variable. Also, correlation analysis can be sensitive to small sample sizes so that plot groupings containing few plots may produce unreliable estimates.

Correlation coefficients measure the amount of variation in one variable that can be accounted for in a second variable. Significance levels (or p-values) for the correlation coefficients indicate whether the linear relationship between two variables is significantly different than 0. A linear relationship close to 0 means that large changes in one variable are only associated with small changes in another variable. So if a large (positive or negative) correlation coefficient with an insignificant p-value exists, then much of the variation in the first variable can be accounted for by the second variable. However the second variable changes only slightly with large changes in the first variable.

Care should be exercised when examining the significance levels for large numbers of variables. Even if there is no association between the variables, if many coefficients are computed, some would be expected to be statistically significant by chance alone.

Table 13 provides correlation coefficients that measure the relationship between military disturbance and the amount of vegetation cover. Correlations were calculated using plot totals for both disturbance and vegetation. Disturbance data was obtained from line transect ground cover surveys. Values used were the percent of measurement points with any observable disturbance. Correlations were not calculated with individual disturbance types since all disturbance categories represented heavy impacts.

Correlation coefficients were calculated separately for each year. Since results from all years were similar, correlation coefficients for all years combined were calculated for final presentation. Correlations using both initial/long-term and short-term surveys were calculated if species level data was not required. If species level information was required, only initial/long-term survey data was used to calculate the coefficients.

P-values are for “two-tailed” tests of significance. Two-tailed tests make no assumptions about the direction of the expected change.

Table 13. Correlations between vegetation and disturbance for Fort Hood, TX, summarized by region.

			Region*									
			Central		East		South		West		Combined	
Data Type	Variable	Years	r	p	r	p	r	p	r	p	r	p
Line transect ground cover	Bare	1989-1992	0.15	0.04	0.67	0.00	0.44	0.00	0.69	0.00	0.45	0.00
	Litter	1989-1992	-0.13	0.07	-0.45	0.00	-0.10	0.44	-0.61	0.00	-0.34	0.00
	Plant	1989-1992	-0.03	0.73	0.39	0.00	-0.02	0.85	0.19	0.00	0.16	0.00
	Rock	1989-1992	-0.04	0.54	-0.36	0.00	-0.10	0.41	0.08	0.22	-0.09	0.02
Line transect total intercepts	Total	1989,1992	-0.35	0.00	-0.43	0.00	0.03	0.89	-0.71	0.00	-0.46	0.00
	Introduced	1989,1992	-0.20	0.17	0.24	0.06	0.13	0.50	0.17	0.08	-0.16	0.02
	Forb (total)	1989,1992	0.14	0.19	0.33	0.00	0.22	0.22	0.07	0.44	0.23	0.00
	Forb (ann)	1989,1992	0.17	0.11	0.39	0.00	0.10	0.59	0.15	0.13	0.35	0.00
	Forb (per)	1989,1992	0.09	0.37	0.19	0.07	0.30	0.09	-0.01	0.94	0.07	0.20
	Grass (total)	1989,1992	0.03	0.79	0.58	0.00	-0.12	0.51	-0.17	0.07	0.08	0.14
	Grass (ann)	1989,1992	0.05	0.61	0.38	0.00	0.48	0.01	-0.32	0.00	0.12	0.03
	Grass (per)	1989,1992	0.03	0.81	0.61	0.00	-0.12	0.50	-0.15	0.11	0.08	0.14
	Shrub	1989,1992	-0.07	0.49	0.35	0.00	0.30	0.09	-0.38	0.00	-0.18	0.00
	Tree	1989,1992	-0.28	0.01	-0.59	0.00	0.01	0.95	-0.62	0.00	-0.41	0.00
Line transect presence absence intercepts	Total	1989-1992	-0.15	0.04	-0.15	0.05	-0.04	0.74	-0.66	0.00	-0.37	0.00
	Introduced	1989,1992	-0.19	0.19	0.24	0.06	0.17	0.36	-0.16	0.10	-0.14	0.03
	Forb (total)	1989,1992	-0.07	0.53	0.21	0.07	0.23	0.21	0.10	0.29	0.01	0.82
	Forb (ann)	1989,1992	0.17	0.10	0.40	0.00	0.10	0.57	0.16	0.09	0.36	0.00
	Forb (per)	1989,1992	0.08	0.44	0.21	0.05	0.30	0.10	0.00	0.99	0.08	0.15
	Grass (total)	1989,1992	-0.06	0.60	0.52	0.00	-0.17	0.36	-0.10	0.31	-0.03	0.65
	Grass (ann)	1989,1992	0.06	0.60	0.39	0.00	0.48	0.01	-0.32	0.00	0.12	0.03
	Grass (per)	1989,1992	0.00	0.97	0.63	0.00	-0.19	0.31	-0.08	0.39	0.11	0.06
	Half shrub	1989,1992	-0.43	0.01	0.13	0.38	0.12	0.56	-0.11	0.34	-0.26	0.00
	Shrub(total)	1989,1992	-0.45	0.00	-0.46	0.00	0.14	0.46	-0.40	0.00	-0.44	0.00
	Shrub(b)	1989,1992	-0.38	0.00	-0.61	0.00	0.07	0.70	-0.48	0.00	-0.43	0.00
	Shrub(c)	1989,1992	-0.04	0.68	-0.45	0.00	0.26	0.15	-0.38	0.00	-0.18	0.00
	Tree	1989,1992	-0.64	0.00	-0.60	0.00	0.01	0.95	-0.62	0.00	-0.57	0.00
	Tree (b)	1989,1992	-0.18	0.09	-0.37	0.00	-0.10	0.60	-0.62	0.00	-0.33	0.00
	Tree (c)	1989,1992	-0.38	0.00	-0.61	0.00	0.07	0.70	-0.48	0.00	-0.43	0.00
	>4m	1989,1992	-0.19	0.07	-0.47	0.00	0.19	0.31	-0.39	0.00	-0.30	0.00
Belt transect	Total	1989-1992	0.05	0.49	-0.44	0.00	-0.19	0.14	-0.61	0.00	-0.32	0.00
	Shrub	1989-1992	0.11	0.14	-0.40	0.00	-0.02	0.86	-0.43	0.00	-0.23	0.00
	Tree	1989-1992	0.00	0.96	-0.41	0.00	-0.21	0.10	-0.65	0.00	-0.34	0.00
	Mortality	1989-1992	-0.13	0.07	-0.22	0.00	0.01	0.96	-0.23	0.00	-0.21	0.00

*Based on 47, 44, 16, 56, and 163 plots for Central, East, South, West and Combined regions, respectively.

Unknown species codes were assumed to be valid data observations that could not be identified or contained erroneous vegetation codes that could not be corrected. Unknown species codes were used to calculate statistics for total vegetation but were not used to calculate statistics for individual form groupings because form types could not be determined for unknown species codes.

Correlation coefficients were calculated for the same data groupings used previously in this report. If a particular trend in vegetation is observed in a data summary, the correlation coefficient is available to evaluate the relationship between the variable and the amount of military disturbance.

Correlations between variables may be explained in more than one logical manner. There may be negative correlation between trees and military disturbance either because tank drivers like to use trees for concealment and the heavy use results in fewer trees or tank drivers may prefer open grasslands where few trees exist. A lack of a correlation between the amount of tree vegetation and military disturbance could result from both processes occurring at the same time. Tank drivers may avoid areas dense with trees but may use trees in grasslands where trees are less common.

Individual vegetation species variables could be correlated with disturbance. Correlation coefficients for belt transect woody vegetation data could be calculated by height class to determine if different height classes were related to disturbance in a similar manner. Mortality correlations could also be calculated by height class.

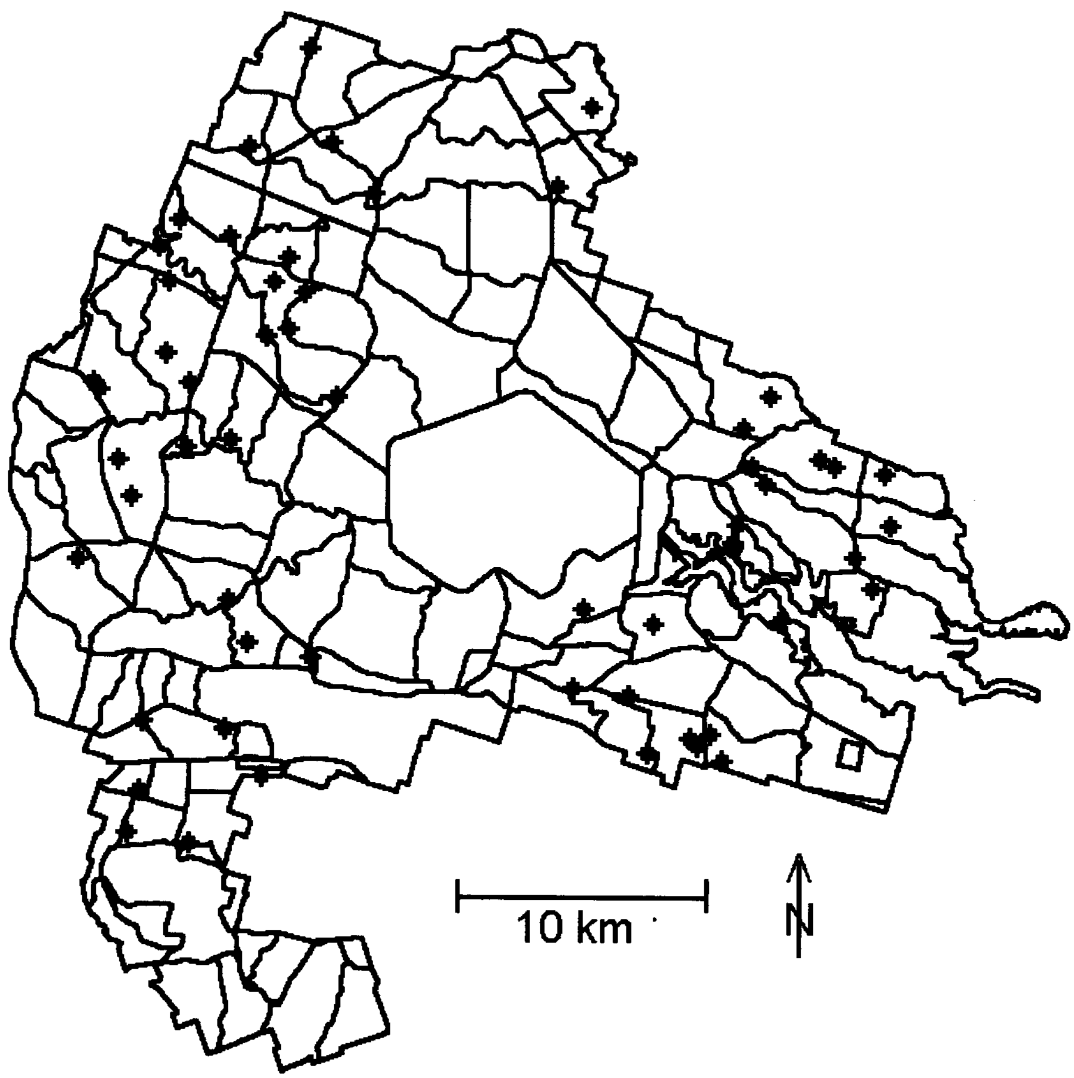
5 Wildlife Data Summaries

Understanding the how, when, and where of wildlife data collection is essential, not only in identifying informative analyses but also in delineating the framework within which interpretations are based. LCTA wildlife surveys are conducted on a random subset (proportionally) of all core plots, with each major landcover and soil type combination being represented by at least one plot (Tazik et al. 1992). It is also important to restate that presently, only landcover/soil type combinations of 5 acres or larger are eligible to receive a LCTA core plot.

Figure 7 shows the LCTA wildlife plot allocation for Fort Hood, TX. Unfortunately, habitats such as marshes, springs, and desert arroyos, areas known to be high in faunal diversity, are often smaller than 5 acres and therefore likely to be under-represented in the standard plot allocation. Consequently, installations with these unique types of habitats often find it necessary to augment the normal wildlife plot allocation with special-use plots. These additional surveys conducted in unique or otherwise under-represented habitats often contribute substantially in documenting new species. Special-use plots permit a greater degree of flexibility because they can be located where they are needed, and are not required to be randomly located within 5-plus acre polygons as delineated from satellite imagery. Changes in survey frequency and methodology can also be accommodated on these plots. Fort Hood, for example, established and maintains numerous special-use plots located within the endangered Black-capped vireo's and Golden-cheeked warbler's nesting habitats to aid in their management.

The wildlife analyses being presented are not exhaustive but represent some basic univariate applications of core plot data. The conscientious use of special-use plots increases the options for analyzing and presenting LCTA data at any installation fielding LCTA. Knowledge of data collection techniques and limitations will enable installation personnel to place LCTA wildlife data in the proper context and, using their knowledge of the installation and its land-use history, more effectively interpret the local LCTA wildlife database.

Wildlife surveys are conducted on or immediately adjacent to the LCTA plot to provide the installation land manager a minimal measure of terrestrial faunal diversity, and to permit the use of vegetative and other variables collected on the line and belt



Lines delineate training areas.

Figure 7. LCTA wildlife plot locations on Fort Hood, TX.

transects in wildlife analyses when appropriate. Small mammal and songbird monitoring are required in the LCTA standard wildlife inventory and monitoring effort (Tazik et al 1992; Diersing, Shaw, and Tazik 1992). Tazik and others (1992) also provide suggested monitoring techniques for medium-sized mammals, bats, and herpetological species or herpetofauna (reptiles/amphibians) but because these surveys are optional they are not directly addressed in this report. Small mammals and songbirds were selected over other vertebrate groups because of their known suitability as biological indicators (Morrison 1986; Douglass 1989; Temple and Wiens 1989; Croonquist and Brooks 1991) and relative ease in monitoring at the scale of the LCTA plot.

Assuming the minimal level of field effort (as described in Tazik et al. 1992) is employed in conducting LCTA surveys, wildlife analyses are most appropriately applied at the level of the installation for four fundamental reasons. First, unlike the vegetation monitoring component of the LCTA program, small mammal and bird surveys are conducted only on a subset of all core plots (approximately 33 percent; based on 200 core plots), which results in a smaller sampling base. Second, a relatively small number of observations or captures per site should be anticipated, a common problem encountered in wildlife surveys. This tendency is particularly true of small mammal and herpetological surveys. Third, LCTA plots frequently fall in close proximity to two or more habitat types, often resulting in a significant "edge effect." In other words, the species observed or captured on these plots are a composite of several habitat types, and not necessarily strongly associated with the one being surveyed. Finally, summarizing wildlife data at the installation level recognizes the great mobility of many wildlife species and their tendency to cross habitat, ecological, and political boundaries.

Unless augmented by special use plots, core plot allocation in general probably is insufficient to evaluate species-habitat associations in a statistically rigorous manner. Likewise, it might be convenient and interesting to summarize wildlife species or groups within military training areas, but unless training areas are used as a stratification factor in the core plot allocation process these analyses should be viewed with caution. This does not, however, preclude the integration of LCTA vegetative and wildlife data in all univariate or multivariate analyses. Rather, LCTA sampling can provide an excellent opportunity to assess covariation through time, for example, in avian abundances with local habitat variables (Warner, Brawn, and Heske DRAFT).

Although LCTA data is a means to quantify discrete habitat variables in a standard way, ecosystems are composed not just of "components" but of processes and countless inter-relationships. The tendency of a habitat to initially attract (short term) and sustain a species long-term is clearly influenced by readily observable structural components such as ground and canopy cover, species density, litter depth, and plant height. The long-term value of a particular habitat to each small mammal or avian species, however, is strongly influenced by ecosystem processes and functions that are less easily observed, including predation, natality (birth rate), mortality, dispersal, and interspecific and intraspecific competition. Many of these variables are known in concept but are poorly understood and difficult to quantify in wild populations. Thus, it may be tempting to over-emphasize the more easily quantified variables such as abundance, to quantitatively rank habitats and assign management or conservation priorities. However, a growing body of evidence suggests that density alone can be an unreliable and even misleading indicator of habitat quality (Van Horne 1983; Brittingham 1994). Subordinate individuals in a population often are forced into marginal habitat, and potentially in relatively high numbers. Moreover, in marginal habitat mortality often exceeds reproduction and the population must rely on immigration to persist. These habitats are termed "sinks" with respect to that particular species. Occasionally wildlife occupying habitats with adequate forage, cover, and structural qualities still have poor reproductive success because of the habitats' small sizes, attractiveness to predators, or practices in adjacent land use. These occurrences highlight the concern that structural characterization of a habitat alone is insufficient to discern an ecological sink.

In contrast to sink habitats, "source" habitats are those in which reproductive success is greater than annual mortality and emigration, resulting in a greater likelihood of the population persisting. Not only can a habitat be a source for one species and a sink for another, each could be reversed in response to changes in weather, predation levels, plant succession, disturbance, and numerous other factors. Analyses focused on sources and sinks are not discussed in this report, but are mentioned simply to emphasize that animal abundance is just one of many variables required to assess habitat suitability or quality. It is possible that the reproductive condition of individuals, nest success, annual mortality, recruitment, dispersal, and other variables could be assessed in varying degrees in the future with modifications and/or augmentations to the LCTA survey protocol, but at present are clearly beyond the scope of the core plot. Therefore, inferences of habitat quality (value) based on LCTA abundance data alone should be made with caution, the data being more suggestive than conclusive.

Bird Survey Data Summaries

Survey Methods and Considerations

The bird survey data used in this report was collected during the 1989 through 1992 nesting seasons. Survey methodology followed the standard LCTA protocol (Tazik et al. 1992). Briefly, the observer starts on the 0 meter point and slowly walks the length of the transect, recording all birds seen or heard within 100 m of the line (e.g., a 200-m belt). No vertical limit is imposed on recording observations. The observer then stops at the 100 m point and conducts an 8-minute point-count, recording birds seen or heard. The observer then slowly walks back to the staring point, again recording birds seen or heard. The total time required to complete the three segments per plot is approximately 20 minutes. When possible, a breeding status code (e.g., singing male) is assigned to each observation as a crude index of the number of breeding pairs in the immediate area of the plot. Lastly, all birds migrating over the plot or outside the 100-m horizontal distance are recorded as "flyovers," as are any unusual sightings while moving between plots. These incidental observations should not be included if inferring species-habitat variable covariation, but they are an important source of presence data for the rare and less commonly observed species such as raptors, certain upland game (e.g., wild turkey), waterfowl, and other wetland species.

Although LCTA bird surveys were timed to coincide with the local peak in breeding activity, periodic access restrictions and adverse weather resulted in considerable variability in the survey frequency and time of day it was conducted. During the 1989 field season, one morning bird survey was performed per plot and was considered the minimum LCTA requirement. In 1990 and beyond, two surveys per plot were suggested as the minimum effort (one morning and one evening). The time interval between the two surveys was not fixed, and varied considerably from 12 hours to 6 weeks. Based on the 1990 field season, the Fort Hood evening bird surveys appeared to be considerably less cost-effective than the morning, and were only occasionally conducted in subsequent years. Three and two morning surveys per plot were conducted in the 1991 and 1992 field seasons, respectively.

Because bird species typically have different detectability coefficients (Bibby, Burgess, and Hill 1992; Reynolds, Scott, and Nussbaum 1980) which may or may not be significant, and acknowledging that compounding factors like migration and survey frequency contribute to variability, statistically robust comparisons of abundance are not appropriate. In other words, some species are more difficult to see or hear and are simply not as likely to be noticed as the more vocal, colorful, or abundant species. Statistical treatment of absolute and relative abundance of a particular species accurately and consistently over time is further confounded by observer turnover and bias (Sauer, Peterjohn, and Link 1994). Successive biologists performing the surveys on an installation are probably not equally adept at detecting all avian species. Moreover, just because a species is not detected does not mean it was not there, nor should it be inferred that the presence of the species on a plot in itself constitutes a biologically meaningful relationship with that plot or habitat. This brings us to three critical assumptions of the LCTA bird survey: (1) all birds are not assumed to have been detected within the survey boundaries, (2) the presence of a species on a plot does not in itself mean that suitable habitat exists on or adjacent to the plot for that species, and (3) observer bias is a constant but difficult to quantify source of error. Consequently, emphasis was not placed on absence data or plot versus plot comparisons but on pooled (e.g., installation-wide) or multi-year trend analyses. The greater use of LCTA avian data to the installation's wildlife biologist or LCTA coordinator lies in identifying the direction of population changes rather than in estimating its magnitude, and only if faunal surveys are continued consistently and indefinitely can one even begin to discriminate trend from inherent natural variability.

Analyses Emphasis and the Guild Concept

Historically, bird surveys were often conducted to document which species were present in an area and then attempt to more clearly define species-habitat relationships. The emphasis during these early studies generally was placed on quantifying species richness rather than ecosystem process or function. While it is indeed important for a manager to know in which habitats a species is likely to be found or which habitat supports the greatest diversity of birds, understanding what role a species plays in supporting community structure is probably of greater importance in maintaining long-term ecosystem health. It has been long understood that stable ecosystems tend to have inherent redundancy both in terms of species functional roles and in various ecological processes, so if one species is lost or an environmental perturbation occurs, the system is less likely to fail.

The avian analyses being presented thus represents a blending of past and present research priorities, incorporating both the single species approach with the grouping of individual species counts into like categories or "guilds." Root (1977) was one of the first to discuss the guild concept, defining guilds as a group of species that exploit the same class of environmental resources in a similar way. More recently, Cooperrider, Boyd, and Stuart (1986) defined guilds as "a group of species having similar ecological resource requirements and foraging strategies and therefore having similar roles in the community." Both of these definitions implicitly state that guilds are composed of two or more species, and both highlight the desirability for guild determinations to be installation-specific. In other words, because habitat preference and bird behavior often varies from ecoregion to ecoregion, it is likely that a species' membership in a particular guild will also vary. It is also possible for a guild to be composed of just one species if it exploits resources in a unique way (Short 1983). While the correct definition-implicit assumptions and application of a guild seems to be a point of considerable debate among researchers (Jaksic 1981), the fundamental premise of community guild analysis is that members of a guild tend to respond to environmental changes in a similar and predictable fashion (Call 1981; Croonquist and Brooks 1991; Landres 1983; Severinghaus 1981; Short 1983). Satisfying both the "similiar and predictable" assumptions is often difficult, but avian guild analysis seems to have some degree of support in the scientific community (Mannan, Morrison, and Meslow 1984; Szaro 1986; Verner 1984). A clear advantage in guild analysis is the ability to view bird presence data from a functional perspective rather than rely soley on the more traditional structural context such as quantifying the various levels of species richness (plot, habitat, or installation wide), similarity indices and other measures of diversity. Grouping species has the added benefit of reducing bias associated with individual species detection while effectively increasing sample size, increasing the power (beta) of statistical tests. Avian guilds are easily defined from species lists and annual LCTA surveys and will provide a better understanding of how species assemblages change over time. Short (1983) expressed the value of guild analyses by stating ". . . it [the guild] provides the linkage between species and habitat so the effects of land-use on the total wildlife community can be evaluated."

Numerous avian guilds are currently recognized or have been proposed (e.g., Short 1983; Terres 1987; Peterjohn and Sauer 1993; Droege and Sauer 1992), and include associations based on nesting substrate/location, feeding strategy, migratory status, and general nesting and feeding habitat. Burnham and Short (1982) describe one of many techniques for structuring (i.e., customizing) wildlife guilds to evaluate environmental impacts on wildlife communities. The assignment of species occurring on Fort Hood LCTA plots into one or more guilds was required to illustrate the analyses and was based on readily available, broad-based species accounts. It should be understood that at each installation, the formation of species into ecologically meaningful guilds should be based on more regional or site-specific data if available.

The total number of plots surveyed each year for wildlife on Fort Hood varied from 62 (1989) to 91 (1991). Increases in sample size generally reflected the addition of special-use plots to monitor endangered species; decreases were often attributed to access restrictions associated with military training exercises. To minimize data collection differences within and between years and to increase compatibility, several steps were taken before analyses were conducted. To rectify differences in plot number between years, only the core-plots common among years were used, resulting in a mean sample size of 56 core plots. Differences in sample days between field seasons were rectified by averaging the species count for any given species per plot by year. In addition, the averages calculated from Fort Hood bird data only included those observations recorded in the morning, as evening data was collected regularly in only 1 year. These methods of reducing the raw data were used to construct a common data set from which summary tables were derived.

Installation Checklist

Table 14 lists the LCTA identification or species code, and the scientific and common names of all bird species observed within the installations boundaries. The table also lists the general habitat where each species is likely to be found, the nest location characterized based on substrate or spacial orientation, the feeding habit or foraging tendency (loosely defined as guilds), and neotropical migrant status. Unlike the remaining bird analyses in this report, observations comprising the installation checklist are derived from all core and special-use plots, incidental sightings, and flyovers. All codes used in the table are defined in the key.

Table 14. Annotated LCTA avian species checklist for Fort Hood, TX.

Species Code	Genus	Species	Common Name	Nest Location	General Habitat	Feeding Habit	Neotropic Status
ACCO	Accipiter	cooperii	Coopers hawk	WUC	FO	CA	B
ACMA	Actitis	macularia	Spotted sandpiper	GR	RI,SHO	IN	NO
ACST	Accipiter	striatus	Sharp-shinned hawk	WUC	FO,FOE	CA	B
AGPH	Agelaius	phoeniceus	Red-winged blackbird	GR,WLC	GR,SM	GR,OM	B
AICA1	Aimophila	cassinii	Cassin's sparrow	GR	GR	GR,IN	B
AIRU	Aimophila	ruficeps	Rufous-crowned sparrow	GR,WLC	GR,SHR	GR,OM	NO
AMSA	Ammodramus	savannarum	Grasshopper sparrow	GR	GR	OM	A
ANDI	Anas	discors	Blue-winged teal	GR	SM,RI,AQ	OM	NO
APCO	Aphelocoma	coerulescens	Scrub jay	WLC	FO,SHR	OM	NO
ARAL1	Archilochus	alexandri	Black-chinned hummingbird	WLC	SHR	OM	A
ARCO	Archilochus	colubris	Ruby-throated hummingbird	WLC	FO,UR	OM	A
ARHE	Ardea	herodias	Great blue heron	CL,GR,WUC	RI,SM	PI	NO
BALO	Bartramia	longicauda	Upland sandpiper	GR	GR	IN	A
BOCE	Bombycilla	cedrorum	Cedar Waxwing	WUC	FO,UR	FR,IN	B
BUIB	Bubulcus	ibis	Cattle egret	WLC	GR,SM	IN	NO
BUJA	Buteo	jamaicensis	Red-tailed hawk	CL,WUC	FO,GR	CA	B
BULI	Buteo	lineatus	Red-shouldered hawk	WUC	FO,RI,SM	CA	B
BUPL	Buteo	platypterus	Broad-winged hawk	WUC	FO	CA	A
BUST	Butorides	striatus	Green-backed heron	GR,WLC	RI,SHO,SM,RI	CR,PI	NO
BUSW	Buteo	swainsoni	Swainson's hawk	WUC	GR	CA,IN	A
BUVI	Bubo	virginianus	Great horned owl	CL,WUC	FO,UR	CA	NO
CAAL	Calidris	alba	Sanderling	GR	SHO	CR,IN,MO	NO
CAAL2	Casmerodius	albus	Great egret	WUC	SM	CA,CR	NO
CACA	Calidris	canutus	Red knot	GR	SHO,SHR,SM	CR,IN,MO	NO
CAAU	Cathartes	aura	Turkey vulture	CA,CL	FO,SHR,GR	CA	B
CACA1	Callipepla	californica	California quail	GR	FO,SHR	GR,HE	NO
CACA3	Caprimulgus	carolinensis	Chuck-will's-widow	GR	FO,GR	IN	A
CACA4	Cardinalis	cardinalis	Northern cardinal	WLC	FO	OM	NO
CAME2	Carpodacus	mexicanus	House finch	CA,WLC	GR,UR	FR,GR	NO
CAME3	Catherpes	mexicanus	Canyon wren	CL	SHR,GR	IN	NO
CAMI1	Calidris	minutilla	Least sandpiper	GR	RI,SHO,SM	CR,IN,VE	NO
CAPS	Carduelis	psaltria	Lesser goldfinch	WLC	FO,GR,UR	GR	B
CAPU1	Carpodacus	purpureus	Purple finch	WUC	FO	FR,GR	B
CATR	Carduelis	tristis	American goldfinch	WLC	FO,GR,SHR	GR,OM	B
CAUS	Catharus	ustulatus	Swainsons thrush	WLC	FO	OM	A
CEAL	Ceryle	alcyon	Belted kingfisher	UN	RI	PI	B
CHGR	Chondestes	grammacus	Lark sparrow	GR,WLC	GR,UR	GR,OM	A
CHMI	Chordeiles	minor	Common nighthawk	GR,MM	GR,UR	IN	A
CHPE	Chaetura	pelagica	Chimney swift	CA,MM	UR	IN	A
CHVO	Charadrius	vociferus	Killdeer	GR	GR,SHO	IN	NO
CICY	Circus	cyaneus	Northern harrier	GR	GR,SM,SHR	CA	B
CIPA	Cistothorus	palustris	Marsh wren	AQ	SM	IN	B
COAM	Coccyzus	americanus	Yellow-billed cuckoo	WLC	RI,SHR	IN	A
COAT	Coragyps	atratus	Black vulture	CA,CL	GR,SHR	CA	NO
COAU	Colaptes	auratus	Northern flicker	CA	FO,FOE,GR	IN,OM	B
COBR1	Corvus	brachyrhynchos	American crow	WUC	FO,GR,UR	OM	NO
COIN1	Columbina	inca	Inca dove	WLC	SHR,UR	GR	NO
COVI	Colinus	virginianus	Northern bobwhite	GR	FOE,SHR	OM	NO
COVI1	Contopus	virens	Easter wood-pewee	WUC	FO	IN	A
CYCR	Cyanocitta	cristata	Blue jay	WLC	FO,UR	OM	NO
DECH	Dendroica	chrysoparia	Golden-cheeked warbler	WLC	SHR	IN	A

Species Code	Genus	Species	Common Name	Nest Location	General Habitat	Feeding Habit	Neotropic Status
DECO	Dendroica	coronata	Yellow-rumped warbler	WUC	FO	IN,OM	B
DEPE1	Dendroica	petechia	Yellow warbler	WLC	SHR,RI,SM	IN	A
DEVI	Dendroica	virens	Black-throated green warbler	WUC	FO	IN	A
DUCA	Dumetella	carolinensis	Gray catbird	WLC	FOE,RI	OM	A
EGCA	Egretta	caerulea	Little blue heron	WLC	RI,SHO,SM	CR,PI	NO
EGTH	Egretta	thula	Snowy egret	GR,WLC	SM	CA,CR	NO
ELFO	Elanoides	forficatus	American swallow-tailed kite	WUC	FO,RI,SM	CA,IN	A
EMMI1	Empidonax	minimus	Least flycatcher	WUC	FO,RI,SHR	IN	A
EMTR	Empidonax	traillii	Willow flycatcher	WLC	FO,RI	IN	A
EMVI	Empidonax	virescens	Acadian flycatcher	WLC	FO	IN	A
ERAL	Eremophila	alpestris	Horned lark	GR	GR,SHR	GR,OM	B
FASP	Falco	sparverius	American kestrel	CA	FOE,GR,UR	CA,IN	B
FUAM	Fulica	americana	American coot	AQ	RI,SM	HE,OM	NO
GAGA	Gallinago	gallinago	Common snipe	GR	SM	OM,VE	NO
GECA1	Geococcyx	californianus	Greater roadrunner	WLC	SHR	CA,IN	NO
GETR	Geothlypis	trichas	Common yellowthroat	GR,WLC	SHR,SM	IN	A
GUCA	Guiraca	caerulea	Blue grosbeak	WLC	FOE,GR,RI	OM	A
HIPY	Hirundo	pyrrhonota	Cliff swallow	CL,MM	UR,RI,SHR	IN	A
HIRU	Hirundo	rustica	Barn swallow	CL,MM	UR,RI,SHR	IN	A
ICGA	Icterus	galbula	Northern oriole	WUC	FO,UR	OM	A
ICSP	Icterus	spurius	Orchard oriole	WLC	FO,RI,UR	IN	A
ICVI	Icteria	virens	Yellow-breasted chat	WLC	RI,SHR,SM	OM	A
LALU	Lanius	ludovicianus	Loggerhead shrike	WLC	GR,SHR	CA	B
MEAU	Melanerpes	aurifrons	Golden-fronted woodpecker	CA	FO,RI	IN,OM	NO
MECA	Melanerpes	carolinus	Red-bellied woodpecker	CA	FO,RI,SM	ON,OM	NO
MEGA	Meleagris	gallopavo	Wild turkey	GR	FO,RI	HE,OM	NO
MIPO	Mimus	polyglottos	Northern mockingbird	WLC	FO,GR,SHR,UR	FR,OM	B
MNVA	Mniotilta	varia	Black-and-white warbler	GR	FO	IN	A
MOAT	Molothrus	ater	Brown-headed cowbird	N	FO,GR,RI,UR	GR,OM	B
MYCI	Myiarchus	cinerascens	Ash-throated flycatcher	CA	FO,SHR	IN	A
MYCR	Myiarchus	crinitus	Great crested flycatcher	CA	FO	FR,IN	A
OTAS	Otus	asio	Eastern screech-owl	CA	FO,RI,UR	CA,IN	NO
PABI	Parus	bicolor	Tufted titmouse	CA	FO,UR	IN,OM	NO
PACA2	Parus	carolinensis	Carolina chickadee	CA	FO	IN,OM	NO
PACI1	Passerina	ciris	Painted bunting	WLC	RI,SHR	OM	A
PACY	Passerina	cyanea	Indigo bunting	WLC	FOE,SHR	OM	A
PADO1	Passer	domesticus	House sparrow	CA,MM	GR,UR	GR	NO
PASA	Passerculus	sandwichensis	Savannah sparrow	GR	GR,SM	GR,OM	B
PEER	Pelecanus	erythrorhynchos	American white pelican	GR	SHO,SM	PI	NO
PHNU	Phalaenoptilus	nuttallii	Common poorwill	GR	GR,SHR	IN	B
PHOL	Phalacrocorax	olivaceus	Olivaceous cormorant	GR,WLC	RI	PI	NO
PHTR	Phalaropus	tricolor	Wilson's phalarope	GR	RI,SHO,SM	IN	NO
PIER	Pipilo	erythrophthalmus	Rufous-sided towhee	GR,WLD	SHR	OM	B
PIFU	Pipilo	fuscus	Brown towhee	WLC	SHR	OM	NO
PIOL	Piranga	olivacea	Scarlet tanager	WUC	FO	IN	A
PIPU	Picoides	pubescens	Downy woodpecker	CA	FO,UR	FR,IN	NO
PIRU	Piranga	rubra	Summer tanager	WUC	FO	IN	A
PISC	Picoides	scalaris	Ladder-backed woodpecker	CA	FO,SHR	FR,IN	NO
POCA	Polioptila	caerulea	Blue-gray gnatcatcher	WLC	FO,RI	IN	A
POGR	Podiceps	grisegena	Red-necked grebe	AQ	RI,SHO,SM	CR,IN,PI	NO
POGR1	Pooecetes	gramineus	Vesper sparrow	GR	GR	GR,OM	B
PRSU	Progne	subis	Purple martin	CA,MM	FO,RI,SM,UR	IN	A
QUME	Quiscalus	mexicanus	Great-tailed grackle	WLC	GR,SHR	OM	NO
QUQU	Quiscalus	quiscula	Common grackle	WLC	GR,UR	OM	NO

Species Code	Genus	Species	Common Name	Nest Location	General Habitat	Feeding Habit	Neotropic Status
RECA	Regulus	calendula	Ruby-crowned kinglet	WUC	FO,SHR	IN	B
RIRI	Riparia	riparia	Bank swallow	UN	RI,SHO	IN	A
SAPH	Sayomis	phoebe	Eastem phoebe	CL,MM	FO,GR,RI,UR	IN	B
SERU1	Setophaga	ruticilla	American redstart	WLC	FO,SHR	IN	A
SISI	Sialia	sialis	Eastem bluebird	CA	FO,GR,UR	FR,IN,OM	B
SPAM	Spiza	americana	Dickcissel	GR,WLC	GR	GR,OM	A
SPPA1	Spizella	pallida	Clay-colored sparrow	SLC	SHR	OM	A
SPPA2	Spizella	passerina	Chipping sparrow	WLC	FOE,RI,UR	GR,OM	A
SPPU1	Spizella	pusilla	Field sparrow	WLC	GR	GR,OM	NO
STMA2	Sturnella	magna	Eastern meadowlark	GR	GR	IN,OM	B
STNE1	Sturnella	neglecta	Western meadowlark	GR	GR	IN,OM	B
STSE	Stelgidopteryx	serripennis	Nothem rough-winged swallow	UN	RI,SHO	IN	A
STVA	Strix	varia	Barred owl	CA	FO,SM	CA	NO
STVU	Sturnus	vulgaris	European starling	CA	GR,SM,UR	OM	NO
THBE	Thryomanes	bewickii	Bewicks wren	CA	RI,SHR	IN	NO
THLU	Thryomanes	ludovicianus	Carolina wren	CA	FO,SHR	IN	NO
TORU	Toxostoma	rufum	Brown thrasher	GR,WLC	SHR,UR	OM	NO
TRAE	Troglodytes	aedon	House wren	CA,MM	SHR,UR	IN	A
TRFL	Tringa	flavipes	Lesser yellowlegs	GR	SHO,SM	CR,IN	NO
TRME	Tringa	melanoleuca	Greater yellowlegs	GR	SHO,SM	IN,PI	NO
TUMI	Turdus	migratorius	American robin	WLC	FO,GR,UR	OM,VE	B
TYFO	Tyrannus	forficatus	Scissor-tailed flycatcher	WUC	GR	IN	A
TYTY	Tyrannus	tyrannus	Eastern kingbird	WUC	FOE,GR,UR	IN	A
TYVE	Tyrannus	verticalis	Western kingbird	WUC	GR,SHR	IN	A
VERU	Vermivora	ruficapilla	Nashville warbler	GR	SHR	IN	A
VIAT	Vireo	atricapillus	Black-capped vireo	WLC	SHR	IN	A
VIBE	Vireo	bellii	Bells vireo	WLC	SHR	IN	A
VIFL	Vireo	favifrons	Yellow-throated vireo	WUC	FO,RI	IN	A
VIGI	Vireo	gilvus	Warbling vireo	WUC	FO,RI	IN	A
VIGR	Vireo	griseus	White-eyed vireo	WLC	SHR	IN,OM	A
VIOL	Vireo	olivaceus	Red-eyed vireo	WUC	FO,UR	IN	A
VISO	Vireo	solitarius	Solitary vireo	WLC	FO	IN,OM	A
WICI	Wilsonia	citrina	Hooded warbler	WLC	FO	IN	A
WIPU	Wilsonia	pusilla	Wilsons warbler	GR	RI,SHR	IN	A
ZEMA	Zenaida	macroura	Mourning dove	WLC	GR,UR	GR	B
ZOAL	Zonotrichia	albicollis	White-throated sparrow	GR	FO,SHR,UR	GR,OM	B
ZOLE	Zonotrichia	leucophrys	White-crowned sparrow	GR	RI,SHR,UR	GR,OM	B

Key to Table 14

Nesting Location/Substrate Information

AQ	Aquatic (in emergent vegetation)
CA	Cavity
CL	Cliffs
GR	Ground
HAG	Herbaceous-above ground
MM	Man-made structures
N	None (nest parasitizers)
UN	Underground (in burrows)
WLC	Woody-lower canopy
WUC	Woody-upper canopy

General Habitat Association Information

FO	Forest
FOE	Forest edge
GR	Grassland
RI	Riparian
SHO	Shoreline
SHR	Shrubland
SM	Swamp/marsh
UR	Urban

Foraging Affinity Information

CA	Camivore (animal flesh)
CR	Crustaceovore (custaceans: crabs, crayfish, shrimp, etc.)
FR	Frugivore (fruit)
GR	Granivore (seeds)
HE	Herbivore (herbaceous vegetation)
IN	Insectivore (insects)
MO	Molluscovore (mollusks: clams, mussels, etc.)
OM	Omnivore (plant and animal matter)
PI	Piscivore (fish)
VE	Vermivore (worms)

Neotropical Migrant Status Information

A	Breed in North America and winter south of the United States. Considered to be "true" Neotropical Migrants.
B	Generally breed and winter in North America, but some populations winter south of the United States.
C	Primarily tropical species with the extreme northern portion of their breeding range extending to the Rio Grande Valley in the southern United States.
D	Tropical Species whose breeding range in the United States is restricted to the Florida Peninsula.
NO	A non-neotropical migrant species.

The installation checklist is derived by generating a list of all unique vertebrate identification codes for the class Aves for the year(s) in question. The time of the survey (a.m. or p.m.) and status of the plot (core or special-use) are irrelevant. Incidental sightings and flyovers are also included. If the full checklist list is not required, the most abundant species or just those species listed in the report may be included.

The installation species checklist is an important but often under-appreciated analysis. Standard, repeatable LCTA bird surveys provide site-specific records that are essential in environmental impact assessment and other requirements of the National Environmental Policy Act (NEPA). Interestingly, Stohlgren and Quinn (1992) reported that of floral and faunal checklists in 40 national parks and monuments in the U.S. Forest Services's Western Region, none were based on systematic surveys of the areas themselves. They further asserted that the majority of the checklists were less than 80 percent complete. A reliance on range maps obtained from field guides is clearly not adequate when compiling an avian checklist. Species ranges for birds are rarely static but are continually expanding or contracting in response to habitat fragmentation, the removal of historic barriers to dispersal, ecological succession, the weather, and countless other biotic and abiotic influences. Furthermore, if suitable habitat exists on an installation it cannot be presumed, although its possible, that all species associated with that habitat indeed occur there.

Table 14 was based solely on bird surveys conducted in the spring and early summer and as such cannot be considered a comprehensive checklist. To a much greater extent than for small mammals, species composition in birds is a function of season, often with distinctly different avian communities occurring on an installation in the spring/fall, summer, and winter. Fort Drum, NY, for example, augmented its spring LCTA bird surveys over a 2-year period with corresponding winter LCTA bird surveys. These winter surveys were intentionally timed to coincide with the national Christmas bird counts, providing a broader context in which to interpret the LCTA results.

Because the nesting season is extremely critical in maintaining bird populations and because conducting one survey period per season (4 total) would be very labor-intensive and costly, the LCTA standard survey effort was restricted to the nesting season. Unfortunately, spring and summer are often the busiest times of the year for military training exercises and access to LCTA plots is often difficult to schedule. An installation's checklist will not be completed in just 1 or 2 years, but is an evolving process. Some species will be present each year while others only intermittently. In summary, how accurately the LCTA checklist reflects the actual diversity of species using the installation's resources annually depends on many factors including observer skill, chance, the weather, number of plots surveyed, number of surveys per plot, survey season, use of special-use plots, and effects from adjacent concurrent military or civilian activity.

Average and Relative Frequency Counts of Bird Species Within Foraging Guilds

Table 15 summarizes all bird observations per year by general foraging strategy (affinity). Additional information includes the year, percentage of total birds observed per year per guild, and average number of birds observed per plot.

Number of plots is the number of plots on which at least one bird from the guild was observed. Percentage of total is the proportion of the total number of birds observed that were classified as belonging to the guild. The number of birds is defined as the average number of birds per plot that belonged to the guild. Species of birds that belong to more than one guild were included in each guild. As a consequence, the total number of birds may be higher than the total number of birds listed in the species summary.

Table 15. Average number per plot and relative frequency of birds based on foraging guild membership for Fort Hood, TX.

Food	1989			1990			1991			1992		
	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %
Omnivore	100	12	45.9	100	17.1	47.5	100	21.1	41.7	100	20.4	42.3
Insectivore	100	7.2	28.5	100	9.5	26.4	100	15.4	30.5	100	15.7	32.6
Granivore	98	3.9	15.5	100	5.6	15.6	100	8.3	16.5	100	6.6	13.8
Frugivore	66	1.4	5.6	95	2.5	7.0	100	2.5	4.9	95	2.5	5.2
Carnivore	54	1.1	4.4	38	1.1	3.1	86	2.6	5.2	86	2.3	4.7
Piscivore	2	0	0.1	7	0.1	0.2	11	0.2	0.5	20	0.3	0.7
Herbivore	0	0	0.0	0	0.0	0.0	14	0.3	0.6	18	0.3	0.5
Crustaceovore	0	0	0.0	5	0.1	0.1	9	0.1	0.2	9	0.1	0.2
Molluscovore	0	0	0.0	0	0.0	0.0	2	0.0	0.0	0	0.0	0.0
Vermivore	0	0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.0	0.0
Total	na	25	100.0	na	36.0	100.0	na	50.6	100.0	na	48.2	100.0

*Based on morning surveys of 56 core plots.

Table 15 indicates that approximately 41 to 47 percent of the bird species on Fort Hood are omnivorous; that is, they are generalists that eat a variety of foods including insects, plant matter, and seeds. Insectivores (insect eaters), many of which are neotropical migrants, and granivores (seed eaters) comprised approximately 30 percent and 15 percent of the Spring bird population, respectively (Figure 8). While Table 15 does not specifically address the issue of species turnover within a guild, relative guild membership deviated only slightly between years, suggesting a degree of functional stability was maintained at least during the nesting seasons over this 4-year period. However, the contribution of each foraging guild to the total would be expected to change seasonally in response to the general decrease in forage availability (e.g., insects and soft mast) in the winter months. The magnitude of this community shift would likely be far more pronounced in the northern United States than on Fort Hood, but it should be anticipated nonetheless.

Again, Table 15 does not provide for cause and effect determinations, and significant changes in the relative foraging guild abundance may reflect ecological succession, an unusually cold or warm spring, a prey species' natural population cycle, and observer bias. These fluctuations might also have been induced or simply intensified by human impacts such as military training, pesticide application, habitat fragmentation, or a combination of these factors. In the case of neotropical migrant species, shifts in guilds could very well be a result of disturbances or resource constraints occurring on the wintering grounds in central and South America, or during migration. Fluctuations in guild relative abundance and composition are therefore best viewed not in isolation, but in concert with other applicable LCTA vegetative and wildlife summaries.

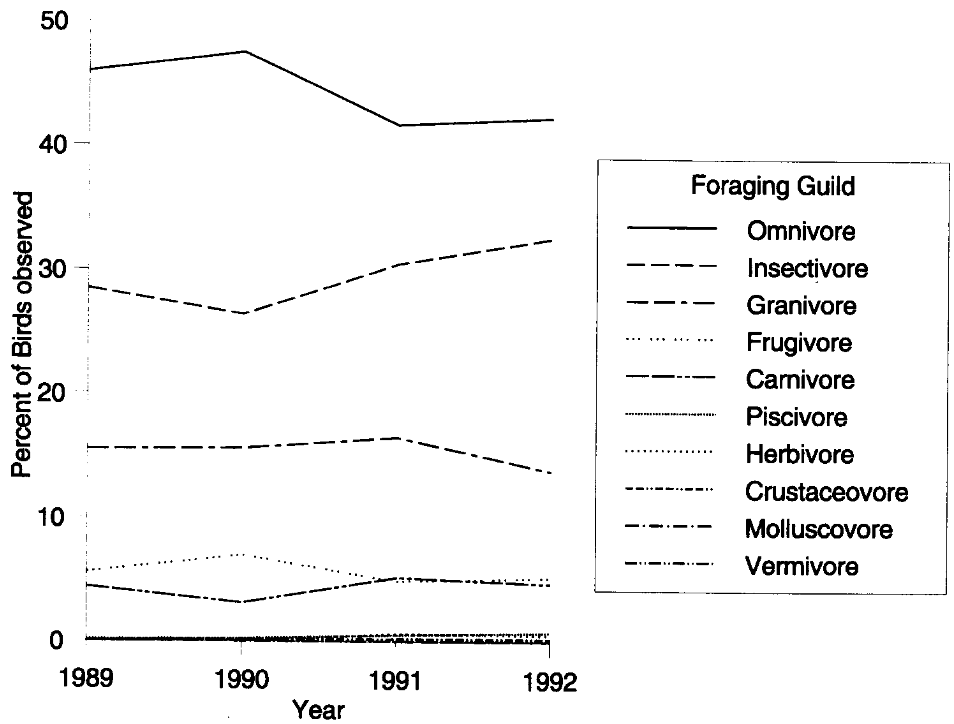


Figure 8. Percentage of birds observed by foraging guild and year for Fort Hood, TX.

Absolute and Relative Frequency Counts of Birds by General Habitat Association

The values in Table 16 reflect the grouping of birds by general habitat association for each year of data. Habitat guilds depict the general environment in which a species is commonly associated with. Information includes the year, habitat guild, percentage of total birds observed per year per guild, and average number of birds observed per plot. Number of plots is the number of plots on which at least one bird from the guild was observed. Percentage of total is the proportion of the total number of birds observed that were classified as belonging to the guild. The number of birds is defined as the average number of birds per plot that belonged to the guild. Species of birds that belong to more than one guild were included in each guild. As a consequence, the total number of birds may be higher than the total number of birds listed in the species summary.

Table 16. Average number per plot and relative frequency of birds within general habitat associations for Fort Hood, TX.

	1989			1990			1991			1992		
Habitat	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %
Grassland	100	8.1	30.9	100	11.4	27.7	100	16.2	32.0	100	13.6	29.4
Forest	95	5.2	19.6	100	9.0	21.9	100	8.8	17.4	100	8.6	18.6
Urban	96	4.9	18.6	100	8.0	19.5	100	9.3	18.3	100	7.5	16.3
Shrubland	96	4.1	15.5	100	5.7	13.8	100	7.6	15.0	100	7.4	16.1
Riparian	84	2.6	9.9	91	4.6	11.2	96	4.8	9.4	95	5.0	10.9
Forest edge	68	0.9	3.6	66	1.2	2.8	95	2.0	4.0	84	2.4	5.1
Shoreline	21	0.3	1.0	16	0.2	0.5	39	0.6	1.1	36	0.5	1.0
Swamp/marsh	18	0.3	0.9	20	1.1	2.6	45	1.4	2.8	52	1.1	2.5
Total	na	26.4	100.0	na	41.2	100.0	na	50.7	100.0	na	46.1	100.0

*Based on morning surveys of 56 core plots.

Table 16 summarizes the avian species assemblages on Fort Hood based on general habitat associations. Unlike many small mammals, birds rarely spend their entire lives within one well-defined habitat type but have home ranges that often intersect numerous habitats and landscapes which, again, can vary by season. It is assumed that core plots were allocated to the various habitat types in proportion to their land area as specified by Tazik and others (1992), and deficiencies in that regard represent a potentially serious source of bias for analysis of Table 16 data. Specifically, based on LCTA plots, 65 percent of Fort Hood was classified as perennial grassland (Tazik, Grzybowski, and Cornelius 1993), and Figure 9 in fact suggests a preponderance in the grassland avian guild. Inferences based on published habitat associations are confounded by site-specific variables in addition to the same factors previously described in the discussion of Table 15 (foraging guilds). Significant changes in relative guild frequencies could reflect a large-scale degradation or improvement of a habitat type, but should not be assumed. Frequent between-year deviations with no clear direction (positive or negative) could indicate major changes in the vegetative characteristics of certain habitats, or that there were changes in survey personnel, plot location, or in bird survey methodology. In Table 15, the perceived changes in the spring/summer avian community over the 4 years are minor and consistency in both plant community composition and avian survey methodology were maintained, suggesting this variability was natural.

Average per Plot and Relative Frequency Counts of Birds Based on Neotropical Migrant Status

Table 17 and Figure 10 summarize all observed birds per year by neotropical migration status. Neotropical migration status denotes a species migration behavior.

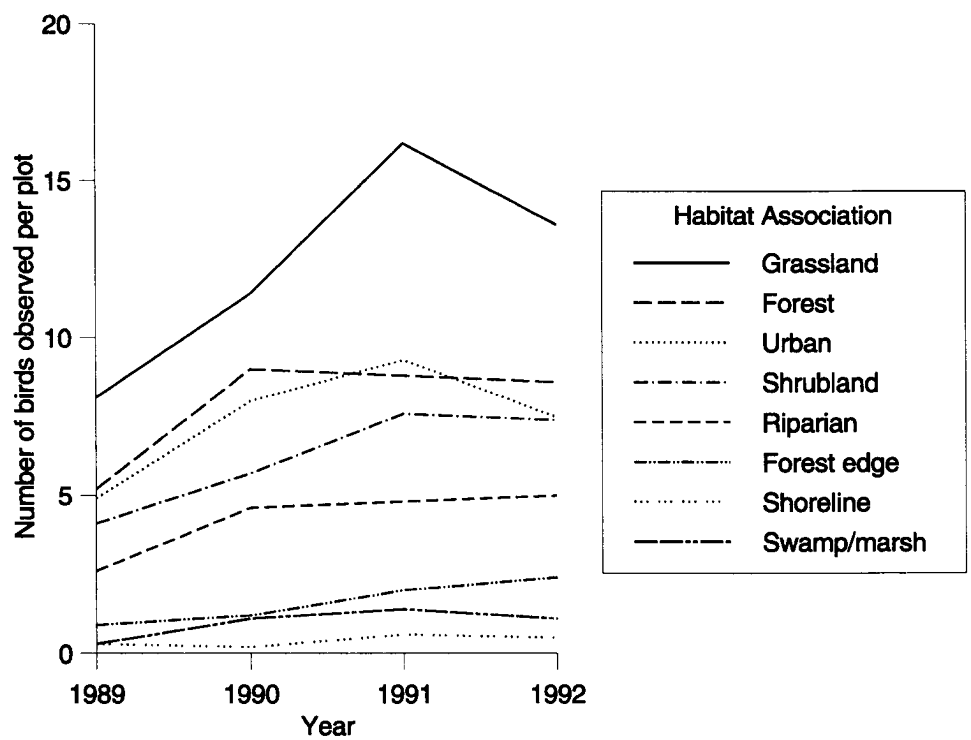


Figure 9. Number of birds observed per plot by habitat association and year for Fort Hood, TX.

Table 17. Average number per plot and relative frequency of birds by neotropical migrant status for Fort Hood, TX.

	1989			1990			1991			1992		
Neotropical status	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %
A**	100	5.4	30.8	100	7.4	30.4	100	11.5	32.9	100	10.8	32.6
B	98	5.1	29.2	100	7.6	31.2	100	8.4	24.2	100	7.4	22.5
C	0	0.0	0.0	0	0.0	0.0	5	0.1	0.2	0	0.0	0.0
D	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
NO	96	7.1	40.0	98	9.3	38.4	100	14.9	42.7	100	14.9	44.9
Total	na	17.6	100.0	na	24.2	100.0	na	34.9	100.0	na	33.2	100.0

*Based on morning surveys of 56 core plots.
**Neotropical species codes:
A Breed in North America and winter south of the United States. Considered to be "true" Neotropical Migrants.
B Generally breed and winter in North America, but some populations winter south of the United States.
C Primarily tropical species with the extreme northern portion of their breeding range extending to the Rio Grande Valley in the southern United States.
D Tropical Species whose breeding range in the United States is restricted to the Florida Peninsula.
NO A non-neotropical migrant species (e.g., a year-round resident).

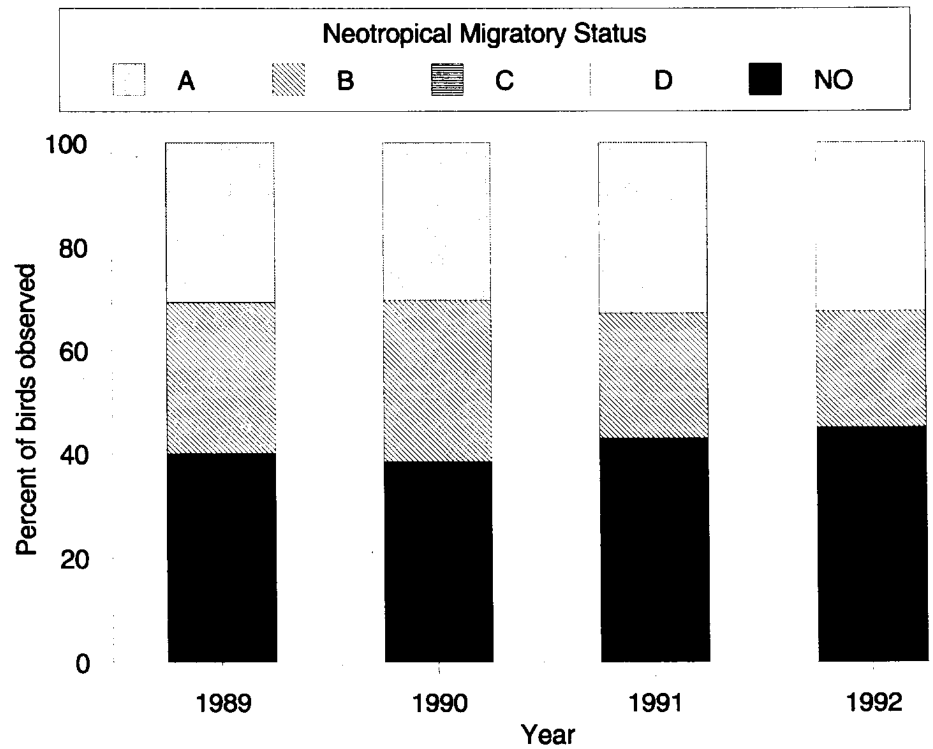


Figure 10. Mean percentages of birds observed on LCTA plots based on neotropical migrant status and year for Fort Hood, TX.

Information includes the year, neotropical status, percentage of total birds observed per year by class, and average number of birds observed per plot. Number of plots is the number of plots on which at least one bird from the guild was observed. Percentage of total is the proportion of the total number of birds observed that were classified as belonging to the guild. The number of birds is defined as the average number of birds per plot that belonged to the guild.

The designation of avian species as Class A through D neotropical migrants is in agreement with designations as provided in the *Partners in Flight* Newsletter (1992). Species of birds that belong to more than one guild were included in each guild. As a consequence, the total number of birds may be higher than the total number of birds listed in the species summary.

Neotropical migrants are an important constituent in natural resource monitoring programs for a number of reasons. Morse (1980) reported that 65 to 85 percent of the breeding species in Eastern U.S. forests were neotropical migrants, representing a significant contribution to both local and regional biodiversity. The approximate percentage of the avian communities in the Southern Great Plains or Western United States that are expected to be neotropical migrants is not known, but represents a highly significant contribution. Neotropical migrants, more so than year-round resident species, tend to respond quickly to environmental disturbance, although some species clearly are more acceptable as environmental indicators of ecosystem health than others. The ovenbird, a forest-associated species, and the Upland Sandpiper, a grassland-associated species, are Class A neotropical migrant species that are highly sensitive to forest or grassland fragmentation and require environmental conditions frequently associated with large blocks of contiguous habitat (Herkert et al. 1993). A *persistent* breeding presence of these or similar species in an area among years could therefore be taken as evidence that suitable forest-interior or grassland-interior conditions exist. In contrast, the Eastern Wood Pewee (forest associated) and Dickcissel (grassland associated) are also Class A neotropical migrants that exhibit low sensitivities to fragmentation of their respective habitats (Herkert et al. 1993), and are therefore less desirable as indicators of habitat change.

Severe declines in many neotropical migrant species were reported by Askins and others (1990) during the 1940s to 1980s across much of North America, but more recent investigations suggest these declines have leveled off or improved for a number of species (Droege and Sauer 1990; Peterjohn and Sauer 1993). Positive or negative trend notwithstanding, deviations in neotropical breeding populations on an installation could very likely be a reflection of landscape-level factors acting on the species on their wintering grounds in Central or South America (Terborgh 1989; Finch 1991).

Absolute and Relative Frequency Counts of Birds by Nesting Guild

Table 18 summarizes by year, all birds observed on all 56 plots and categorizes them by nesting guild. A nesting guild includes the birds that require a specific habitat structure for nesting activity.

Number of plots is the number of plots on which at least one bird from the guild was observed. Percentage of total is the proportion of the total number of birds observed that were classified as belonging to the guild. The number of birds is defined as the average number of birds per plot that belonged to the guild. Species of birds that belong to more than one guild were included in each guild. As a consequence, the total number of birds may be higher than the total number of birds listed in the species summary.

Table 18. Average number per plot and relative frequency of birds based on nesting guild for Fort Hood, TX.

	1989			1990			1991			1992		
Nesting Habit	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total%
Woody-lower canopy	100	8.4	40.2	100	11.8	40.4	100	14.3	33.8	100	14.2	35.9
Ground	98.2	4.9	23.3	91	6.1	20.9	100	9.9	23.4	100	9.4	23.7
Cavity	89.3	3.6	16.9	89.3	5.5	18.9	98.2	8.9	20.9	94.6	8.3	21.0
Cliffs	51.8	1.5	7.1	53.6	1.6	5.6	91	3.2	7.6	78.6	2.4	6.2
Woody-upper canopy	66.1	0.9	4.5	50	1.2	4.0	98.2	3.1	7.4	89.3	3.1	7.9
Man-made structures	37.5	0.9	4.2	39.3	1.6	5.5	71.4	1.8	4.3	62.5	1.3	3.4
None (nest parasitizers)	53.6	0.8	3.8	67.8	1.3	4.4	83.9	1.0	2.3	44.6	0.7	1.7
Underground	0	0.0	0.0	3.6	0.1	0.2	5.4	0.1	0.2	5.4	0.1	0.2
Aquatic	0	0.0	0.0	0	0.0	0.0	1.8	0.0	0.0	3.6	0.0	0.1
Herbaceous-above ground	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	na	21.0	100.0	na	29.3	100.0	na	42.3	100.0	na	39.5	100.0

*Based on morning surveys of 56 core plots.

Approximately 37 percent of the birds on Fort Hood are classified as woody-lower canopy nesters on average, but other guilds appear to be well represented (Figure 11). In interpreting this and other multi-year LCTA bird data sets, several points should be remembered if strong negative or positive trends are perceived. A significant reduction in a guild between years could be an indication of habitat degradation or loss, but this should not be assumed. Conversely, a significant increase in a particular guild could indicate an increase in habitat quantity or improvement in habitat quality, but again this should not be assumed. Continuity in survey timing, personnel, and methodology should be verified before inferences or conclusions are drawn. And lastly (again), a relatively large portion of breeding species on an installation could be neotropical migrants, and investigators (Morse 1980; Peterjohn and Sauer 1993; Terborgh 1989) caution against drawing cause and effect conclusions based on abundance data alone.

Table 18 contains data that is particularly useful for biological diversity conservation and environmental impact assessment. The long-term survival of a species within an area depends largely on its ability to successfully reproduce. Moreover, it has been reported that avian species with relatively few potential nest sites and/or a lower reproductive potential have an increased risk of extirpation or extinction (Mertz 1971). Although reproductive success and other parameters are not directly measured in LCTA, the characterization of an installation's bird community based on nesting tendencies provides land managers an additional tool to predict, reduce, or mitigate impacts from future actions. For example, if a bivouac site were proposed to be created in a previously undisturbed woodland habitat, the potential impacts to the ground, herbaceous-above ground, and woody-lower canopy guilds would likely be greater than those anticipated for the other guilds (e.g., cavity or man-made structure nesters). In fact, Table 18 suggests that approximately 60 percent or more of the birds observed

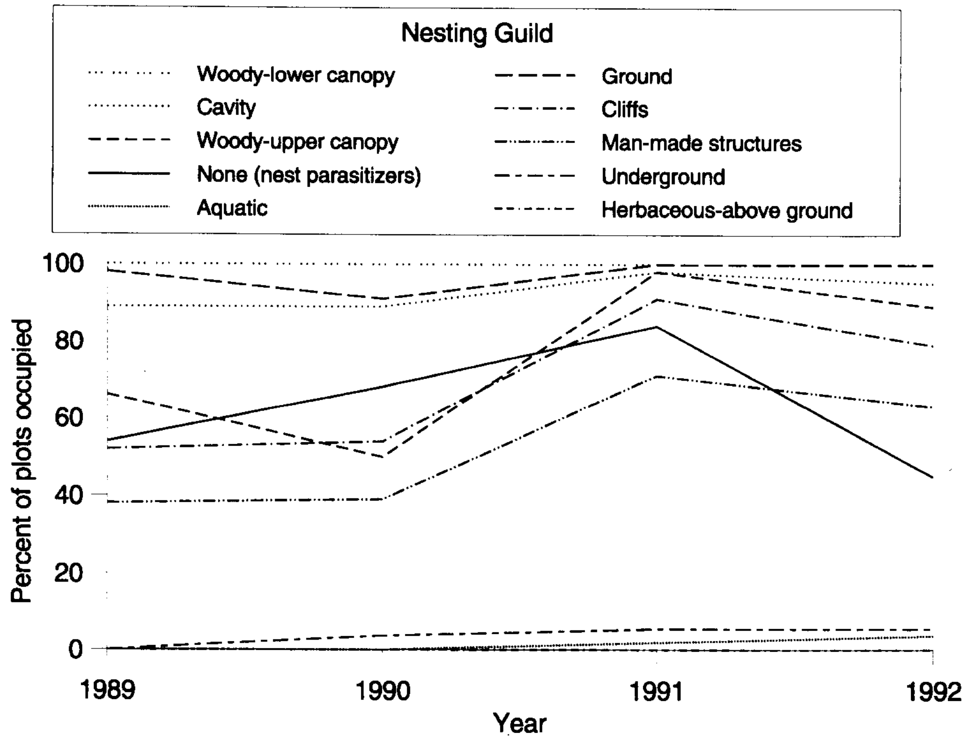


Figure 11. Percentages of birds observed on LCTA plots based on nesting guild affinity for Fort Hood, TX.

during the nesting season would potentially be negatively affected. Monitoring changes in nesting guilds therefore can be viewed as a crude index of habitat stability (in a structural sense), but more appropriately serves as a warning signal of potential negative impacts if increasingly fewer potential nesters are observed within a guild. If a significant negative trend is perceived in one or more guilds, controlled investigations should then be initiated to confirm the observed changes in the affected guild(s) and develop a mitigation strategy if appropriate.

Absolute and Relative Frequency Counts of Selected Avian Species Followed Over a 4-year Period

Table 19 uses 1989 as a base year, summarizes the 20 bird species most frequently observed from that year, and reports their status for the following 3 years. Information includes the number of plots the birds were found on, the percentage of the overall

Table 19. Average number and relative frequency of the 20 most abundant bird species in 1989 at Fort Hood, TX, followed over 4 years.

	1989			1990			1991			1992		
Species	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plots %	Birds #	Total %	Plot s%	Birds#	Total %
AICA1	21	0.3	1.9	4	0.0	0.1	27	0.5	1.3	7	0.1	0.3
AMSA	13	0.3	1.6	9	0.2	0.9	43	0.7	2.1	36	0.8	2.3
CAAU	32	0.7	3.7	29	1.0	3.9	68	1.2	3.5	50	0.8	2.4
CACA4	77	1.9	10.9	80	2.6	10.7	88	1.5	4.1	88	1.9	5.6
CHGR	54	1.1	6.3	70	1.6	6.8	100	1.3	3.7	88	1.0	3.1
CHMI	18	0.3	1.5	18	0.3	1.1	38	0.5	1.5	29	0.4	0.9
COAM	48	0.6	3.1	54	0.6	2.5	89	1.0	3.0	61	0.8	2.4
COBR1	29	0.3	1.8	21	0.3	1.4	63	1.0	2.8	55	0.9	2.6
COVI	66	0.9	5.2	66	1.1	4.7	95	1.6	4.7	80	1.8	5.4
HIPY	7	0.4	2.0	11	0.2	0.8	14	0.5	1.3	18	0.5	1.1
MIPO	57	1.1	6.3	91	2.0	8.3	98	1.4	3.9	91	1.2	3.7
MOAT	54	0.8	4.6	68	1.3	5.4	80	0.9	2.6	45	0.7	2.0
PABI	52	0.8	4.8	52	0.9	3.8	82	1.3	3.6	82	1.7	5.2
PACA2	29	0.5	2.7	38	0.7	2.9	84	1.5	4.2	75	1.5	4.5
PACI1	66	1.0	5.9	77	1.2	5.1	91	1.0	2.8	86	1.1	3.3
SPPU1	23	0.3	1.6	41	0.7	3.0	54	0.8	2.4	34	0.6	1.9
STMA2	39	1.0	5.6	45	1.8	7.3	61	1.2	3.4	46	1.1	3.3
THBE	50	0.8	4.6	52	0.7	2.9	86	1.0	2.8	86	1.0	3.1
TYFO	20	0.3	1.6	27	0.6	2.4	61	0.7	2.0	45	0.6	1.6
ZEMA	50	0.9	5.0	57	0.9	3.7	100	1.5	4.2	95	1.5	4.5

*Based on morning surveys of 56 core plots.

total accounted for by that species, and average number of a species observed per plot. Number of plots is the number of plots on which at least one bird from the guild was observed. Percentage of total is the proportion of the total number of birds observed that were classified as belonging to the guild. The number of birds is defined as the average number of birds per plot that belonged to the guild.

Unlike the preceding tables, which are at the guild level, Table 19 is a quantification of abundance at the species level. Analysis at this tier is required if a particular species needs to be monitored (e.g., threatened and endangered species [TES] or keystone species). Analysis at the species level can also be used in conjunction with guild membership information in Table 14 if species composition or turnover within a guild is of interest. The number of plots each species was observed on provides the context in which to assess distribution, while the percentage of total is an index of each species contribution to the total number of bird observations for the survey period. As a space-saving measure, only the 20 most abundant species observed on core plots were listed in this table. This does not in any way infer a higher "value" was placed on these species. To the contrary, often it is the least common species that are of most concern, especially when addressing issues related to threatened and endangered species management or the conservation of biological diversity. Regardless, these same statistics can be calculated for any and all species existing on a installation to assess trends in abundance or distribution.

Dominance of a species within a community or landscape should not be inferred from relative frequency values, although it might be tempting to do so. One can assess dominance in a meaningful manner only if all species within the plot limits were detected, and the reality that each individual or species does not have an equal chance of being detected makes this unlikely. Caution should also be exercised when assessing a trend for a species. It is possible that a significant change in between-year abundance suggests a longer-term directional movement in the population is occurring, but several other factors should be investigated before declaring a state of emergency. Some of the factors are:

- Was a new survey crew trained?
- Did a change in the weather delay or accelerate spring migration?
- Were the survey dates changed?
- Were plots added or removed from the survey route?

Changes in migrant species abundances can be the result of factors outside the installation boundaries (Morse 1980), and focusing on resident species is one way to reduce some of the spacial and temporal effects, but unfortunately these species generally are very common and unless they are of special concern at the State or Federal level, they are not given a high management priority.

Small Mammal Survey Data Summaries

Survey Methods and Considerations

Small mammals are monitored on the same set of LCTA core plots on which birds are surveyed. A trapline is established approximately 15 m from each side of the line transect and runs parallel to it. Each trapline consists of 20 trap stations approximately 7 m apart. Each trap station consists of one Museum Special snap trap, with a rat trap being placed 2 m away from the 3rd, 7th, 11th, 15th, and 19th station on each side. Sherman live traps can be substituted for the rat and Museum Special traps and are placed in the same pattern. Individuals captured in live traps must be marked to identify those animals captured two or more times. The 50 traps are left on each LCTA plot for 2 consecutive days and nights for a total of 100 trapnights per plot, and 6,000 total trapnights per annual trapping period (assuming 60 core plots are surveyed).

Small mammal surveys are conducted during a period of the year in which trapping success is greatest. In the southern United States this is often in the middle to late winter months, as competition from fire ants is somewhat less severe (Masser and Grant 1986; Gettinger 1990) and the decrease in natural food supply makes many mammalian species more likely to approach the bait. In the northern United States, spring or fall trapping can yield sufficient numbers of captures. Regardless of trapping season, trends can only be discerned if consistency is maintained in trapping season, as small mammals generally have two peaks in abundance. The first peak is in late spring and the second, and often the larger, occurs in early fall. Because of these seasonal highs and lows and multiple litters within a breeding season, it is essential that the trapping period be consistent between years and as short as possible within years to minimize temporal effects.

Unlike the bird surveys previously described, small mammals generally are not merely observed but must be physically captured. It is well known that no single trap design captures all species equally well. Galindo-Leal (1990) reported snap trapping slightly more effective than live trapping at capturing the white-footed mouse (*Peromyscus leucopus*), an abundant species found throughout the United States. In contrast, Museum Special and rat traps with wide plastic treadles often capture shrews (W.R. Whitworth, Principal Investigator, U.S. Army Construction Engineering Research Laboratories, Champaign, IL, professional observation), although pitfall traps have been shown conclusively to be more effective at capturing this taxon (Williams and Braun 1983). Both the design and size of a trap, the weather, and phase of the moon (Kaufman and Kaufman 1982) individually and collectively influence the quantity and diversity of mammals that are likely to respond to bait and get captured (Galindo-Leal 1990; Holdenried 1954; Jorgensen, Demaris, and Whitworth 1994; O'Farrell et al. 1994; Menyak and Guynn 1987; Slade et al. 1993; Weiner and Smith 1972; Yang, Krebs, and Keller 1970). Finally, the scent of previously captured small mammals has been shown to be a significant factor in influencing subsequent captures (Mazder, Capone, and Drickamer 1976; Stoddart 1976; Daly, Wilson, and Faux 1978). These studies highlight the desirability of conducting site-specific studies to determine the optimal trap for an installation.

It should not be assumed that all small mammal species have an equal probability of being captured, although supplementing the standard trapping array with pitfalls and/or additional trap types can increase this probability. Moreover, once a trap is "occupied" or accidentally tripped, it is no longer available to capture another individual that day, further limiting the number of individuals and species that could be recorded on a plot. This is in contrast to the bird surveys in which the maximum number of species and individuals per plot tend to be limited by the speed at which the observer can make positive identifications and record data.

Analyses Emphasis

Small sample sizes for the majority of species recorded each year was a primary constraint in identifying appropriate analyses. One way to compensate for small sample sizes at the species level is to pool data into meaningful groups. Unfortunately, guild analysis seems to be more common with respect to bird populations, and relatively few studies have been published regarding mammals. A number of researchers (Call 1981; Croonquest and Brooks 1991; Severinghaus 1981; MacMahon 1976; Short 1983; and Burnham and Short 1982) address, in varying degrees, the definition and use of mammalian guilds in impact assessment. As with the bird guilds, mammalian guilds have been based on foraging strategy, dependency on a specific microhabitat type, and other more elaborate means of characterizing resource use or ecosystem function.

Small mammal data were not rectified before analysis for two reasons. First, consistency in the number of LCTA plots in which small mammals were surveyed (n = 60) was maintained over the 3-year period. Second, unlike the considerable variability in the two LCTA bird surveys per plot, each small mammal survey lasted for 2 consecutive days, resulting in minimal within-plot temporal bias.

Installation checklist

Table 20 represents a composite of all small mammal captures on all LCTA wildlife plots (including special-use, if any) and any incidental mammalian observations recorded on the installation during one or more LCTA monitoring periods. In contrast to the avian list, this checklist does not provide additional information and as such is not considered annotated. This list was derived by identifying all unique codes recorded under the Class Mammalia. Data from all core plots, special-use plots, and incidental sightings of medium-sized mammals (e.g., raccoon, rabbit), carnivores (e.g., bear, coyotes) and ungulants (e.g., deer) were used.

The importance of an installation checklist being based on standard surveys (e.g., Stohlgren and Quinn 1992) and not range maps from a field guide cannot be overstated. Bogan, Finley, and Petersburg (1988) reported that site-specific studies initiated in and near Dinosaur National Monument in northwestern Colorado added 11 mammalian species to the known fauna. They further emphasized that incomplete knowledge of mammalian fauna on public lands hinders our ability to predict or mitigate management actions.

Unlike the LCTA bird surveys, the LCTA mammalian checklist reflects species composition on the installation with less bias from seasonal effects. In other words,

Table 20. LCTA mammalian checklist for species known to occur on Fort Hood, TX.

VertID	Family	Genus	Species	Common Name
BATA	Muridae	Baiomys	taylori	Northern pygmy mouse
CALA2	Canidae	Canis	latrans	Coyote
CRPA	Soricidae	Cryptotis	parva	Least shrew
LECA1	Leporidae	Lepus	californicus	Black-tailed jack rabbit
MEME1	Mustelidae	Mephitis	mephitis	Striped skunk
NEFL	Muridae	Neotoma	floridana	Eastern woodrat
NEOTOM	Muridae	Neotoma		Woodrats and packrats
ODVI	Cervidae	Odocoileus	virginianus	White-tailed deer
PEAT1	Muridae	Peromyscus	attwateri	Texas mouse
PEBO	Muridae	Peromyscus	boylii	Brush mouse
PEHI	Heteromyidae	Perognathus	hispidus	Hispid pocket mouse
PELE1	Muridae	Peromyscus	leucopus	White-footed mouse
PEMA1	Muridae	Peromyscus	maniculatus	Deer mouse
PEPE2	Muridae	Peromyscus	pectoralis	White-ankled mouse
PEROMY	Muridae	Peromyscus		Deer and white-footed mice
PRLO	Procyonidae	Procyon	lotor	Raccoon
REFU	Muridae	Reithrodontomys	fulvescens	Fulvous harvest mouse
REITHR	Muridae	Reithrodontomys		Harvest mouse
REMO	Muridae	Reithrodontomys	montanus	Plains harvest mouse
SIHI	Muridae	.Sigmodon	hispidus	Hispid cotton rat
SYFL	Leporidae	Sylvilagus	floridanus	Eastern cottontail

the checklist is likely to remain the same whether one was characterizing the summer or the winter mammalian community. This is simply because small mammals in the lower 48 states are less mobile than birds and do not migrate long distances each fall and spring. Bats in general represent the exception to this mobility constraint, but surveys for this order of mammals are optional, not conducted in association with core plots, and therefore are acknowledged to be under-represented in a standard LCTA-based checklist.

Absolute and Relative Frequency of Small Mammals Summarized by Species

In contrast to composition, abundance in small mammals, however, can be strongly correlated with season and is addressed Table 21. The table summarizes total captures, relative abundance, and the mean number captured per 100 trapnights (per plot) per species per year. Percent of plots is the proportion of plots that at least one specimen of the species was trapped. Number of captures is the number of specimens trapped per 100 trapnights. The number of trapnights is the number of traps used multiplied by the number of nights the traps were located at the plot. Percent of total is the relative proportion of all specimens represented by the species.

Populations of some small mammal species fluctuate year to year with little or no consistency in direction while other species undergo regular and predictable cycles.

Table 21. Average number and relative frequency of mammals trapped per 100 trapnights at Fort Hood, TX.

Species	1989			1990			1991		
	Plots %	Captures #	Total %	Plots %	Captures #	Total %	Plots %	Captures #	Total %
BATA	3	0.05	0.9	15.00	0.40	17.1	23	0.93	34.3
CRPA	0	0.00	0.0	1.67	0.02	0.9	8	0.12	4.4
MEME1	0	0.00	0.0	1.67	0.02	0.9	0	0.00	0.0
NEFL	3	0.03	0.6	0.00	0.00	0.0	2	0.02	0.7
NEOTOM	0	0.00	0.0	0.00	0.00	0.0	2	0.02	0.7
PEAT1	50	2.78	51.5	21.67	0.67	28.6	25	0.47	17.3
PEBO	0	0.00	0.0	5.00	0.10	4.3	0	0.00	0.0
PEHI	7	0.08	1.5	13.33	0.22	9.4	7	0.08	3.0
PELE1	22	0.58	10.7	6.67	0.13	5.6	7	0.08	3.0
PEMA1	18	0.53	9.8	15.00	0.27	11.5	0	0.00	0.0
PEPE2	18	0.70	13.0	10.00	0.20	8.5	3	0.03	1.1
PEROMY	3	0.10	1.9	8.33	0.18	7.7	8	0.23	8.5
PRLO	2	0.02	0.4	0.00	0.00	0.0	0	0.00	0.0
REFU	12	0.20	3.7	3.33	0.03	1.3	12	0.28	10.3
REITHR	0	0.00	0.0	0.00	0.00	0.0	5	0.05	1.8
REMO	8	0.12	2.2	5.00	0.05	2.1	7	0.08	3.0
SIHI	3	0.18	3.3	1.67	0.05	2.1	10	0.32	11.8
SYFL	3	0.03	0.6	0.00	0.00	0.0	0	0.00	0.0
Total	na	5.40	100.0	na	2.34	100.0	na	2.71	100.0

The long known and often studied 8- to 11-year cycle of the snowshoe hare (Cox 1936; MacLulich 1937; Elton and Nicholson 1942; Keith and Windberg 1978; Brand and Keith 1979) is one example of a population trend that is fairly predicable. Predators of the hare, specifically the Lynx, can amplify the magnitude of the hares' decline but do not appear to play a role in initiating it. A number of small mammal species (e.g., voles and lemmings) occurring in the United States undergo fairly regular population fluctuation cycles (Jones, Armstrong, and Choate 1985). Fluctuations in some species are more predictable than in others, and are generally not in synchrony throughout the species' entire range. And although population cycles are not completely understood in small mammals (e.g., Krebs and Myers 1974; Desy and Batzli 1989), peaks in density are believed to promote the dispersal of individuals to previously unoccupied areas and habitats (Verner and Getz 1985).

Table 21 indicates dramatic decreases (up to 75 percent) in several species of deer and white-footed mice (*Peromyscus sp.*) abundance, taxon that are generally more tolerant of habitat disturbance than other genera, and in general adapted to a broad range of environmental extremes. Other species exhibited a less pronounced decrease, a slight increase, or no change at all during this period. As was previously mentioned, whenever dramatic between-year changes are observed for a wildlife species, you need to review the species' life-cycle characteristics and verify the consistency in data collection timing and methods before interpreting the data. Table 21, for example, suggests that a significant change in overall mammal abundance occurred between

1989 and 1990, but further study reveals it is more likely an predictable outcome resulting from deviations in data collection protocol. More specifically, LCTA small mammal trapping was initiated on Fort Hood in 1989 and occurred during the months of February through June (approximately 20 weeks). Although abundance is generally lower in winter than late spring or fall, mammals tend to be more trappable because the cooler temperatures result in less foraging overall and reduced competition from fire ants, resulting in more captures. Trapping in 1990 and 1991, however, occurred in August (4 weeks). Abundance during this period should have been moderately high, but a greater quantity of forage was available to attract small mammals away from the traps. In addition, the warm/hot nocturnal temperatures allowed for maximum fire ant activity (quickly consuming the bait), thus contributing to lower rodent capture rates.

In summary, several points related to cyclical tendencies and other characteristics of small mammal populations should be remembered when interpreting LCTA data. First, a peak in a population does not necessarily mean habitat quality is optimal and vise versa. Secondly, although increased military disturbance and a perceived decline in relative abundance are occurring concurrently, a cause and effect relationship should not be assumed. Third, consistency should be maintained within and between trapping periods to permit between-year comparisons. And last, LCTA presence data can be used to generalize species distribution and installation-wide trends, but by itself cannot identify which habitats are sources or sinks.

6 Summary

Inventory and monitoring of land resources is an important fundamental issue in thorough natural resources management. The LCTA program was developed as a means to inventory and monitor natural resources on military installations. The LCTA program uses standard methods of natural resources data collection, analysis, and reporting that are designed to meet multiple goals and objectives. LCTA provides officials at all levels with standard natural resources inventory information for installations across the continental United States and overseas. Specific objectives of LCTA are to: (1) characterize installation natural resources, (2) implement standards for collection, analysis, and reporting of acquired data that enable compilation and reporting 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 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.

This report described several LCTA statistical data analysis procedures and reporting formats designed to meet the needs of individual installations and the Department of the Army. The data summaries are designed to assist in the exploration of LCTA data sets and to highlight patterns in the biotic communities of the installation. The importance, limits, and interpretation of each data summary were provided.

This report emphasized simple univariate descriptive data summaries. These types of summaries are useful for preliminary analysis of LCTA data that characterizes installation natural resources and documents trends in those resources.

It is anticipated that this report will be followed by additional publications on multivariate analyses, plant succession models, and carrying capacity models that make use of LCTA data.

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