# Nesting Habitat Requirements of the Golden-cheeked Warbler

Thesis

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by

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# INTRODUCTION

Currently, 555 bird species are known to have occurred in Texas (Texas Ornithological Society 1984). Of these, only the Golden-cheeked Warbler (Dendroica chrysoparia: Emberizidae) nests only in Texas (Oberholser 1974). The approximate nesting range of this species is the eastern one-third of the Edwards Plateau and the southeastern one-quarter of the Cross Timbers and Prairies ecological areas, as described by Gould (1975). Most recent authors have indicated that the population numbers of the Golden-cheeked Warbler are decreasing due to loss of suitable nesting habitat. Oberholser (1974) discussed 3 main causes for the habitat loss: land clearing for agricultural use, land development for housing, and reservoir construction. As habitat loss continues, we must develop a more refined understanding of habitat suitability requirements for the species.

The Golden-cheeked Warbler was first described by Philip Lutley Sclater and Osbert Salvin following its discovery by Salvin on its wintering grounds in Guatemala (Sclater and Salvin 1860). Little was written about the bird in the ensuing years; however, Benners (1887), Beckham (1888), Attwater (1892), Lacey (1911), and Smith (1916) provided significant natural history information. Chapman (1907) and Simmons (1924) wrote accounts describing the

bird's nesting habitat. Johnston et al. (1952) provided the first quantification of breeding habitat. Pulich (1976) wrote the first comprehensive work on the life history and nesting of the bird. Several unpublished reports have been written by students at the University of Texas at Austin, most notably McDonald (1972), Choban (1974), and Thompson (1983). Kroll (1980) recorded quantitative data on nesting and wintering habitat. Preliminary results of the present study were reported by Baccus and Ladd (1984).

Pulich (1976) forecasted the possible extinction of the Golden-cheeked Warbler by the end of this century. Since the Kerr Wildlife Management Area (KWMA) appears to provide essential habitat necessary for the breeding of this species, the KWMA was chosen as the primary study site. The status of the species at the KWMA was unclear prior to this study. Sightings of the bird had been reported from Spring Pasture at the KWMA. However, no information was available on population density, distribution, amount of preferred habitat, or habitat use in this pasture or others at the KWMA.

The purpose of this study is to provide information on population density, distribution, and habitat characteristics at the KWMA, and to compare habitat characteristics at the KWMA with other areas of Golden-cheeked Warbler habitat throughout the nesting range of the species. A more complete understanding of Golden-cheeked Warbler habitat requirements is necessary for

the management of the species at the KWMA.

Field studies of the Golden-cheeked Warbler were conducted for 3 seasons. Most of the preliminary work of vegetation surveys and initial habitat evaluation at the KWMA was conducted during the spring of 1983. Detailed censusing of the KWMA and visits to other areas were conducted in the spring of 1984, and habitat use was verified during the 1985 nesting season.

## STUDY AREAS

### Kerr Wildlife Management Area

The Kerr Wildlife Management Area (KWMA) is located in western Kerr County, about 19 km west of Hunt, Texas, on Ranch Road 1340 (lat. 39° 04' N., long. 99° 30' W).

The KWMA contains approximately 2,628 ha, of which 717 ha in the southern one-third of the area were used in this study (Fig. 1). Topography of the study area is gently rolling to very hilly, with elevations ranging from approximately 585 m to 661 m. The area is in the watershed of the North Fork of the Guadalupe River, which forms the southern boundary of the KWMA. The study area is drained by several ephemeral tributary systems. The 3 largest creeks in the study area have springs or seeps in their lower reaches, within 1 km of the Guadalupe River. These springs are perennial and flow during the Golden-cheeked Warbler breeding season. Mean annual rainfall for the KWMA is 63 cm, with peak rainfall occurring in August, September, and October. The mean annual temperature is 17.8° C with a January average of 8.9° C and a July average of 26.7° C (Hunter 1983).

Dominant woody species of the canyons and steep slopes of the KWMA study area include Ashe juniper (*Juniperus Ashei*) and Texas oak (*Quercus texana*). Black cherry (*Prunus serotina*), chinkapin oak (*Q. Muhlenbergii*),

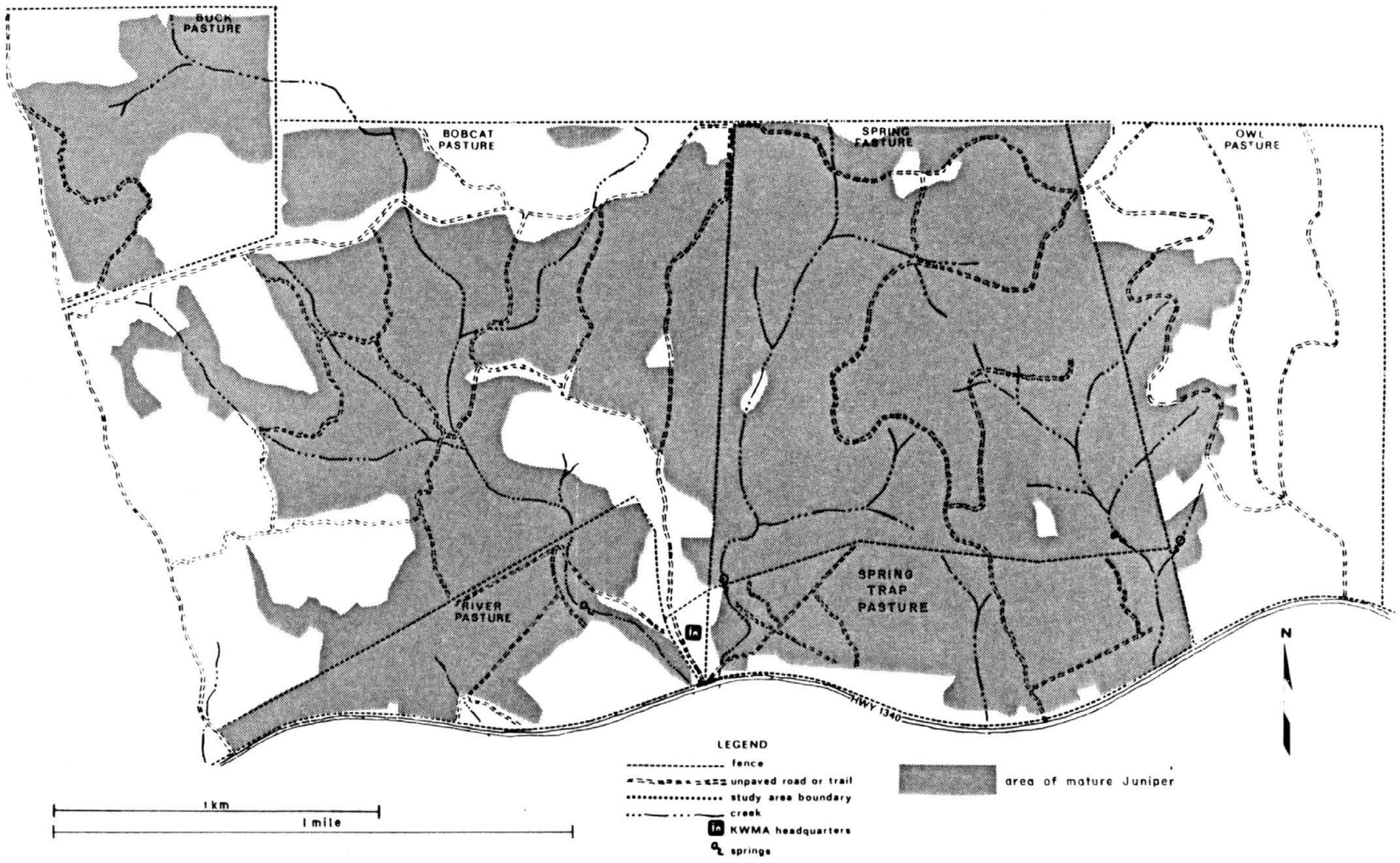


Figure 1. Study area at the Kerr Wildlife Management Area (KWMA).

and walnut (Juglans sp.) occur in the more mesic canyon bottoms. On the hilltops, Ashe juniper and plateau live oak (Q. fusiformis) are common overstory species, with shin oak (Q. sinuata), Texas kidneywood (Eysenhardtia texana), and Texas persimmon (Diospyros texana) common in the shrub layer. Taxonomy follows Correll and Johnston (1979) (Appendix 1).

Additional information on the vegetation of Kerr County and the Edwards Plateau may be obtained from Palmer (1920) and Buechner (1944). Hahn (1951) wrote an account of the history of the KWMA. Background information on the present management of the KWMA was reported by Harmel (1985).

Secondary Study Areas

In addition to the KWMA, 9 secondary study areas were visited (Fig. 2): Lost Maples State Natural Area, Meridian State Recreation Area, Fort Hood Military Reservation, Schneider Ranch, Friedrich Wilderness Park, land owned by the R.E. McDonald family, Wild Basin Wilderness Preserve, Travis Audubon Sanctuary, and Possum Kingdom State Recreation Area. These areas were selected because they had documented populations of Golden-cheeked Warblers and were widely distributed over the breeding range of the species. Location information for these areas is provided in Appendix 2.

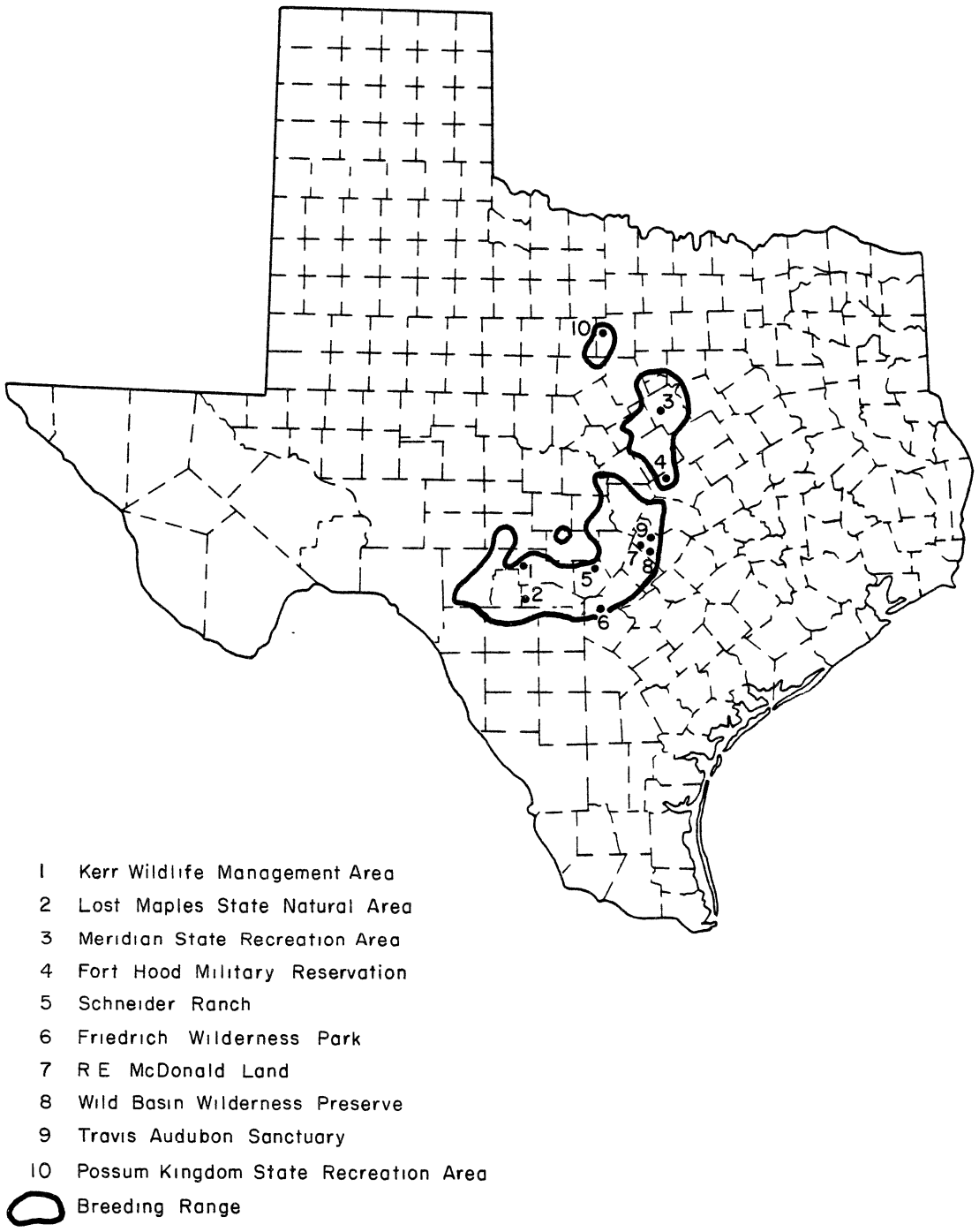


Figure 2. Location of study areas and breeding range (Parrot 1974) of the Golden-cheeked Warbler.

# METHODS AND MATERIALS

## Vegetation Analysis: Point-Centered Quarter Method

The point-centered quarter method (Cottam and Curtis 1956, Brower and Zar 1977) was used to determine relative density, relative frequency, relative dominance, and importance values of woody vegetation at the KWMA study area. Sampling intensity was approximately 1 point per 0.8 ha.

Transect locations were chosen for each pasture by aerial photo interpretation and observation of vegetation patterns during a ground reconnaisance. Vegetation transects were widely spaced to provide for maximum coverage of the different plant community types. Transect locations are shown in Figure 3.

All transects contained 35 points. For most transects, the distance between points was 5 m (170 m total length). Sparseness of vegetation in some areas necessitated an increased distance between points, to avoid duplicate sampling. The point-to-point distance for these transects was 10 m (340 m total length).

Tree size was recorded as diameter at 10 cm height. Formulas used in the determination of relative density, relative frequency, relative dominance, and importance value were obtained from Brower and Zar (1977). Dominance values were calculated from basal areas.

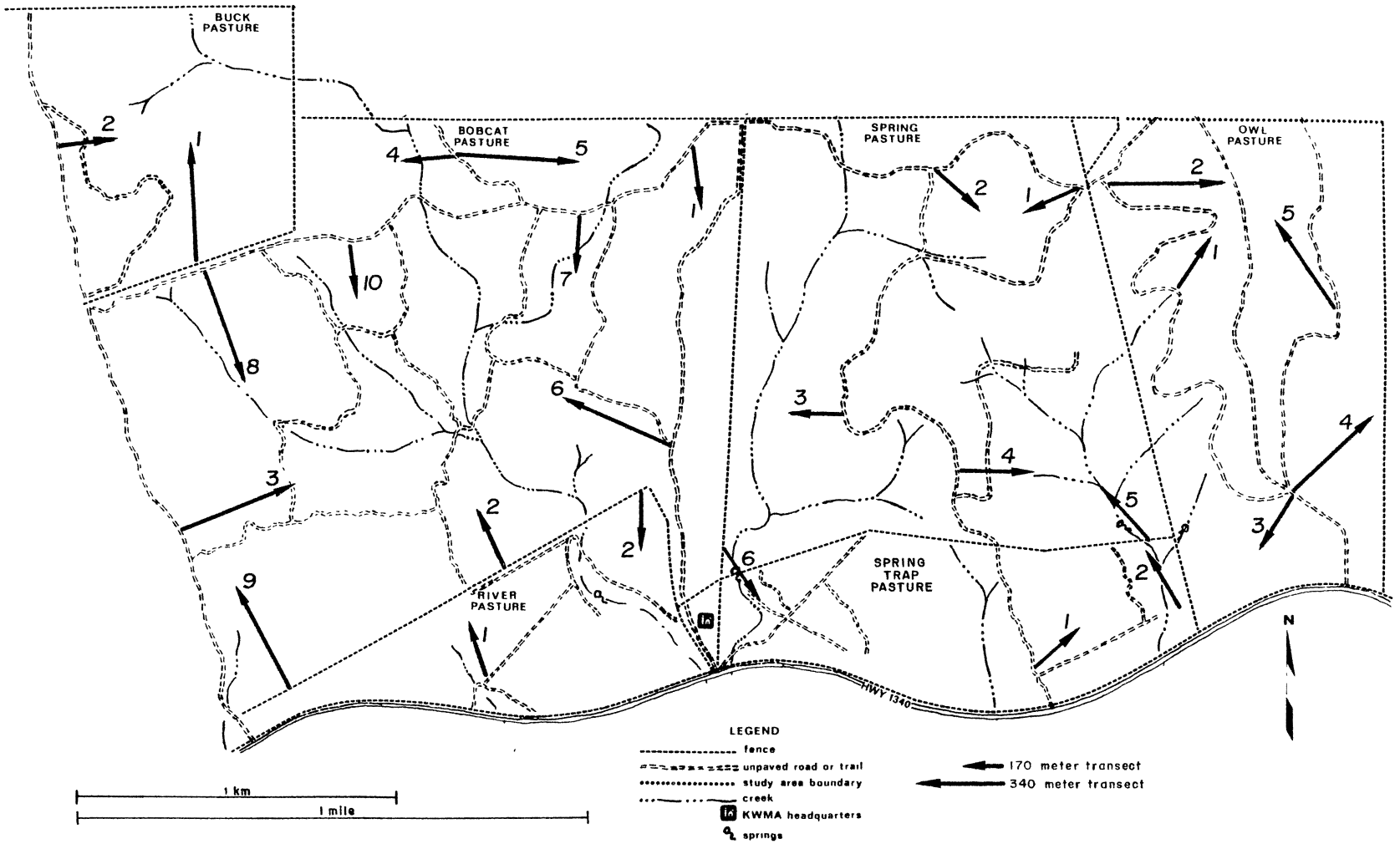


Figure 3. Location of vegetation transects (point-centered quarter method), KWMA, summer 1984.

When plants with a multi-stem growth arrangement were encountered, an ocular estimate of size was used. These estimates were made by comparison with taxonomically related plants of similar height, canopy size, and amount of biomass, but with a single stem.

Vegetation Analysis: Relative Abundance

In all 10 study areas, species lists were compiled for the woody plants observed in Golden-cheeked Warbler habitat. Because no Golden-cheeked Warblers were observed at Possum Kingdom State Recreation Area, it was necessary to subjectively estimate where the most suitable habitat was located in the park, and then compile a species list for those areas.

Each woody species was assigned a numerical value based on its relative abundance: 4 = abundant, 3 = common, 2 = uncommon, and 1 = rare. Abundance values were determined based on observer estimates. The abundance values for each species from the 9 study areas with warblers were then summed and ranked to give a total abundance value indicative of the abundance of that plant species in Golden-cheeked Warbler habitat (maximum possible = 36).

Golden-Cheeked Warbler Censusing

Four transects were established on the KWMA study area to locate areas with Golden-cheeked Warbler populations (Fig. 4). Transect census routes were widely spaced to

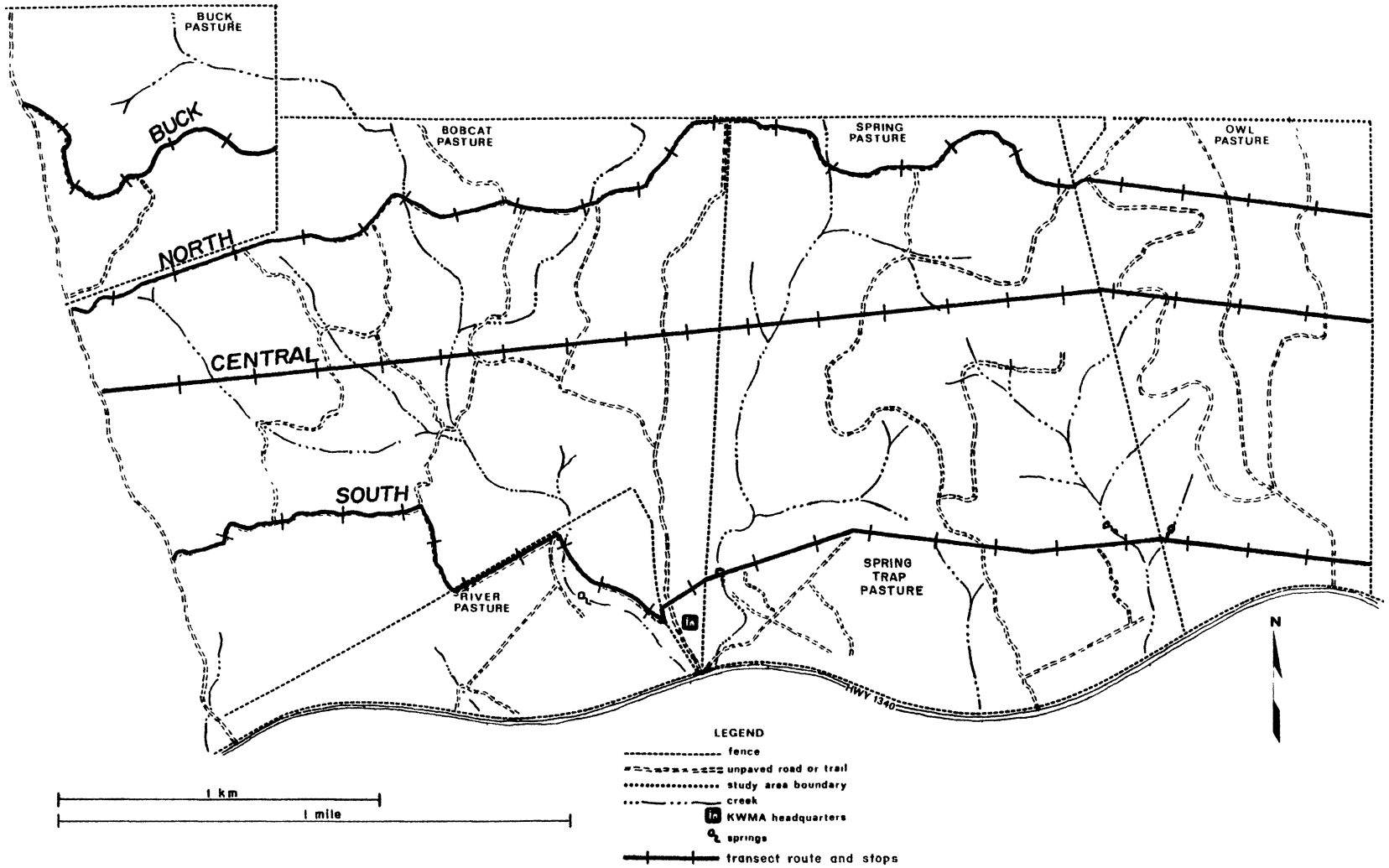


Figure 4. Transects used for locating Golden-cheeked Warbler populations, KWMA, spring 1984.

provide for maximum coverage of the study area. Habitat characteristics were not considered in the selection of transect routes.

Listening stops were established along each transect at intervals of 200 m. Both end points of each transect were also treated as stops. Length and number of stops for each transect were as follows: south transect - 4.3 Km, 23 stops; central transect - 4.0 Km, 21 stops; north transect - 4.5 Km, 24 stops; Buck Pasture transect - 1.1 Km, 7 stops.

All transects were walked twice from east to west and twice from west to east, alternately and once weekly, between 20 March and 19 April 1984. Each transect was walked once again, from west to east, between 29 May and 31 May. Due to circumstances associated with a wildfire which occurred on 27 March, the south transect was walked on that day also, but the other transects were not walked during that week. The south transect was thus walked 6 times, while the others were walked 5 times. The transects were walked between 0630 and 0900. Transects were conducted quietly, with 3 min listening pauses at each stop. Total time spent walking the transects was 44 h.

The results of the 4 population detection transects were used to select areas for more intensive censusing of Golden-cheeked Warbler populations. Additionally, aerial photos, field surveys, and playback of recorded Golden-cheeked Warbler songs were used to identify other possible areas of Golden-cheeked Warbler habitat. If any

evidence suggested that a particular area might contain a population of the warblers, or if the habitat was assessed to be even marginally suitable, that area was censused.

The censuses were conducted using the mapping method (International Bird Census Committee 1970). A map of the KWMA was prepared for use during census visits which showed all fences, roads, creeks, and dominant vegetation in sufficient detail to permit accurate mapping of Golden-cheeked Warbler contacts. The scale of the map was approximately 1:11,000. One copy of the map was used for each census visit and for the final compilation of species maps. All contacts were recorded on the visit maps by number. Detailed notes of each contact were recorded on a data sheet accompanying each visit map.

Golden-cheeked Warbler census efforts were started on 12 March and were ended on 21 June 1984. Total time spent on censusing activities, including time spent walking transects to locate populations, was 239.5 h.

During the 1985 breeding season, additional information on habitat use was obtained. Several census visits were conducted on 30 - 31 March and 20 - 21 April 1985 to determine additional areas of Golden-cheeked Warbler habitat during the 1985 season.

The 9 secondary study areas were not censused for the warbler. Each of these areas was visited during the 1984 breeding season.

Terrain Analysis

Topographical analysis of the KWMA study area was performed by 2 methods: land surface ruggedness index (LSRI) and relative relief. A map of the study area was prepared by enlarging the U.S. Geological Survey (USGS 1964) 7.5 min topographic maps (contour interval = 20 ft) to a scale of approximately 1:11,380, a 2.11X enlargement. A grid was then drawn on the map, parallel to the cardinal compass axes, with each square being 4 $cm^2$. Each 4 $cm^2$ represented approximately 5.2 ha. Of the 163 squares totally or partially within the study area, 43 were in areas occupied by Golden-cheeked Warblers and 120 were in unoccupied areas.

LSRI is a method developed by Beasom et al. (1983) to quantify land surface ruggedness. To determinine LSRI in the present study, a dot grid of 64 evenly spaced dots on a transparent plastic sheet was placed over each square, aligned parallel to the cardinal compass axes, and the number of dot-contour intersections were counted and recorded as the LSRI for that area.

Relative relief (Schumm 1956) was obtained by determining the difference between the maximum and minimum elevations within each square.

The significance of the relationships of LSRI and relative relief to Golden-cheeked Warbler occupancy was determined with the Mann-Whitney Test (two-tailed). The alpha level used was 0.05.

## RESULTS AND DISCUSSION

### Censusing and Population

Several previous researchers have estimated Golden-cheeked Warbler populations and densities at various areas throughout the breeding range of the species. A comparison of their results with those from my study are shown in Table 1. Estimates of the number of hectares required to support a pair of warblers range from 1.9 ha to 8.5 ha.

Results of the 4 transects used to locate Golden-cheeked Warbler populations on the KWMA in spring 1984 are shown in Figure 5. Golden-cheeked Warbler contacts resulting from the transects were added to those obtained while performing the mapping method censuses to estimate the number of territories in spring 1984 (Fig. 6).

Efforts to locate Golden-cheeked Warblers on the KWMA study area began on 12 March 1984, and the first sighting was on 15 March. After that date, censusing was conducted almost daily. Golden-cheeked Warbler song activity and sightings peaked in late April. By late May, activity of the warblers had decreased noticeably. The last sighting was on 19 June. Censusing was discontinued on 21 June.

The total number of active territories recorded in spring 1984 was 18. A wildfire occurred at the KWMA on 27 March 1984. Two territories in the eastern part of River

Table 1. Estimated number of hectares per pair of Golden-cheeked Warblers, by previous researcher and county of study.

| Researcher | County | ha/pair |
|---|---|---|
| Kroll 1980 | Bosque | 4.5 - 8.5 |
| Johnston, et al. 1952 | Travis | 2.3 |
| Webster, et al. 1954 | Travis | 2.7 |
| McDonald 1972 | Travis | 2.3 |
| Choban 1974 | Travis | 1.9 |
| McKinney 1975 | Travis | 2.0 |
| Pulich 1976 | Kendall | 2.0 |
| Lacey (in Cooke 1923) | Kerr | 4.3 |
| Ladd 1985 | Kerr | 2.0 |

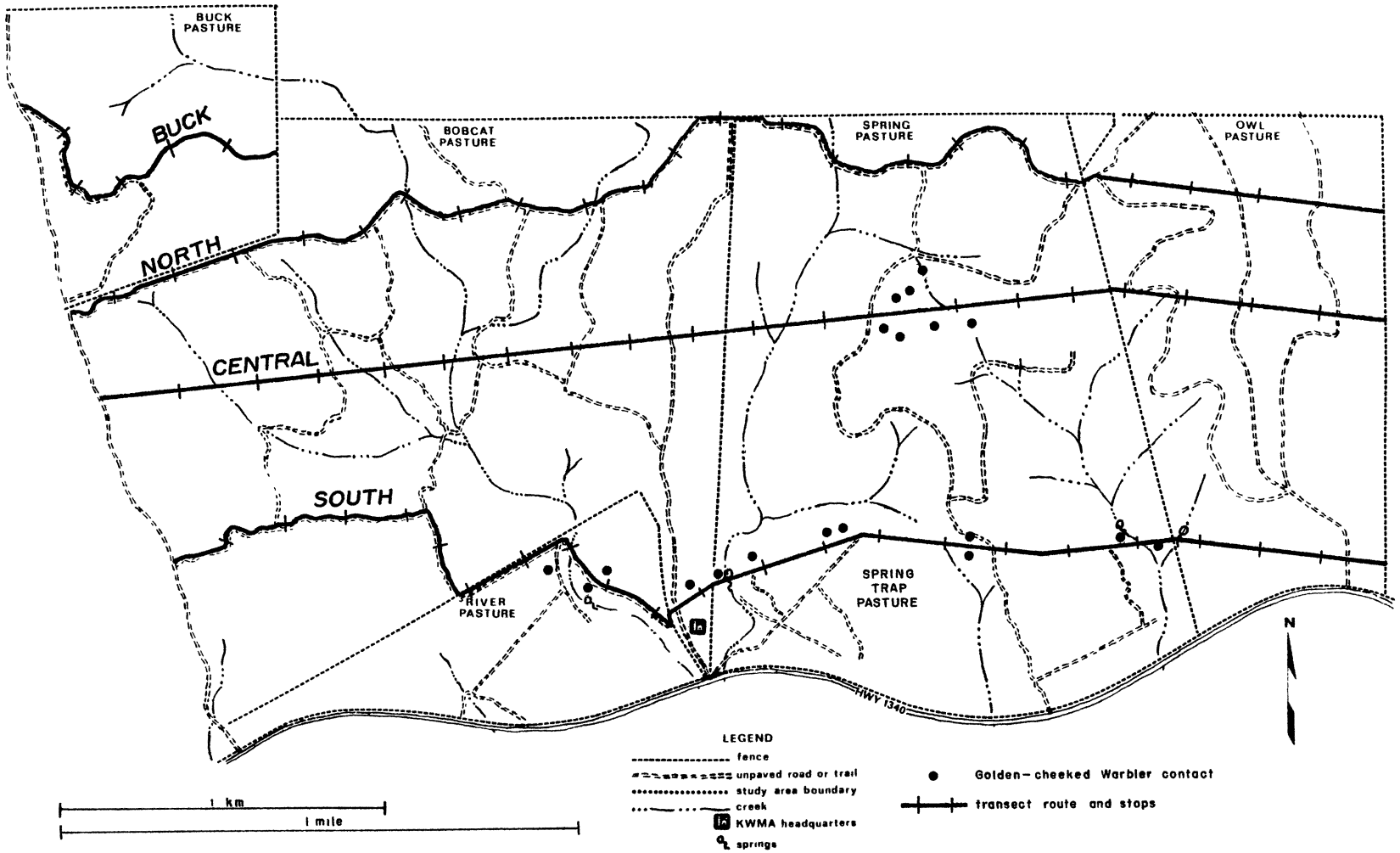


Figure 5. Transects used for locating Golden-cheeked Warbler populations, and resulting observations of the species, KWMA, spring 1984.

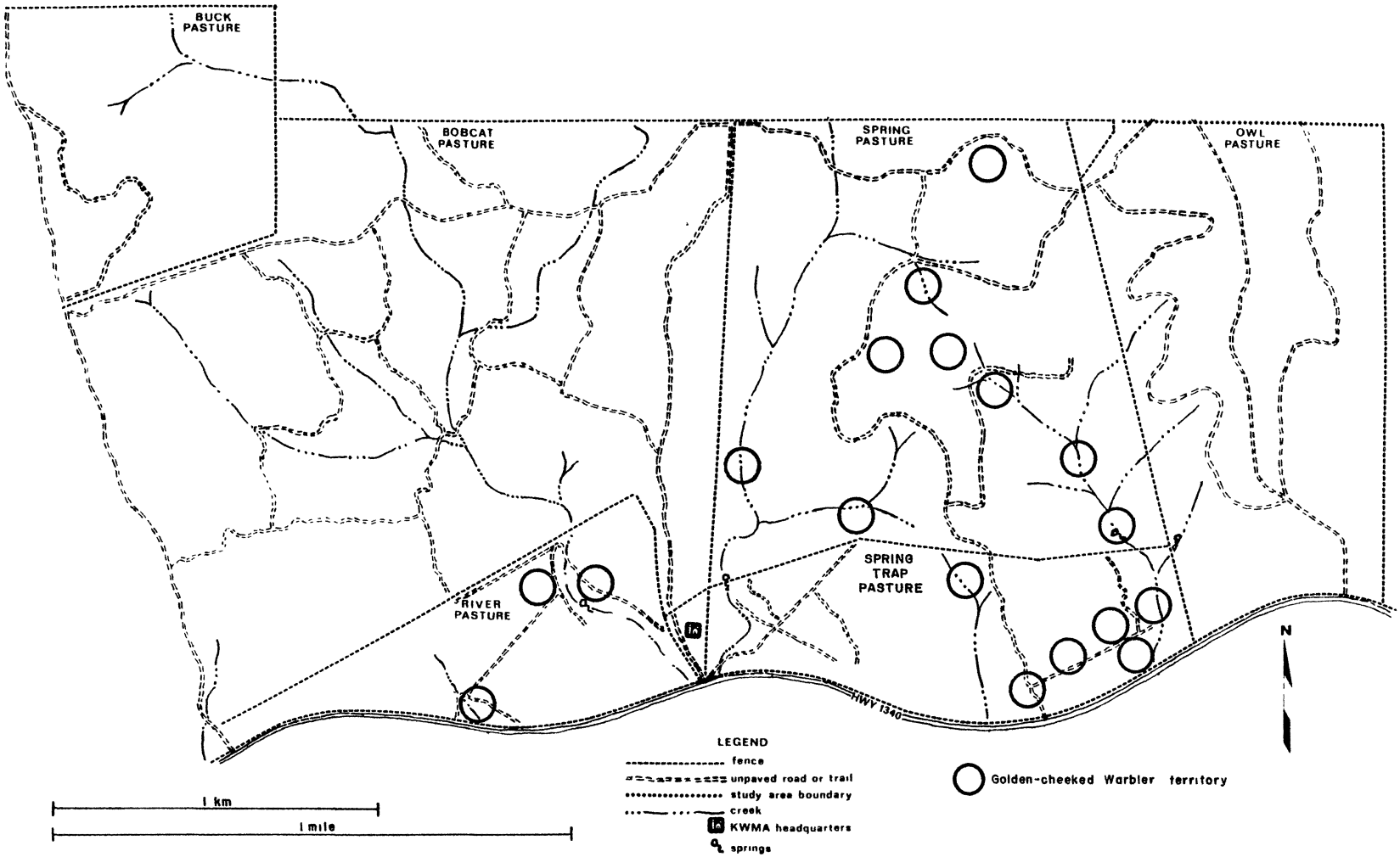


Figure 6. Golden-cheeked Warbler territories, KWMA, spring 1984.

Pasture were in an area where crown fires occurred. These territories were abandoned, thus an estimate of 16 territories for the season is more accurate. The effects of the fire are discussed in greater detail below.

In Spring Pasture and Spring Trap (222 ha total), there were 15 territories during this season. The average rate of occurrence for these pastures is thus 1 territory per 14.8 ha. This estimate necessarily includes some non-habitat areas, and therefore represents the rate of occurrence only in large areas of juniper woodland in Kerr County.

The 5 territories in the southeastern corner of Spring Trap during 1984 were contiguous, therefore the average size of these territories could be calculated without regard for the size and shape of individual territories. The average size of these territories was 2.0 ha, which is thought to be the minimum area required for a territory at the KWMA.

During the 1985 breeding season, 44 observations of the species were recorded at the KWMA (Fig. 7). Most were in areas where Golden-cheeked Warblers occurred in 1984 (i.e., Spring Pasture and Spring Trap) with the exception of 1 male observed at 4 locations in Buck Pasture.

Vegetative Characteristics of Habitat

Previous authors have discussed the vegetation of Golden-cheeked Warbler nesting habitat, primarily in

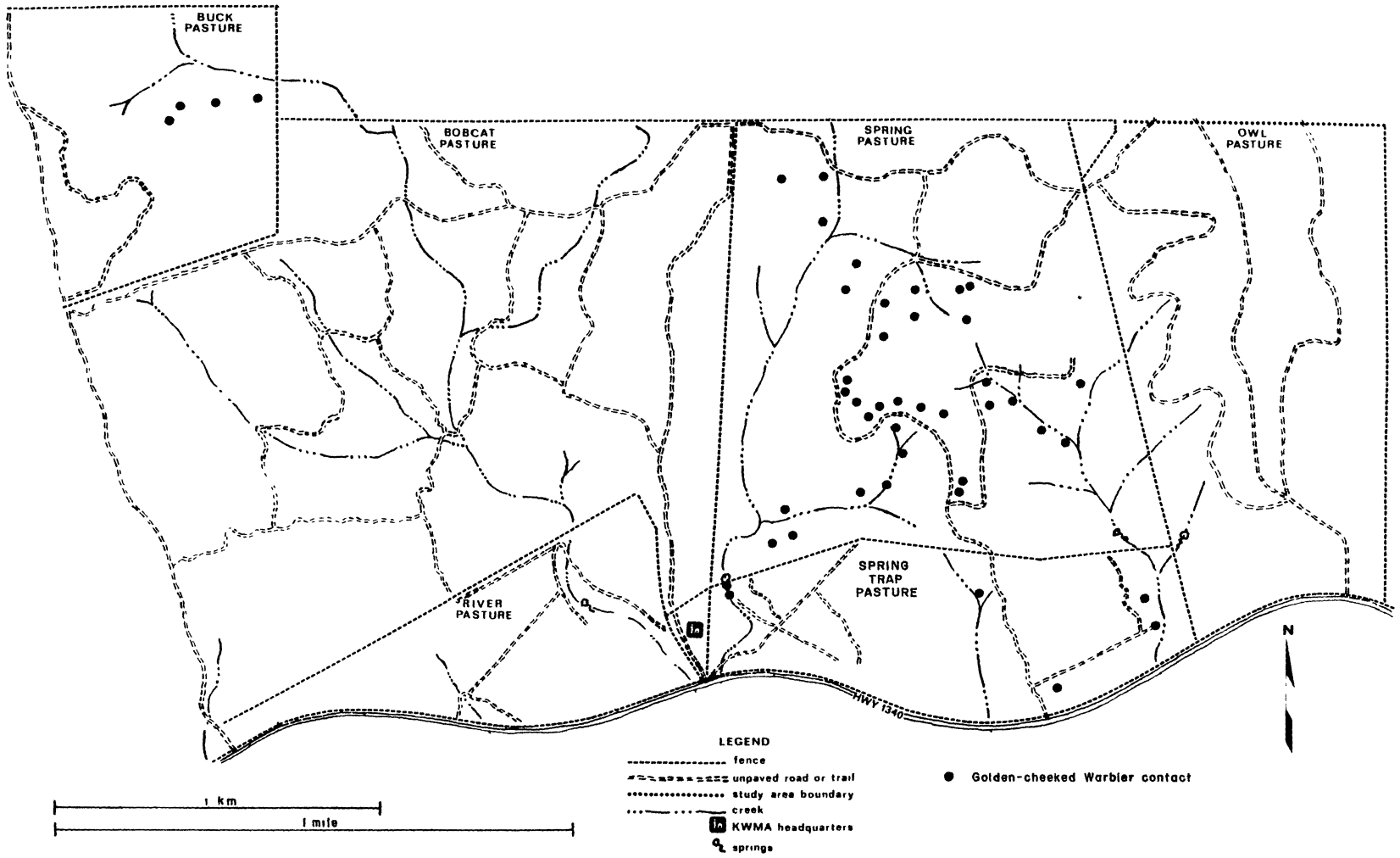


Figure 7. Golden-cheeked Warbler observations, KWMA, spring 1985.

qualitative terms. Attwater (in Chapman 1907) provided the first qualitative description of Golden-cheeked Warbler habitat:

> The trees which compose this growth consist chiefly of mountain cedar (juniper), Spanish or mountain oak, black oak, and live oak on the higher ground, and live oak and Spanish oak clumps or thickets on the lower flats among the foothills, interspersed in some localities with dwarf walnut, pecan and hackberry. All these trees grow on an average from 10 to 20 feet high, the cedar often forming almost impenetrable 'brakes'. Whatever space remains among the oaks and cedars is generally covered with shin oak brush, which is a characteristic feature of the region.

Pulich (1976) elaborated on a qualitative evaluation of Golden-cheeked Warbler habitat, including geographic variation:

> Except for slight differences, yet demonstrable and quantifiable, particularly at the extreme southern and northern parts of the Golden-cheeked Warbler range, the binding vegetation dominants throughout the warbler nesting range are similar. The predominant woody species over most of the range are junipers discussed above (Juniperus Ashei, J. pinchotii, and J. virginiana), live oak (Quercus fusiformis), Spanish oak (Q. texana), scrub oak (Q. sinuata var. breviloba), elms (Ulmus americana and U. crassifolia), hackberry (Celtis reticulata and C. laevigata), ash (Fraxinus texensis), persimmon (Diospyros texana), bumelia (Bumelia lanuginosa), redbud (Cercis canadensis var. texensis), various sumacs (Rhus spp.), poison ivy (Rhus toxicodendron), Virginia creeper (Parthenocissus quinquefolia), grape (Vitis spp.), black haw (Viburnum rufidulum), springherald (Forestiera pubescens), Texas mulberry (Morus microphylla), soapberry (Sapindus saponaria var. drummondii), mescalbean (Sophora secundiflora), escarpment cherry (Prunus serotina), and wafer-ash (Ptelea trifoliata).
>
> In the southwestern part of the range in Kinney, Edwards, Uvalde, Real and Bandera Counties, in addition to Ashe juniper, scrub oak, live oak, mescalbean and sumac, are recorded pinon

> pine (Pinus cembroides var. remota), Lacy oak (Q. glaucoides), madrone (Arbutus xalapensis), big tooth maple (Acer grandidentatum), Arizona walnut (Juglans major), basswood (Tilia floridana), agarita (Berberis trifoliolata), and several species of cacti (Opuntia spp.).

Johnston, et al. (1952) reported the first quantitative description of Golden-cheeked Warbler habitat, based on visual estimates. For the 16th Audubon breeding-bird census, they described juniper-oak woods on limestone hills in northwestern Austin, Texas as:

> hillsides clad with open Juniper-Oak woods (Juniperus mexicanus occupying about 50% of the surface area, Quercus texensis 15%, Quercus breviloba 5%, and grassy slopes 30%), trees mostly less than 15 feet tall, becoming dense with a greater percentage of oaks high on the hills (Juniperus mexicanus 35%, Q. texensis 60%, Q. breviloba 5%); in creek bottoms, along with the species already mentioned, grow Ash (Fraxinus texensis), Wild Cherry (Prunus serotina), Cedar-elm (Ulmus crassifolia), becoming 25 feet tall.

Kroll (1980) provided a quantitative description of Golden-cheeked Warbler habitat at Meridian State Recreation Area in Bosque County. His results indicated that habitat was composed of 51.6% Ashe juniper, 32.5% shin oak, 4.8% Texas oak, 3.2% Texas ash, and 6.4% other species. Because of the abundance of shin oak, these results are considered atypical of habitat as described previously, and would be limited in their application to Golden-cheeked Warbler habitat in Bosque County.

Importance values for major woody species in areas occupied and unoccupied by Golden-cheeked Warblers at the KWMA are summarized in Table 2. Relative density, relative

Table 2. Importance values for major woody species in areas occupied and unoccupied by Golden-cheeked Warblers, KWMA, spring 1984.

| | IMPORTANCE VALUE | | | | | |
|---|---|---|---|---|---|---|
| | OCCUPIED | | | UNOCCUPIED | | |
| SPECIES | N | RANGE | MEAN | N | RANGE | MEAN |
| Ashe juniper | 8 | 42.6-84.5 | 64.1 | 19 | 3.0-91.5 | 45.7 |
| Texas oak | 8 | 2.1-19.5 | 8.9 | 2 | 4.5-13.9 | 9.2 |
| Shin oak | 5 | 3.6-19.9 | 8.8 | 16 | 1.0-48.8 | 21.8 |
| Cedar elm | 2 | 4.6- 7.2 | 5.9 | 0 | --- | --- |
| Plateau live oak | 7 | 1.3-12.5 | 5.8 | 18 | 2.1-45.6 | 18.3 |
| Walnut | 4 | 0.9- 5.7 | 2.6 | 0 | --- | --- |
| Hackberry | 2 | 0.7-15.7 | 8.2 | 10 | 1.0-20.8 | 5.8 |

frequency, relative dominance, and importance values for woody species sampled in the 27 point-centered quarter method vegetation transects conducted at the KWMA study area in spring 1983 are presented in Appendices 3 through 8.

On 27 March 1984, during the second season of the study, a 103 ha wildfire occurred in Bobcat and River Pastures of the KWMA (Fig. 8). The fire crowned in most of the burned area, resulting in the loss of 78 ha of mature Ashe juniper and virtually all other vegetation (Harmel 1985). Potential Golden-cheeked Warbler habitat in this area was lost. The fire began in the area of Bobcat 8 vegetation transect. A crown fire occurred in the area of Bobcat 2, and in parts of Bobcat 10 and River 2. Spot burning occurred in the areas of River 1 and Bobcat 6 vegetation transects. There were 2 small spot fires in Spring Pasture, each less than 1 ha in extent. These fires did not crown, and the damage to trees was minimal.

Lists of all woody species observed in Golden-cheeked Warbler habitat at the 10 areas visited in spring 1984, and the relative abundance of each species, are presented in Table 3. The species are listed in the order of total relative abundance at the 9 areas where Golden-cheeked Warblers were observed in spring 1984 (excludes Possum Kingdom State Recreation Area).

In this study, I have attempted to evaluate the vegetative characteristics of Golden-cheeked Warbler habitat at the KWMA and 9 other areas, to correlate these

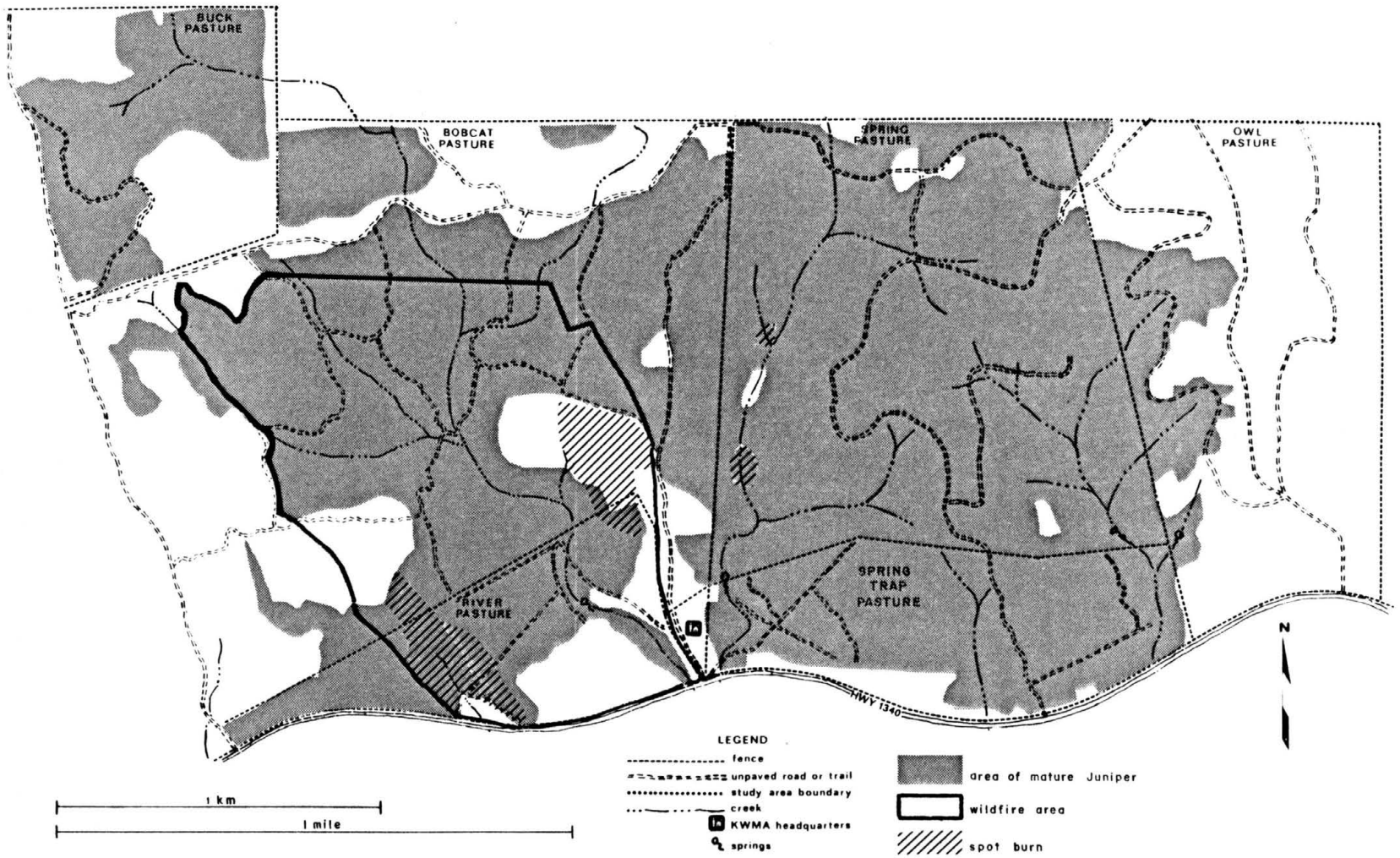


Figure 8. Distribution of mature Ashe juniper at KWMA in 1984, and path of 27 March 1984 wildfire.

Table 3. Relative abundance values for all woody species observed in 10 areas of Golden-cheeked Warbler habitat, ranked by total abundance at the 9 areas where Golden-cheeked Warblers were observed during spring 1984 (excludes Possum Kingdom State Recreation Area).

| | | SITE[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | SUM | KWMA | LMSNA | MSRA | FHMR | SR | FWP | ML | WBWP | TAS | PKSRA |
| Ashe juniper | 36 | 4[b] | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Texas oak | 27 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| Shin oak | 23 | 3 | 2 | 4 | 3 | 2 | 3 | 3 | 0 | 3 | 2 |
| Cedar elm | 22 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 |
| Plateau live oak | 22 | 3 | 0 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 |
| Walnut | 21 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 1 |
| Hackberry | 19 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 0 | 1 |
| Texas ash | 18 | 0 | 3 | 3 | 2 | 0 | 2 | 3 | 2 | 3 | 2 |
| Texas persimmon | 18 | 2 | 2 | 0 | 2 | 3 | 3 | 1 | 2 | 3 | 0 |
| Sweet mountain grape | 15 | 2 | 2 | 0 | 0 | 2 | 2 | 2 | 3 | 2 | 0 |
| Cat-brier | 14 | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 2 | 0 |
| Beargrass | 14 | 2 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 0 |
| Coma | 13 | 2 | 0 | 0 | 2 | 2 | 2 | 3 | 2 | 0 | 2 |
| Agarito | 13 | 1 | 2 | 0 | 0 | 2 | 3 | 1 | 2 | 2 | 2 |
| Elbow-bush | 13 | 0 | 0 | 2 | 3 | 0 | 2 | 2 | 2 | 2 | 1 |
| Redbud | 13 | 0 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 3 | 0 |
| Prickly pear | 11 | 1 | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 0 |
| Texas mountain laurel | 11 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 2 | 0 | 0 |
| Lacey oak | 9 | 2 | 4 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Polecat bush | 8 | 0 | 0 | 0 | 3 | 0 | 2 | 2 | 1 | 0 | 1 |
| Black cherry | 8 | 2 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 |
| Sycamore | 8 | 0 | 2 | 0 | 2 | 0 | 0 | 2 | 2 | 0 | 0 |
| Evergreen sumac | 8 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 0 | 0 |
| Monilla | 7 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 1 | 1 |
| Pecan | 7 | 0 | 2 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 |
| Chinkapin oak | 6 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red buckeye | 6 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 |
| Prairie flameleaf sumac | 6 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 0 | 0 |
| Southern black-haw | 5 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| Sugar maple | 5 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lindheimer silk-tassel | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 0 |
| Virginia creeper | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 |
| Tickle-tongue | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 0 |
| Texas kidneywood | 4 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Eastern cottonwood | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Skunk-bush | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| Honey mesquite | 3 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 3 |
| Mimosa sp. | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Black willow | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Mustang grape | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| Chinaberry-tree | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Alabama supple-jack | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| American beautyberry | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Common buttonbush | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red-berried moonseed | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |

Table 3, concluded.

| | | SITE[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | SUM | KWMA | LMSNA | MSRA | FHMR | SR | FWP | ML | WBWP | TAS | PKSRA |
| Rough-leaf dogwood | 2 | 0[b] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Common fig | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Possum-haw | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Big-tree plum | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Creek plum | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Jaboncillo | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| American elm | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eve's necklace | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pepper-vine | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Texas madrone | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coral-berry | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| TOTAL NUMBER OF SPECIES | | 24 | 23 | 11 | 27 | 16 | 29 | 33 | 27 | 23 | 15 |
| TOTAL ABUNDANCE (TOP 8 SPECIES) | | 19 | 21 | 22 | 23 | 19 | 22 | 22 | 19 | 21 | 17 |
| TOTAL ABUNDANCE (ALL SPECIES) | | 46 | 56 | 27 | 63 | 36 | 66 | 67 | 59 | 53 | 28 |

[a]KWMA = Kerr Wildlife Management Area, LMSNA = Lost Maples State Natural Area, MSRA = Meridian State Recreation Area, FHMR = Fort Hood Military Reservation, SR = Schneider Ranch, FWP = Friedrich Wilderness Park, ML = McDonald Land, WBWP = Wild Basin Wilderness Preserve, TAS = Travis Audubon Sanctuary, PKSRA = Possum Kingdom State Recreation Area.

[b]4 = abundant, 3 = common, 2 = uncommon, 1 = rare, 0 = not recorded.

characteristics into a description of habitat requirements for the warbler, and to place the results into the context of previous findings. Examination of the vegetation data for the KWMA study area shown in Table 2 reveals several trends. Several tree species which had high total abundance values at the 9 areas where Golden-cheeked Warblers occurred in spring 1984 (Table 3) had significant importance values in transect areas occupied by Golden-cheeked Warbler at the KWMA study area. Some of these species occurred only in transect areas inhabited by Golden-cheeked Warblers.

Not surprisingly, transect areas occupied by Golden-cheeked Warblers had higher importance values for Ashe juniper than unoccupied areas. The total relative abundance value for this species (36) was the maximum possible (Table 3). The mean importance value for Ashe juniper in the areas occupied by Golden-cheeked Warbler territories at the KWMA was 64.0. The mean importance value for Ashe juniper in unoccupied areas was 45.7.

Texas oak ranked second in total relative abundance, with a value of 27. Texas oak occurred in all vegetation transect areas that were occupied by Golden-cheeked Warblers in spring 1984. Importance values ranged from 2.1 to 19.5. Only 2 unoccupied transects contained Texas oak: Bobcat 8 (Texas oak importance = 13.9) and Bobcat 1 (Texas oak importance = 4.5). However, Bobcat 8 had few large Ashe junipers (importance = 3.0); this lack of juniper is the probable explanation for the lack of Golden-cheeked Warblers

in that area. The Bobcat 1 transect had an Ashe juniper importance of 64.9, and high importance values for other oak species which were associated with Golden-cheeked Warbler habitat (plateau live oak importance = 11.8, shin oak importance = 17.7). This area had been identified in spring 1983 as potential habitat; however, no Golden-cheeked Warblers were found there during the 3 seasons of study. One explanation for this is the possible lack of suitable topographic characteristics in this area. This is discussed in greater detail below.

Shin oak ranked third in total relative abundance, with a value of 23. Plateau live oak and cedar elm were next in rank, with a value of 22. Shin oak and plateau live oak were widespread on the KWMA study area, and occurred in almost all 27 transects. The mean importance value for shin oak in the occupied areas was 8.8 (N = 5), and was 21.8 (N = 16) in the unoccupied areas. The mean importance value for plateau live oak was 5.8 (N = 7) in the occupied areas, and was 18.3 (N = 18) in the unoccupied areas.

Cedar elm (total relative abundance value = 22) occurred in only 2 transects. Both transects were in areas containing Golden-cheeked Warbler territories. The area of Spring Trap 2 had an importance value for cedar elms of 7.2, while in River 2 the importance value for this tree was 4.6. Both transects were in riparian areas.

Walnut, with a value of 21, ranked sixth in total relative abundance. Arizona walnut occurred in 3 occupied

transect areas: Spring 5 (importance = 0.9), Spring Trap 2 (importance = 5.7), and River 2 (importance = 2.1). Little walnut occurred in 1 occupied transect area: Spring 6 (importance = 1.9). Walnut did not occur in any unoccupied transect area. It is interesting to note that both Lacey (1911) and Smith (1916), the earliest authors on the birds of Kerr County (location of the KWMA study area), discussed the occurrence of walnut trees in Golden-cheeked Warbler habitat in that county.

The seventh-ranked tree species was hackberry. Its total relative abundance value was 19. Netleaf hackberry occurred in 2 occupied transects at the KWMA, Spring Trap 2 (importance = 0.7) and River 2 (importance = 15.7). Both transects were in riparian areas. This species occurred in 10 unoccupied transects, with a mean value of 5.8.

Texas ash ranked eighth in total relative abundance (18). This species, however, did not occur in any transect area at KWMA.

Previous investigators (Smith 1916, Simmons 1924, McDonald 1972, Pulich 1976) have stated that the Golden-cheeked Warbler forages for insects in tree canopies. The 8 woody species with the highest total abundance in the 9 study areas where Golden-cheeked Warblers were found in spring 1984 (Table 3) are all species that usually grow with a tree-like form, with the exception of shin oak. These 8 species were found in Golden-cheeked Warbler habitat at all study areas, with only 4 exceptions: no Texas ash occurred

at KWMA, no Plateau live oak was observed at Lost Maples State Natural Area, no Shin oak was recorded at Wild Basin Wilderness Preserve, and no hackberry was observed at Travis Audubon Sanctuary. If these species were overlooked at these areas, then their abundance was probably low.

Golden-cheeked Warblers were observed at all 10 areas visited in spring 1984, except Possum Kingdom State Recreation Area. Possum Kingdom had the lowest total relative abundance for the top 8 woody species (17) (Table 3). Major tree components of Golden-cheeked Warbler habitat were absent or uncommon at this location. Possum Kingdom also had the second lowest total number of woody species (15), or diversity of species, after Meridian State Recreation Area (11). The total abundance of all species at Possum Kingdom was also the second lowest (28), again after Meridian (27). These facts may account for the lack of the warbler there during the spring 1984 visit.

Habitat Profile: Vegetation

Based on vegetation data from the KWMA and the 9 other areas visited, the following profile of tree species composition of Golden-cheeked Warbler habitat is offered. Ashe juniper is the dominant tree species wherever Golden-cheeked Warblers occur. Texas oak is also of great importance, particularly in the central part of their range in Travis, Hays, Comal, Kendall, and Blanco Counties. As discussed by Pulich (1976), there are differences in the

vegetation at the northern and southern ends of the range of the species. Other oak species eclipse the importance of Texas oaks in parts of the Golden-cheeked Warbler range. To the north of the central part of the range, such as at Fort Hood Military Reservation (Bell and Coryell Counties), shin oak occurs in Golden-cheeked Warbler habitat with a frequency approximately equal to that of Texas oak. At the northernmost site where Golden-cheeked Warblers were observed in 1984 (Meridian State Recreation Area in Bosque County), shin oak was co-dominant with Ashe juniper. To the south and west of the central part of the range, Lacey oak occurs with a greater frequency. This species was found in some occupied areas at the KWMA and was common at Friedrich Wilderness Park in Bexar County. At Lost Maples State Natural Area in Bandera County (the southwesternmost area where the bird was observed in 1984), Lacey oak was co-dominant with Ashe Juniper. It is interesting to note that 2 of the areas where Golden-cheeked Warblers were most abundant in 1984 were the 2 areas with oaks co-dominating with Ashe juniper: Lost Maples in the southwestern part of the range, and Meridian in the northern part of the range. Cedar elm, plateau live oak, walnut, hackberry, and Texas ash complete the list of tree species of common occurrence in Golden-cheeked Warbler nesting habitat.

### Topographic Characteristics of Habitat

Several authors have commented on the topography of

Golden-cheeked Warbler nesting habitat. Most have suggested that the warblers are typically found in areas of steep slopes, canyon heads, draws, and ridgetops, but this has never been demonstrated.

Attwater (in Chapman 1907) described Golden-cheeked Warbler habitat as occurring,

> on the rough wooded hillsides, ...the slopes and 'points' leading up from the canyons, and the boulder strewn ridges or 'divides' which separate the heads of the creeks.

Simmons (1924) seemed to have a different view. Writing on Golden-cheeked Warbler habitat in the Austin region, he stated that their habitat was:

> Always on flat slopes of cedar-clad limestone hills and on summits of canyon slopes and ridges...Never in ravines or gullies, even on hillsides, and never at base of hills near the water of rivers and creeks; never found nesting in dense cedar brakes.

In his section on nest location, he stated that their nests are found,

> on limestone hillsides in mountainous sections and at summits of canyon slopes; never in dense cedar brakes.

Oberholser (1974) stated that their habitat was found on "broken terrain." Pulich (1976) included a chapter on physiography and soils, and stated the following:

> The Edwards Plateau is young with mature margin of moderate to strong relief. In part, the physiography in the southern part may be called mountainous with elevations ranging from slightly under 500 feet to more than 3,000 feet. The Central Texas section is mature and exhibits later stages of erosion. Where erosion has been most active, streams have cut steep canyons and valleys. It is the canyons and scarps that comprise typical habitat areas for the

Golden-cheeked Warbler.

The measurement of land surface roughness at the KWMA study area presented several problems. As discussed by Hobson (1972), the definition of surface roughness is difficult. It may be impossible to provide a single, concise definition. Currently, no widely accepted method for the measurement of surface roughness exists, especially for use in areas the size of the KWMA study area. Available methods are better suited for use on a regional scale. The methods chosen for use in this study, LSRI (Beasom, et al. 1983) and relative relief (Schumm 1956), were the only methods found that were suitable for use at this scale. Readers who desire more information on the measurement of surface roughness are urged to read Pike and Wilson (1971), Hobson (1972), and Cooke and Doornkamp (1974).

The topography of Golden-cheeked Warbler habitat areas at the KWMA was generally rougher than uninhabited areas. During the spring 1984 nesting season, 15 territories were recorded in Spring Pasture and Spring Trap, and 3 occurred in River Pasture. Spring Pasture and Spring Trap are generally more extensively divided by drainage channels, and have narrower canyons and steeper slopes than other pastures on the KWMA study area (Fig. 9). Most Golden-cheeked Warbler contacts during spring 1984 were on steep slopes near the bottoms of the creeks and draws, or near the ridges of the plateaus.

A statistical analysis of land surface ruggedness

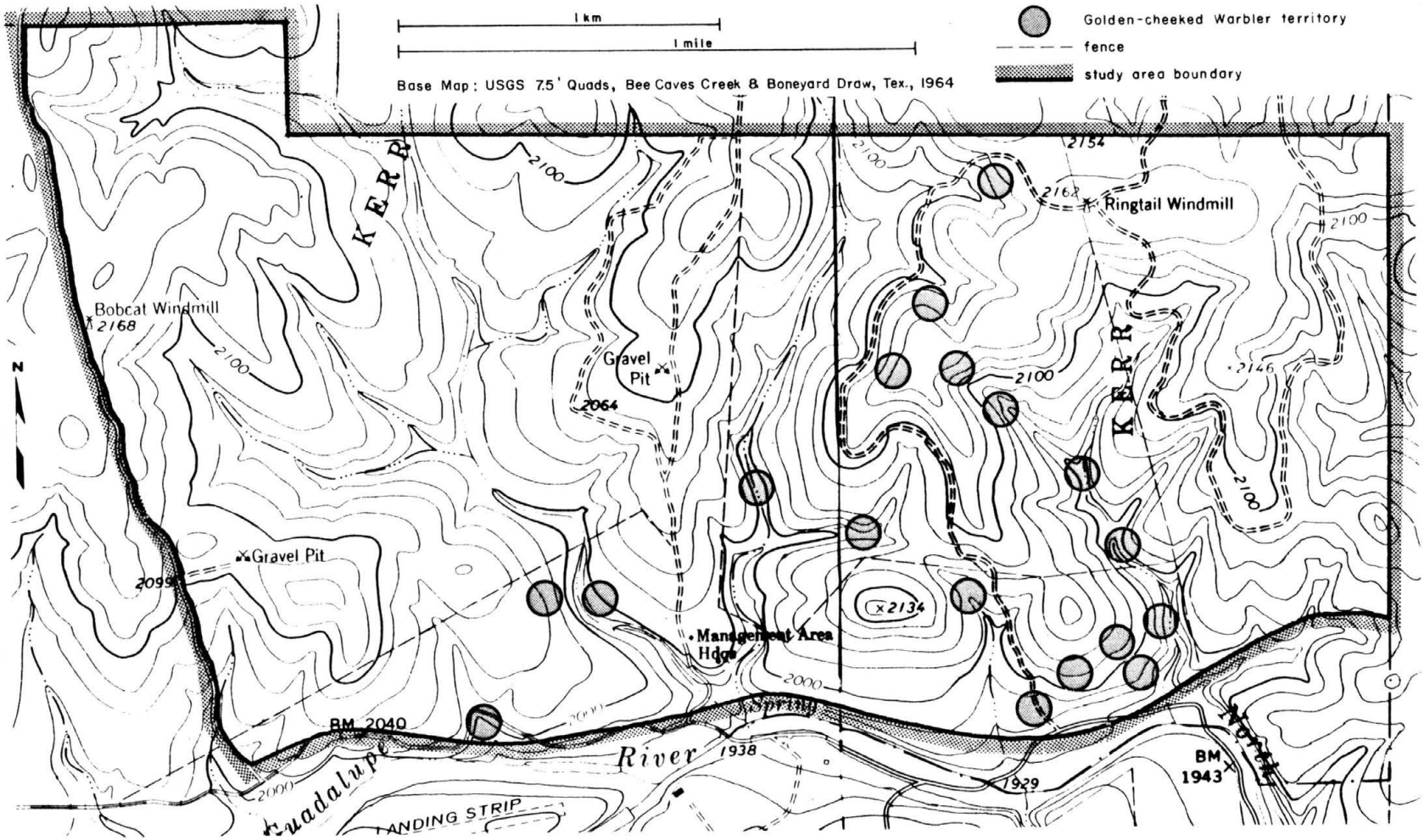


Figure 9. Topographic map of KWMA study area and Golden-cheeked Warbler territories, spring 1984.

index (LSRI) and relative relief of the KWMA study area is presented in Table 4. Results of the Mann-Whitney tests (two-tailed) indicated a significant difference between areas occupied and unoccupied by Golden-cheeked Warblers for both LSRI and relative relief ($0.05>P>0.01$). The Pearson correlation coefficient ($r$) between LSRI and relative relief at the KWMA was 0.65. LSRI values relative to Golden-cheeked Warbler territories at the KWMA in spring 1984 are shown in Figure 10. Corresponding data for relative relief are shown in Figure 11.

Although more than 86 h were spent searching for nests at the KWMA, only one possible Golden-cheeked Warbler nest was found. This nest was found during the 1983 season, but because of its deteriorated condition was thought to be from the 1982 season. The nest was found in the southeast corner of Spring Pasture, less than 50 m west of the bottom of the east draw (known locally as Gobbler Hollow), and about 125 m west-northwest of the major springs in Gobbler Hollow. The value for LSRI (20) in the area of the nest site was high (Fig. 10), as was relative relief (90) (Fig. 11), indicating topographic roughness in this area.

The area in the northeast corner of Bobcat Pasture, which includes the Bobcat 1 vegetation transect, was discussed above as being vegetatively similar to occupied transect areas, yet no Golden-cheeked Warblers were found there during the 3 seasons of study. Examination of Figures 10 and 11 reveals that this area had low values for both

Table 4. Statistical parameters for LSRI and relative relief analysis of areas occupied and unoccupied by Golden-cheeked Warblers, KWMA, spring 1984.

| Parameter | Occupied | Unoccupied |
|---|---|---|
| LSRI* | | |
| $\bar{X}$ | 13.4 | 9.9 |
| N | 43 | 120 |
| $s_{\bar{x}}$ | 0.88 | 0.33 |
| Relative Relief* | | |
| $\bar{X}$ | 80.2 | 65.6 |
| N | 43 | 120 |
| $s_{\bar{x}}$ | 3.34 | 1.87 |

* Significant difference (0.05>P>0.01) between occupied and unoccupied areas.

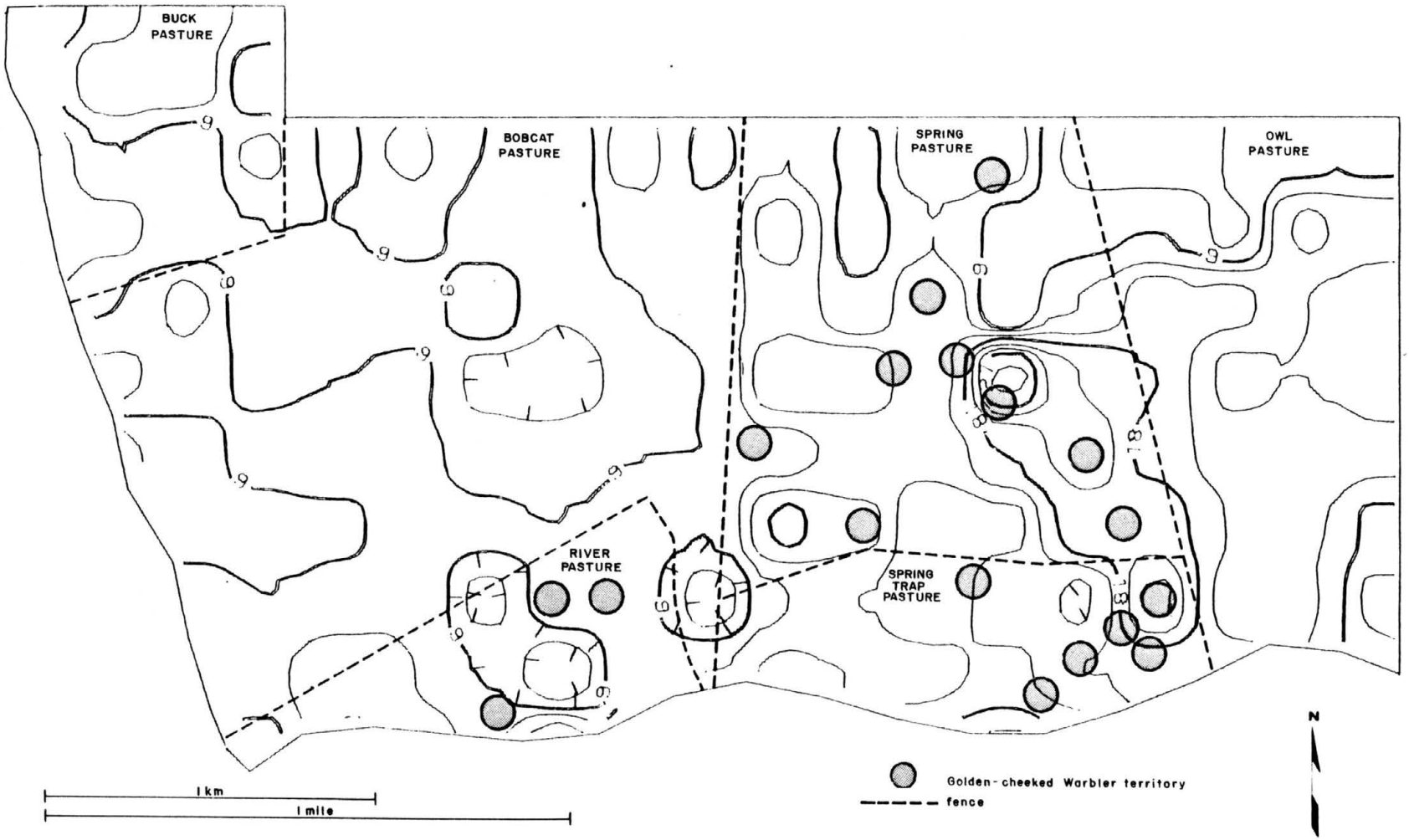


Figure 10. Land surface ruggedness index (LSRI) and Golden-cheeked Warbler territories, KWMA, spring 1984.

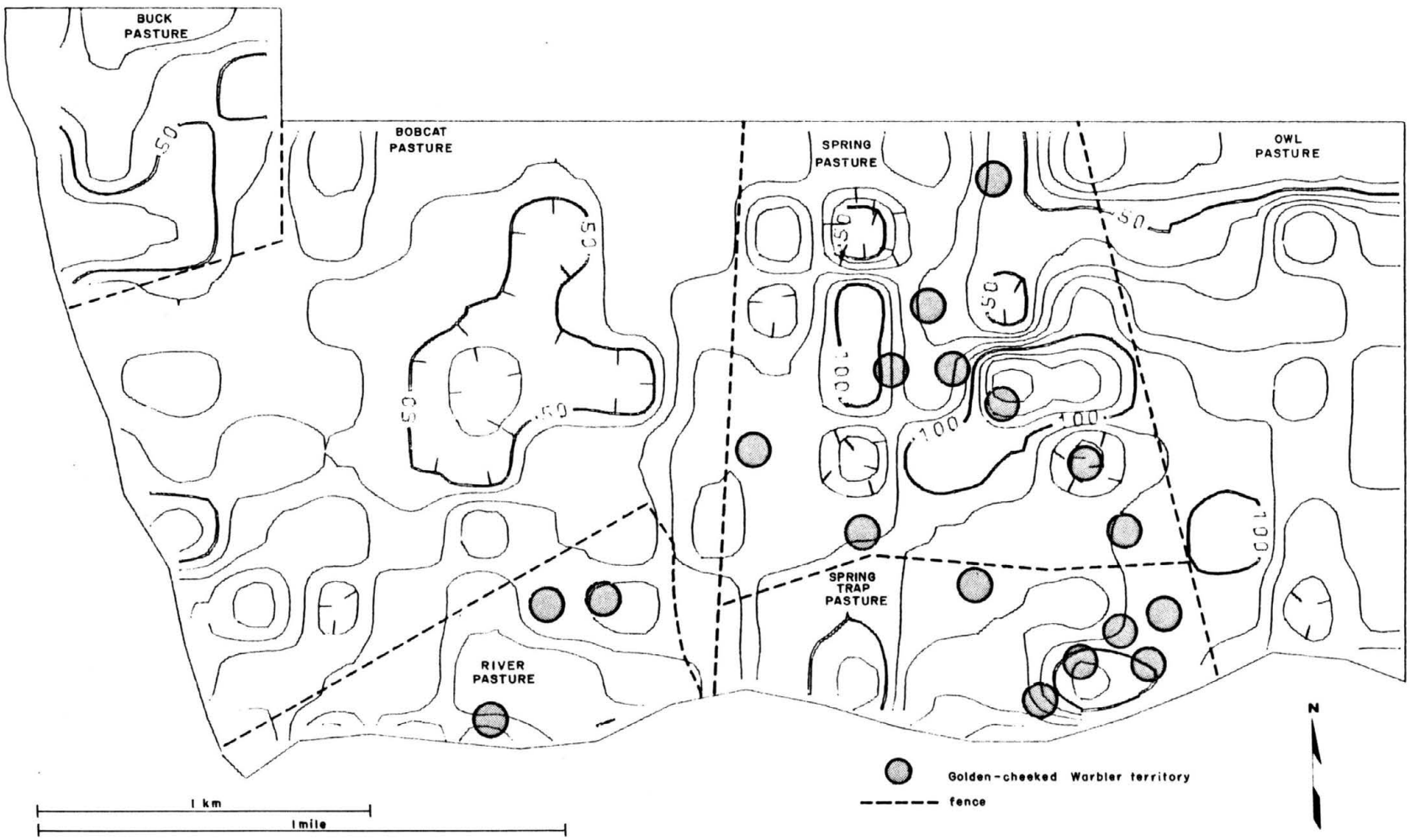


Figure 11. Relative relief and Golden-cheeked Warbler territories, KWMA, spring 1984.

LSRI (8) and relative relief (65). Figure 9 depicts this area as the top of a broad hill. A possible explanation for the lack of warbler use of this area is that topographic characteristics make the area unsuitable habitat.

Habitat Profile: Former and Current Conditions

In the preceding discussion it has been stated that Golden-cheeked Warbler nesting habitat typically occurs in areas forested with mature Ashe juniper, several species of oaks, and other deciduous tree species in areas of rough topography, such as in canyons and on steep slopes. Exceptions do occur, but the general pattern remains the same throughout the nesting range of the species. Pulich (1976) and Kroll (1980) stated that Golden-cheeked Warbler territories were often bounded by an edge of different vegetative composition, such as a road, clearing, or pasture. Several territories at the KWMA in spring 1984 were bounded by such an edge. Many were bounded by pasture roads which dissected otherwise homogenous habitat. In order to more fully understand the characteristics of Golden-cheeked Warbler habitat, it is helpful to consider vegetative changes that have occurred since settlement of the region which encompasses the breeding range of the species.

It has been widely stated that grasses occupied a much greater percentage of central Texas in presettlement times than in modern times (Bray 1904, 1906, Foster 1917,

Schmid 1969). Buechner (1944) and Hahn (1951) also discussed such ecological changes, with specific reference to Kerr County. The general consensus among these authors is that fires periodically swept through the region, suppressing the growth of woody species. Grazing by domestic livestock has also contributed to the shift from prairie to woodland. Wooded areas were formerly found only in narrow canyons, on steep slopes, and in areas of rock outcrop with soils that were too thin to support prairie grasses. It is generally believed that fires could not easily spread in such areas, thus allowing for the growth of woody species.

The overall character of vegetation under such circumstances would be that grasslands occupied the vast majority of the area, with woody species such as Ashe juniper, oaks, cedar elms, etc. occurring in canyons, on steep slopes, and in other areas of rough terrain. Wooded areas would be demarcated by prairie vegetation, creating a clear edge in most cases. Such areas would provide excellent nesting habitat for the Golden-cheeked Warbler. Conditions may also have been favorable for the development of Black-capped Vireo (Vireo atricapillus) habitat, in areas where fires maintained woody species in a brushy state.

The extent of cedar brakes in the central Texas region in former times is not well known. It is generally agreed that they are much more widespread now. However, this is often the subject of intense discussion among those

who are familiar with the area. There may now be more Golden-cheeked Warbler habitat than in presettlement times. The fact that the species is generally found in rough terrain, and was found in rough terrain at the KWMA, may be more indicative that vegetative components of habitat are found in such topography than of the converse set of conditions. Rough terrain may be only an incidental condition of Golden-cheeked Warbler habitat, or it may function as a habitat cue.

Effects of Wildfire on Habitat Use

Two territories were recorded in the area of the creek in the east part of River Pasture (Fig. 6) prior to the wildfire which occurred on 27 March 1984. Most of the vegetation in this area was destroyed by the fire. Several searches of the area were made in the weeks after the fire, but no Golden-cheeked Warbler contacts were recorded. It is not known if these birds later established new territories in the study area. It is assumed that the flying abilities of the species enabled these birds to move safely to other areas.

Two Golden-cheeked Warbler territories on the KWMA in 1984 were in areas where spot fires occurred during the wildfire. These territories were in the southern part of River Pasture and in the area of a creek in the western part of Spring Pasture (Fig. 6). Both territories were unrecorded before the fire.

A male Golden-cheeked Warbler was observed proclaiming his territory in the area of the spot burn in Spring Pasture during an examination of fire conditions on 29 March, while much of that area was still smoldering. The species was observed in this area on several occasions in the ensuing weeks, including a female on at least one occasion.

A male Golden-cheeked Warbler was observed in the area of the small draw in the southern part of River Pasture on several occasions in the weeks after the fire. The wildfire burned a large area of juniper-oak woodland approximately 100 m east of the draw. No female Golden-cheeked Warbler was observed in this area.

# CONCLUSIONS

As reported by virtually all previous authors on the Golden-cheeked Warbler, Ashe juniper is the dominant tree species in the breeding habitat of the species. Texas oak also occurs frequently, especially in the central part of their range, such as in Travis, Hays, Comal, Kendall, and Blanco Counties. In the northern and southern parts of the range, other species of oaks become more common, and may replace Texas oak as the dominant oak species. At Fort Hood Military Reservation in Bell and Coryell Counties, north of the central part of the range, shin oak occurs in Golden-cheeked Warbler habitat with a frequency approximately equal to that of Texas oak. At the northernmost site where the warbler was observed in 1984 (Meridian State Recreation Area in Bosque County), shin oak was co-dominant with Ashe juniper. To the south and west of the central part of the range, Lacey oak occurs with a greater frequency. This species was common at Friedrich Wilderness Park in Bexar County. At the southwesternmost area where the bird was observed in 1984 (Lost Maples State Natural Area in Bandera County), Lacey oak was co-dominant with Ashe Juniper. Other tree species of common occurrence in Golden-cheeked Warbler nesting habitat are cedar elm, plateau live oak, walnut, hackberry, and Texas ash. These species occurred in almost all areas of Golden-cheeked

Warbler habitat visited.

As in other parts of the breeding range of the Golden-cheeked Warbler, Ashe juniper is the dominant species in warbler habitat at the KWMA. Texas oak is the dominant oak species, and occurred in all vegetation transects that were in areas occupied by Golden-cheeked Warbler territories. This species occurred in only 2 transect areas that were not occupied by the warbler. Plateau live oak and shin oak are also of common occurrence in warbler habitat at the KWMA. Cedar elm and walnut occurred only in transect areas that were occupied by Golden-cheeked Warblers. Lacey oak is the dominant oak in the southwestern end of the breeding range of the warbler, as at Lost Maples State Natural Area. This species also occurred in warbler habitat at the KWMA, although it was uncommon.

The topography of Golden-cheeked Warbler habitat areas at the KWMA was generally rougher than uninhabited areas. Most territories recorded during the spring 1984 nesting season at the KWMA were in Spring Pasture and Spring Trap. These pastures are generally more divided by drainage channels, and have narrower canyons and steeper slopes than other pastures on the KWMA study area. Most warbler contacts during spring 1984 were on steep slopes near the bottoms of the creeks and draws, or near the ridges of the plateaus.

Several territories at the KWMA in spring 1984 were bounded by an edge of different vegetative composition, such

as a road or clearing. Some were bounded by pasture roads which dissected otherwise homogenous habitat.

The total number of active territories recorded in spring 1984 was 18. A wildfire occurred at the KWMA on 27 March 1984. Two territories were in the wildfire area, and were abandoned. Thus an estimate of 16 territories for the season is more accurate.

The average rate of occurrence in Spring Pasture and Spring Trap during the 1984 nesting season was 1 territory per 14.8 ha. Some parts of these pastures were not utilized by the warblers. This estimate therefore represents the rate of occurrence only in extensive areas of juniper woodland in Kerr County.

Estimates of previous researchers of the number of hectares required to support a pair of Golden-cheeked Warblers have ranged from 1.9 ha to 8.5 ha. The average size of 5 territories in the southeastern corner of Spring Trap at the KWMA during spring 1984 was 2.0 ha. This is thought to be the minimum area required for a territory at the KWMA.

The results of this study would be of little value if they were not applicable to the management needs of the Golden-cheeked Warbler. Although more work needs to be done on this warbler, results of my study and other recent studies provide the basis needed to begin managing for the species.

The following management objectives are applicable to

the large area of the Golden-cheeked Warbler breeding range in the Edwards Plateau. Belts of Ashe juniper-Texas oak woodland should be retained along creeks, draws, and areas of rough terrain. Based on the estimated 2.0 ha minimum size of warbler territories, the width of such belts should be approximately 150 m. Such woodlands on steep slopes and bluffs should also be retained. Selective thinning of dense stands of young Ashe juniper should be performed to promote the growth of Texas oak, cedar elm, and other hardwood species. Large areas of mature juniper-oak woodlands should be broken up by narrow, linear clearings, of sizes approximating pasture roads or trails. Cutting of large Ashe junipers and hardwoods should be avoided in the clearing of such areas.

With careful planning, management for the warbler can be successfully integrated with management for other wildlife species and livestock.

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Appendix 1: Scientific and common names of plants

Scientific and common names of plants discussed in the text follow Correll and Johnston (1979). In cases where Correll and Johnston do not provide a common name, those of Lynch (1981) or Gould (1975) were used.

| Scientific Name | Common Name |
|---|---|
| Aceraceae | Maple Family |
| *Acer grandidentatum* | Sugar maple |
| Anacardiaceae | Sumac Family |
| *Rhus aromatica* | Polecat bush |
| *Rhus lanceolata* | Prairie flameleaf sumac |
| *Rhus toxicodendron* | Poison ivy |
| *Rhus virens* | Evergreen sumac |
| Aquifoliaceae | Holly Family |
| *Ilex decidua* | Possum-haw |
| Berberidaceae | Barberry Family |
| *Berberis trifoliolata* | Agarito |
| Cactaceae | Cactus Family |
| *Echinocereus* sp. | Hedgehog cactus |
| *Mammillaria* sp. | Fish-hook cactus |
| *Opuntia* sp. | Prickly pear |
| Caprifoliaceae | Honeysuckle Family |
| *Symphoricarpos orbiculatus* | Coral-berry |
| *Viburnum rufidulum* | Southern black-haw |
| Cornaceae | Dogwood Family |
| *Cornus Drummondii* | Rough-leaf dogwood |
| *Garrya Lindheimeri* | Lindheimer silk-tassel |
| Cupressaceae | Cypress Family |
| *Juniperus Ashei* | Ashe juniper |
| Ebenaceae | Persimmon Family |
| *Diospyros texana* | Texas persimmon |
| Ericaceae | Heath Family |
| *Arbutus xalapensis* | Texas madrone |
| Fagaceae | Beech Family |
| *Quercus fusiformis* | Plateau live oak |
| *Quercus glaucoides* | Lacey oak |
| *Quercus marylandica* | Blackjack oak |
| *Quercus Muhlenbergii* | Chinkapin oak |
| *Quercus sinuata* | Shin oak |
| *Quercus texana* | Texas oak |
| Hippocastanaceae | Buckeye Family |
| *Aesculus Pavia* | Red buckeye |
| Juglandaceae | Walnut Family |
| *Carya illinoinensis* | Pecan |
| *Juglans major* | Arizona walnut |
| *Juglans microcarpa* | Little walnut |

Appendix 1, continued.

| Scientific Name | Common Name |
|---|---|
| Leguminosae | Legume Family |
| *Acacia Roemeriana* | Catclaw acacia |
| *Acacia* sp. | Acacia |
| *Cercis canadensis* | Redbud |
| *Dalea frutescens* | Black dalea |
| *Eysenhardtia texana* | Texas kidneywood |
| *Mimosa biuncifera* | Cat's claw mimosa |
| *Mimosa borealis* | Pink mimosa |
| *Prosopis glandulosa* | Honey mesquite |
| *Sophora affinis* | Eve's necklace |
| *Sophora secundiflora* | Texas mountain laurel |
| Liliaceae | Lily Family |
| *Smilax Bona-nox* | Cat-brier |
| *Yucca rupicola* | Twisted-leaf yucca |
| *Yucca* sp. | Beargrass |
| Meliaceae | Mahogany Family |
| *Melia Azedarach* | Chinaberry-tree |
| Menispermaceae | Moonseed Family |
| *Cocculus carolinus* | Red-berried moonseed |
| Moraceae | Mulberry Family |
| *Ficus carica* | Common fig |
| *Morus microphylla* | Mountain mulberry |
| Oleaceae | Olive Family |
| *Forestiera pubescens* | Elbow-bush |
| *Fraxinus texensis* | Texas ash |
| Platanaceae | Plane-tree Family |
| *Platanus occidentalis* | Sycamore |
| Rhamnaceae | Buckthorn Family |
| *Berchemia scandens* | Alabama supple-jack |
| *Condalia Hookeri* | Brasil |
| *Condalia* sp. | Condalia |
| *Ziziphus obtusifolia* | Lotebush |
| Rosaceae | Rose Family |
| *Prunus mexicana* | Big-tree plum |
| *Prunus rivularis* | Creek plum |
| *Prunus serotina* | Black cherry |
| Rubiaceae | Madder Family |
| *Cephalanthus occidentalis* | Common buttonbush |
| Rutaceae | Citrus Family |
| *Ptelea trifoliata* | Skunk-bush |
| *Zanthoxylum Clava-Herculis* | Pepperbark |
| *Zanthoxylum hirsutum* | Tickle-tongue |
| Salicaceae | Willow Family |
| *Populus deltoides* | Eastern cottonwood |
| *Salix nigra* | Black willow |
| Sapindaceae | Soap-berry Family |
| *Sapindus Saponaria* | Jaboncillo |
| *Ungnadia speciosa* | Monilla |

Appendix 1, concluded.

| Scientific Name | Common Name |
|---|---|
| Sapotaceae | Sapodilla Family |
| *Bumelia lanuginosa* | Coma |
| Ulmaceae | Elm Family |
| *Celtis laevigata* | Texas sugarberry |
| *Celtis reticulata* | Netleaf hackberry |
| *Ulmus americana* | American elm |
| *Ulmus crassifolia* | Cedar elm |
| Verbenaceae | Vervain Family |
| *Aloysia gratissima* | Common bee-brush |
| *Callicarpa americana* | American beautyberry |
| Vitaceae | Grape Family |
| *Ampelopsis arborea* | Pepper-vine |
| *Cissus incisa* | Marine-ivy |
| *Parthenocissus quinquefolia* | Virginia creeper |
| *Vitis monticola* | Sweet mountain grape |
| *Vitis mustangensis* | Mustang grape |

Appendix 2: Secondary study areas

Lost Maples State Natural Area (LMSNA): 6 Km north of Vanderpool, Bandera County. Lat. 29° 48′ N., long. 99° 36′ W. Owner: Texas Parks and Wildlife Department. 890 ha. Visited on 10-11 May 1984.

Meridian State Recreation Area (MSRA): 6 Km southwest of Meridian, Bosque County. Lat. 31° 53′ N., long. 97° 42′ W. Owner: Texas Parks and Wildlife Department. 203 ha. Visited on 23-24 May 1984.

Fort Hood Military Reservation (FHMR): Bell and Coryell Counties. Lat. 31° 13′ N., long. 97° 32′ W. Owner: U.S. Army. 87,800 ha. Visited on 22-23 May 1984.

Schneider Ranch (SR): 18 Km northeast of Boerne, Kendall County. Lat. 29° 55′ N., long. 98° 37′ W. Owners: Mr. and Mrs. Walter Schneider. 130 ha. Visited on 13-14 June 1984.

Friedrich Wilderness Park (FWP): 26 Km northwest of San Antonio, Bexar County. Lat. 29° 38′ N., long. 98° 38′ W. Owner: City of San Antonio, Department of Parks and Recreation. 94 ha. Visited on 13 June 1984.

R.E. McDonald land (ML): 22 Km northwest of Austin, Travis County. Lat. 30° 27′ N., long. 97° 51′ W. Owner: R.E. McDonald estate. 58 ha. Visited on 12 May 1984.

Wild Basin Wilderness Preserve (WBWP): 8 Km northwest of Austin, Travis County. Lat. 30° 18′ N., long. 97° 49′ W. Owner: County of Travis. 82 ha. Visited on 18 and 24 March, 2 and 5 May 1984.

Travis Audubon Sanctuary (TAS): 29 Km northwest of Austin, Travis County. Lat. 30° 29′ N., long. 97° 53′ W. Owner: Travis Audubon Society. 38 ha.

Possum Kingdom State Recreation Area (PKSRA): 28 Km west-northwest of Palo Pinto, Palo Pinto County. Lat. 32° 52′ N., long. 98° 34′ W. Owner: Texas Parks and Wildlife Department. 619 ha. Visited on 24-25 May 1984.

Appendix 3. Community composition of Spring Pasture, FWMA, spring 1983.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 1 | | | | |
| Ashe juniper | 93.6 | 81.4 | 99.6 | 91.5 |
| Plateau live oak | 1.4 | 4.6 | 0.4 | 2.1 |
| Texas kidneywood | 3.6 | 9.3 | <0.1 | 4.3 |
| Shin oak | 0.7 | 2.3 | 0.1 | 1.0 |
| Agarito | 0.7 | 2.3 | <0.1 | 1.0 |
| Transect 2* | | | | |
| Ashe juniper | 80.0 | 56.4 | 81.6 | 72.7 |
| Plateau live oak | 3.6 | 6.4 | 2.8 | 4.3 |
| Texas kidneywood | 4.3 | 9.7 | 0.1 | 4.7 |
| Shin oak | 2.9 | 6.4 | 1.5 | 3.6 |
| Agarito | 0.7 | 1.6 | <0.1 | 0.8 |
| Texas persimmon | 0.7 | 1.6 | 0.1 | 0.8 |
| Beargrass | 2.9 | 6.4 | 0.1 | 3.1 |
| Cat-brier | 0.7 | 1.6 | <0.1 | 0.8 |
| Texas oak | 4.3 | 9.7 | 13.9 | 9.3 |
| Transect 3 | | | | |
| Ashe juniper | 72.9 | 66.0 | 56.1 | 65.0 |
| Shin oak | 25.0 | 27.7 | 43.8 | 32.1 |
| Texas persimmon | 0.7 | 2.1 | <0.1 | 1.0 |
| Coma | 0.7 | 2.1 | 0.1 | 1.0 |
| Elbow-bush | 0.7 | 2.1 | <0.1 | 1.0 |
| Transect 4* | | | | |
| Ashe juniper | 86.4 | 70.0 | 91.8 | 82.7 |
| Plateau live oak | 7.9 | 16.0 | 3.9 | 9.2 |
| Beargrass | 0.7 | 2.0 | <0.1 | 0.9 |
| Texas oak | 4.3 | 10.0 | 4.4 | 6.2 |
| Mimosa sp. | 0.7 | 2.0 | <0.1 | 0.9 |
| Transect 5* | | | | |
| Ashe juniper | 71.4 | 52.2 | 66.1 | 63.2 |
| Shin oak | 2.1 | 4.5 | 0.6 | 2.4 |
| Texas persimmon | 4.3 | 9.0 | 0.1 | 4.4 |
| Beargrass | 0.7 | 1.5 | <0.1 | 0.7 |
| Texas oak | 15.0 | 19.4 | 24.0 | 19.5 |
| Coma | 0.7 | 1.5 | <0.1 | 0.7 |
| Black cherry | 3.6 | 7.5 | 8.6 | 6.6 |
| Arizona walnut | 0.7 | 1.5 | 0.6 | 0.9 |
| Sweet mountain grape | 0.7 | 1.5 | <0.1 | 0.7 |
| Chinkapin oak | 0.7 | 1.5 | <0.1 | 0.7 |

Appendix 3, concluded.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 6* | | | | |
| Ashe juniper | 58.6 | 47.1 | 89.3 | 65.0 |
| Plateau live oak | 3.6 | 5.7 | 0.4 | 3.2 |
| Shin oak | 27.1 | 27.1 | 5.3 | 19.9 |
| Agarito | 1.4 | 2.9 | <0.1 | 1.4 |
| Texas persimmon | 0.7 | 1.4 | <0.1 | 0.7 |
| Cat-brier | 0.7 | 1.4 | <0.1 | 0.7 |
| Texas oak | 4.3 | 7.1 | 3.4 | 4.9 |
| Sweet mountain grape | 2.1 | 4.3 | 0.1 | 2.2 |
| Little walnut | 1.4 | 2.9 | 1.5 | 1.9 |

* Area occupied by Golden-cheeked Warblers during spring 1984.

Appendix 4. Community composition of Spring Trap Pasture, KWMA, spring 1983.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 1* | | | | |
| Ashe juniper | 78.6 | 57.6 | 84.1 | 73.4 |
| Plateau live oak | 9.3 | 17.0 | 11.2 | 12.5 |
| Texas kidneywood | 1.4 | 3.4 | <0.1 | 1.6 |
| Shin oak | 5.7 | 11.9 | 2.9 | 6.8 |
| Texas persimmon | 0.7 | 1.7 | <0.1 | 0.8 |
| Beargrass | 0.7 | 1.7 | <0.1 | 0.8 |
| Cat-brier | 1.4 | 1.7 | <0.1 | 1.0 |
| Texas oak | 1.4 | 3.4 | 1.7 | 2.2 |
| Prickly pear | 0.7 | 1.7 | <0.1 | 0.8 |
| Transect 2* | | | | |
| Ashe juniper | 45.7 | 31.4 | 7.9 | 28.3 |
| Texas persimmon | 2.1 | 1.2 | <0.1 | 1.1 |
| Texas oak | 18.6 | 19.8 | 19.7 | 19.3 |
| Black cherry | 6.4 | 9.3 | 10.4 | 8.7 |
| Arizona walnut | 5.0 | 8.1 | 3.8 | 5.6 |
| Chinkapin oak | 7.9 | 11.6 | 32.1 | 17.2 |
| Lacey oak | 3.6 | 5.8 | 5.1 | 4.8 |
| Southern black-haw | 1.4 | 1.2 | 0.9 | 1.2 |
| Cedar elm | 6.4 | 7.0 | 8.1 | 7.2 |
| American elm | 2.1 | 3.5 | 11.8 | 5.8 |
| Netleaf hackberry | 0.7 | 1.2 | 0.2 | 0.7 |

* Area occupied by Golden-cheeked Warblers during spring 1984.

Appendix 5. Community composition of River Pasture, KWMA, spring 1983.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 1* | | | | |
| Ashe juniper | 89.3 | 70.0 | 94.2 | 84.5 |
| Plateau live oak | 5.0 | 14.0 | 4.1 | 7.7 |
| Shin oak | 3.6 | 10.0 | 0.8 | 4.8 |
| Agarito | 0.7 | 2.0 | <0.1 | 0.9 |
| Texas oak | 1.4 | 4.0 | 0.9 | 2.1 |
| Transect 2* | | | | |
| Ashe juniper | 40.7 | 29.3 | 57.8 | 42.6 |
| Plateau live oak | 0.7 | 1.0 | 2.3 | 1.3 |
| Shin oak | 9.3 | 11.1 | 6.7 | 9.0 |
| Texas persimmon | 7.1 | 9.1 | 0.1 | 5.5 |
| Texas oak | 5.7 | 8.1 | 10.0 | 7.9 |
| Coma | 7.1 | 9.1 | 0.3 | 5.5 |
| Black cherry | 2.1 | 3.0 | 7.1 | 4.1 |
| Arizona walnut | 1.4 | 2.0 | 2.8 | 2.1 |
| Lacey oak | 1.4 | 2.0 | 1.5 | 1.7 |
| Cedar elm | 2.1 | 3.0 | 8.5 | 4.6 |
| Netleaf hackberry | 22.1 | 22.2 | 2.8 | 15.7 |

* Area occupied by Golden-cheeked Warblers during spring 1984.

Appendix 6. Community composition of Owl Pasture, KWMA, spring 1983.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 1 | | | | |
| Ashe juniper | 92.1 | 76.1 | 96.4 | 88.2 |
| Plateau live oak | 2.9 | 8.7 | 3.4 | 5.0 |
| Shin oak | 0.7 | 2.2 | 0.2 | 1.0 |
| Agarito | 1.4 | 4.4 | <0.1 | 1.9 |
| Beargrass | 0.7 | 2.2 | <0.1 | 1.0 |
| Cat-brier | 0.7 | 2.2 | <0.1 | 1.0 |
| Mimosa sp. | 0.7 | 2.2 | <0.1 | 1.0 |
| Netleaf hackberry | 0.7 | 2.2 | <0.1 | 1.0 |
| Transect 2 | | | | |
| Ashe juniper | 7.9 | 10.4 | 28.6 | 15.6 |
| Plateau live oak | 33.6 | 22.9 | 64.0 | 40.2 |
| Texas kidneywood | 0.7 | 1.0 | <0.1 | 0.6 |
| Agarito | 4.3 | 5.2 | 0.5 | 3.3 |
| Texas persimmon | 15.0 | 15.6 | 2.3 | 11.0 |
| Beargrass | 5.7 | 8.3 | 0.3 | 4.8 |
| Cat-brier | 0.7 | 1.0 | <0.1 | 0.6 |
| Mimosa sp. | 1.4 | 2.1 | 0.2 | 1.2 |
| Netleaf hackberry | 16.4 | 16.7 | 3.4 | 12.2 |
| Prickly pear | 8.6 | 10.4 | 0.2 | 6.4 |
| Honey mesquite | 1.4 | 2.1 | <0.1 | 1.2 |
| Sumac sp. | 1.4 | 2.1 | <0.1 | 1.2 |
| Common bee-brush | 2.9 | 2.1 | 0.3 | 1.7 |
| Transect 3 | | | | |
| Ashe juniper | 35.7 | 29.1 | 38.1 | 34.3 |
| Plateau live oak | 10.0 | 9.7 | 53.1 | 24.3 |
| Shin oak | 2.1 | 2.9 | 3.0 | 2.7 |
| Agarito | 5.0 | 5.8 | 1.0 | 3.9 |
| Texas persimmon | 10.0 | 12.6 | 2.7 | 8.4 |
| Beargrass | 2.9 | 3.9 | 0.3 | 2.4 |
| Cat-brier | 0.7 | 1.0 | <0.1 | 0.6 |
| Coma | 2.1 | 2.9 | 0.1 | 1.7 |
| Netleaf hackberry | 5.0 | 6.8 | 0.4 | 4.1 |
| Prickly pear | 21.4 | 19.4 | 1.1 | 14.0 |
| Redbud | 2.9 | 2.9 | 0.1 | 2.0 |
| Hedgehog cactus | 2.1 | 2.9 | 0.1 | 1.7 |

Appendix 6, concluded.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 4 | | | | |
| Ashe juniper | 52.1 | 31.8 | 83.9 | 55.9 |
| Plateau live oak | 4.3 | 7.1 | 0.4 | 3.9 |
| Texas kidneywood | 0.7 | 1.2 | <0.1 | 0.6 |
| Agarito | 6.4 | 10.6 | 2.6 | 6.5 |
| Texas persimmon | 7.1 | 9.4 | 2.2 | 6.3 |
| Beargrass | 4.3 | 5.9 | 0.1 | 3.4 |
| Cat-brier | 6.4 | 5.9 | 0.2 | 4.2 |
| Coma | 1.4 | 2.4 | 0.1 | 1.3 |
| Lacey oak | 0.7 | 1.2 | 4.2 | 2.0 |
| Netleaf hackberry | 10.0 | 15.3 | 6.1 | 10.5 |
| Prickly pear | 5.7 | 8.2 | 0.1 | 4.7 |
| Hedgehog cactus | 0.7 | 1.2 | <0.1 | 0.6 |
| Transect 5 | | | | |
| Ashe juniper | 19.3 | 17.2 | 13.4 | 16.6 |
| Plateau live oak | 9.3 | 8.6 | 14.8 | 10.9 |
| Texas kidneywood | 5.7 | 4.3 | 3.0 | 4.3 |
| Agarito | 15.0 | 17.2 | 20.4 | 17.5 |
| Texas persimmon | 12.9 | 14.0 | 8.1 | 11.6 |
| Beargrass | 18.6 | 15.0 | 2.8 | 12.1 |
| Cat-brier | 0.7 | 1.1 | <0.1 | 0.6 |
| Sweet mountain grape | 1.4 | 2.2 | 1.8 | 1.8 |
| Netleaf hackberry | 12.9 | 14.0 | 35.5 | 20.8 |
| Prickly pear | 2.9 | 4.3 | 0.1 | 2.4 |
| Honey mesquite | 1.4 | 2.2 | 0.1 | 1.2 |

Appendix 7. Community composition of Buck Pasture, KWMA, spring 1983.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 1 | | | | |
| Ashe juniper | 27.9 | 27.2 | 8.1 | 21.0 |
| Plateau live oak | 17.1 | 21.0 | 10.7 | 16.3 |
| Texas kidneywood | 2.9 | 3.7 | 0.6 | 2.4 |
| Shin oak | 40.0 | 30.9 | 75.4 | 48.8 |
| Agarito | 3.6 | 6.2 | 2.6 | 4.1 |
| Texas persimmon | 3.6 | 3.7 | 1.6 | 3.0 |
| Beargrass | 1.4 | 1.2 | 0.1 | 0.9 |
| Sweet mountain grape | 1.4 | 2.5 | 0.1 | 1.3 |
| Netleaf hackberry | 0.7 | 1.2 | 0.7 | 0.9 |
| Evergreen sumac | 0.7 | 1.2 | 0.1 | 0.7 |
| Mountain mulberry | 0.7 | 1.2 | <0.1 | 0.6 |
| Transect 2 | | | | |
| Ashe juniper | 65.0 | 52.3 | 88.9 | 68.7 |
| Plateau live oak | 20.7 | 27.7 | 3.2 | 17.2 |
| Shin oak | 10.7 | 12.3 | 7.9 | 10.3 |
| Texas persimmon | 1.4 | 3.1 | <0.1 | 1.5 |
| Beargrass | 1.4 | 3.1 | <0.1 | 1.5 |
| Marine-ivy | 0.7 | 1.5 | <0.1 | 0.8 |

Appendix 8. Community composition of Bobcat Pasture, KWMA, spring 1983.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 1 | | | | |
| Ashe juniper | 58.6 | 45.2 | 90.9 | 64.9 |
| Plateau live oak | 13.6 | 17.8 | 4.1 | 11.8 |
| Shin oak | 21.4 | 24.7 | 1.9 | 16.0 |
| Beargrass | 2.1 | 4.1 | <0.1 | 2.1 |
| Texas oak | 3.6 | 6.8 | 3.1 | 4.5 |
| Mimosa sp. | 0.7 | 1.4 | <0.1 | 0.7 |
| Transect 2 | | | | |
| Ashe juniper | 92.1 | 76.1 | 97.7 | 88.6 |
| Plateau live oak | 5.7 | 17.4 | 1.9 | 8.3 |
| Shin oak | 0.7 | 2.2 | 0.4 | 1.1 |
| Agarito | 0.7 | 2.2 | <0.1 | 1.0 |
| Texas persimmon | 0.7 | 2.2 | <0.1 | 1.0 |
| Transect 3 | | | | |
| Ashe juniper | 27.9 | 31.4 | 20.2 | 26.5 |
| Plateau live oak | 5.7 | 8.6 | 1.2 | 5.2 |
| Shin oak | 55.7 | 40.0 | 78.2 | 58.0 |
| Texas persimmon | 5.7 | 10.0 | 0.2 | 5.3 |
| Beargrass | 0.7 | 1.4 | <0.1 | 0.7 |
| Cat-brier | 0.7 | 1.4 | <0.1 | 0.7 |
| Netleaf hackberry | 2.1 | 4.3 | 0.1 | 2.2 |
| Prickly pear | 1.4 | 2.9 | <0.1 | 1.4 |
| Transect 4 | | | | |
| Ashe juniper | 40.0 | 43.6 | 36.7 | 40.1 |
| Plateau live oak | 5.0 | 6.4 | 0.8 | 4.1 |
| Shin oak | 52.9 | 46.8 | 62.5 | 54.0 |
| Agarito | 1.4 | 1.6 | <0.1 | 1.0 |
| Hedgehog cactus | 0.7 | 1.6 | <0.1 | 0.8 |
| Transect 5 | | | | |
| Ashe juniper | 6.4 | 8.1 | <0.1 | 4.9 |
| Plateau live oak | 37.9 | 29.1 | 71.0 | 46.0 |
| Shin oak | 33.6 | 29.1 | 26.9 | 29.8 |
| Agarito | 5.0 | 8.1 | 1.4 | 4.8 |
| Texas persimmon | 3.6 | 4.6 | <0.1 | 2.8 |
| Beargrass | 5.0 | 8.1 | 0.2 | 4.4 |
| Cat-brier | 1.4 | 1.2 | <0.1 | 0.9 |
| Sweet mountain grape | 0.7 | 1.2 | <0.1 | 0.6 |
| Netleaf hackberry | 2.9 | 4.6 | <0.1 | 2.5 |
| Black dalea | 2.1 | 3.5 | 0.2 | 2.0 |
| Redbud | 1.4 | 2.3 | 0.2 | 1.3 |

Appendix 8, continued.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 6 | | | | |
| Ashe juniper | 29.3 | 24.7 | 20.9 | 25.0 |
| Plateau live oak | 37.9 | 34.6 | 64.4 | 45.6 |
| Texas kidneywood | 0.7 | 1.2 | <0.1 | 0.6 |
| Shin oak | 7.1 | 7.4 | 12.4 | 9.0 |
| Agarito | 3.6 | 6.2 | 0.5 | 3.4 |
| Texas persimmon | 10.7 | 9.9 | 1.6 | 7.4 |
| Beargrass | 7.9 | 11.1 | 0.1 | 6.4 |
| Fish-hook cactus | 0.7 | 1.2 | <0.1 | 0.6 |
| Coma | 0.7 | 1.2 | <0.1 | 0.7 |
| Acacia sp. | 1.4 | 2.5 | 0.1 | 1.4 |
| Transect 7 | | | | |
| Ashe juniper | 69.3 | 55.0 | 91.8 | 72.0 |
| Plateau live oak | 9.3 | 13.3 | 1.4 | 8.0 |
| Shin oak | 19.3 | 26.7 | 6.8 | 17.6 |
| Agarito | 2.1 | 5.0 | <0.1 | 2.4 |
| Transect 8 | | | | |
| Ashe juniper | 4.3 | 4.8 | <0.1 | 3.0 |
| Plateau live oak | 28.6 | 25.0 | 47.3 | 33.6 |
| Texas kidneywood | 1.4 | 2.4 | 0.2 | 1.3 |
| Shin oak | 35.7 | 27.4 | 18.4 | 27.2 |
| Agarito | 1.4 | 2.4 | 0.2 | 1.3 |
| Texas persimmon | 5.7 | 7.1 | 1.2 | 4.7 |
| Beargrass | 5.7 | 6.0 | 0.2 | 4.0 |
| Texas oak | 7.9 | 9.5 | 24.2 | 13.8 |
| Lacey oak | 2.9 | 4.8 | 6.4 | 4.7 |
| Netleaf hackberry | 1.4 | 2.4 | <0.1 | 1.3 |
| Black dalea | 3.6 | 6.0 | 0.2 | 3.2 |
| Redbud | 0.7 | 1.2 | 0.1 | 0.7 |
| Catclaw acacia | 0.7 | 1.2 | 1.7 | 1.2 |
| Transect 9 | | | | |
| Ashe juniper | 30.7 | 26.4 | 9.0 | 22.0 |
| Plateau live oak | 22.1 | 18.4 | 70.9 | 37.1 |
| Shin oak | 12.9 | 11.5 | 13.5 | 12.6 |
| Agarito | 14.3 | 17.2 | 3.0 | 11.5 |
| Texas persimmon | 11.4 | 14.9 | 3.4 | 9.9 |
| Beargrass | 4.3 | 4.6 | 0.1 | 3.0 |
| Cat-brier | 0.7 | 1.2 | <0.1 | 0.6 |
| Coma | 0.7 | 1.2 | <0.1 | 0.6 |
| Netleaf hackberry | 1.4 | 2.3 | <0.1 | 1.3 |
| Acacia sp. | 1.4 | 2.3 | 0.1 | 1.3 |

Appendix 8, concluded.

| Transect/Species | Relative Density (%) | Relative Frequency (%) | Relative Dominance (%) | Importance Value |
|---|---|---|---|---|
| Transect 10 | | | | |
| Ashe juniper | 59.3 | 47.8 | 85.5 | 64.2 |
| Plateau live oak | 10.0 | 15.9 | 2.0 | 9.3 |
| Shin oak | 30.7 | 36.2 | 12.5 | 26.5 |