EVALUATION OF ROAD-BASED SURVEYS OF RIO GRANDE WILD TURKEYS IN TEXAS

by

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ABSTRACT

Many techniques have been used to index or estimate abundance, density, and trends of Rio Grande wild turkey (*Meleagris gallopavo intermedia*) populations. Though traditional index-based monitoring techniques can indicate trends in wild turkey populations, they were not designed with the sensitivity necessary to detect anything but drastic changes. Recent research on line transect-based distance sampling from roads has indicated road-based surveys may provide an efficient, effective, and inexpensive technique for monitoring wild turkey populations on an ecoregion scale. Our goal was to evaluate the applicability of road-based distance sampling in the Cross Timbers, Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas. Our research objectives were to: (1) quantify the association of male and female Rio Grande wild turkeys to roads according to ecoregion, season, and time of day, and examine potential biases associated with using roads as transects for distance sampling; (2) conduct road-based surveys in each ecoregion to determine wild turkey flock encounter rates and the amount of survey effort required to obtain adequate sample sizes for road-based distance sampling; and (3) conduct field simulation surveys using inflatable wild turkey decoys to determine flock detection probabilities and evaluate factors affecting wild turkey flock detectability.

We found that Rio Grande wild turkey populations are randomly distributed around roads from 1 December–15 March in most areas. Our results suggested that road-based surveys conducted during that period will produce generally unbiased results. We conducted road-based surveys in 4 ecoregions of Texas from 1 December 2007–15 March 2008. Encounter rates of wild turkey flocks obtained from road-based surveys varied from 0.1 (0.0–0.6; 95% CI) to 2.2 (0.8–6.0) flocks/100 km surveyed. Encounter rates from surveys restricted to riparian communities varied from 0.2 (0.1–0.6; 95% CI) to 2.9 (1.5–6.7) flocks/100 km surveyed. Flock detection probabilities obtained from field simulations ranged from 22.5% (16.3–29.8%; 95% CI) to 25.0% (13.6–39.6%). Flock detection probabilities were lower than expected in each ecoregion, which resulted in low encounter rates. Estimated survey effort required to obtain adequate sample sizes for distance sampling ranged from 2,765 km (2,597–2,956 km; 95% CI) in the Edwards Plateau to 37,500 km (33,333–42,857 km) in South Texas. When road-based surveys were restricted to riparian communities, estimated survey effort ranged from 2,222 km (2,092–2,370 km; 95% CI) in the Edwards Plateau to 22,222 km (19,782–25,349 km) in South Texas. Our modeling efforts suggested that distance to the flock and vegetative cover combined played important roles in wild turkey flock detectability. Frequent rains during the 2007 growing season created dense understory vegetation that made flock detectability difficult in every ecoregion. Our results indicated that too much survey effort was required to make road-based surveys a feasible technique for monitoring wild turkey populations in most ecoregions of Texas. However, when surveys were restricted to areas ≤1 km from a river or stream, the technique was feasible for monitoring wild turkey populations in the Edwards Plateau and Rolling Plains ecoregions.

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CHAPTER I

INTRODUCTION

The wild turkey (*Meleagris gallopavo*) once ranged across North America from Ontario, Canada to southern Mexico and from the Rocky Mountains east to the Atlantic coast (Schorger 1966). This gallinaceous game bird is represented by five subspecies throughout North America. These subspecies include the eastern wild turkey (*M. g. silvestris*), Rio Grande wild turkey (*M. g. intermedia*), Merriam's wild turkey (*M. g. merriami*), Florida wild turkey (*M. g. Osceola*), and Gould's wild turkey (*M. g. Mexicana*) (Kennamer et al. 1992). Unfortunately, knowledge concerning Rio Grande wild turkey (RGWT) populations has not kept pace with that of other wild turkey subspecies (Peterson 1998).

RGWTs historically ranged throughout the south-central plains states and northern Mexico (Beasom and Wilson 1992). Prior to European settlement, the estimated RGWT population size was 1.8–2.0 million birds (Schorger 1966). Throughout North America, European settlement and civilization led to decreases in abundance of wild turkeys. Unregulated hunting and habitat destruction during the late 1800s to early 1900s led to extirpation of the RGWT from much of its historical range (Schorger 1966, Beasom and Wilson 1992). By 1928, RGWT abundance in Texas was approximately 96,000 (Texas Game, Fish, and Oyster Commission [TGFOC] 1929:91, TGFOC 1945:15-33).

Fortunately, habitat regeneration and large-scale restocking efforts have restored wild turkey populations across much of the United States. The TGFOC began restocking

RGWTs as early as 1930 and by 1991, 22,968 wild turkeys had been released on 750 different sites in Texas (Beasom and Wilson 1992). Most restocking efforts have been successful, leading to a widespread expansion of wild turkeys. By 2004, wildlife managers suggested there were approximately 585,000 RGWTs in Texas (Tapley et al. 2007).

Few studies have focused on developing rigorous techniques for estimating abundance, density, and trends of wild turkey populations because they have been on the rebound for most of the 20th century (Butler 2006). However, wildlife managers in Texas are now concerned that wild turkey populations have begun to decline across much of the state (Brunjes 2005). Fewer observations during poult-hen counts and fewer winter roost sites have suggested populations are declining in the Texas Panhandle (Brunjes 2005). Data from Texas Parks and Wildlife Department (TPWD) annual hen-poult counts show a slight decrease in poults/hen for the southern rolling plains ecoregion (TPWD unpublished data). Brunjes (2005) conducted a study to project population dynamics on 3 study sites in the Texas Panhandle and one study site in Southwestern Kansas. His results predicted an increasing population at one site, a stable population at one site, and a decreasing population at 2 other sites.

Concerns of diminishing populations caused TPWD biologists to conduct frequent wild turkey population surveys. These surveys included winter roost counts, hen-poult counts, gobble counts, and harvest surveys (Burk 2001). One problem with these survey techniques was a lack of power to detect trends in population change (Schwertner et al. 2003, Butler 2006, Butler et al. 2007*c*). Schwertner et al. (2003) found that poult-hen counts had very low power (<0.50) to detect long term changes of <20%.

Poult-hen counts conducted by TPWD have little value for detecting long term changes in recruitment (Schwertner et al. 2003, Butler et al. 2007*c*). Because they are index-based techniques, they do not estimate actual population abundance (Anderson 2001, Burk 2001, Butler et al. 2006). The techniques used, also have no verification that they are related to turkey population size. Poult-hen counts can detect changes in reproduction and recruitment, however this index may not relate to abundance or density (Butler et al. 2007*c*). Roost counts can be useful for estimating abundance at a local scale; however, the amount of effort required reduces feasibility on ecoregion scales. Other survey techniques (e.g., aerial surveys, mark-resight) are often prohibitively expensive (DeYoung and Priebe 1987, Butler 2006, Butler et al. 2007*b*) and therefore cannot be used on a large scale.

Distance sampling is a group of related methods that is widely used to estimate the density of wildlife populations. The 2 primary methods of distance sampling are line transects and point counts (Buckland et al. 2001). In line transect-based distance sampling, the observer travels along a line and records the distance from the line to each animal or cluster of animals detected (Buckland et al. 2001). In point counts, the observer records all objects detected and their distances from a fixed point. One disadvantage of this technique is that the object is often disturbed or flushed away before the observer approaches the survey point. Also, more time is spent traveling to the survey point and less time is spent surveying (Bibby et al. 2000, Buckland et al. 2001). Both methods have been used with great success in many different habitats and with many different species (Bibby et al. 2000).

Distance sampling is popular because it eliminates many problems associated with indices such as poult-hen counts or roost counts (Rosenstock et al. 2002). The distance sampling method corrects for detectability bias by modeling a detection function that relates detectability with distance. Index counts do not incorporate a detection function (Anderson 2001). The basic idea underlying the detection function is that the probability of detecting an animal decreases with increasing distance (Burnham et al. 1980, Buckland et al. 2001). Distance however, is not the only factor that affects detectability. Detectability can also be affected by coloration, size, movement, grouping size and behavior, and environmental factors such as vegetation, wind, sunlight, and precipitation (Burnham et al. 1980, Bibby et al. 2000, Anderson 2001, Buckland et al. 2001). The models used to estimate the detection function, however, are typically robust to those variations in detection probability (Burnham et al. 1980). This presents managers and researchers with a technique that is practical, accurate, and cost-effective for estimating animal density. "For objects distributed sparsely across large geographic areas, there are often no competing methods (Buckland et al. 2001:v)."

Since wildlife biologists and researchers are concerned that wild turkey populations may be declining, it is important that managers have accurate and precise techniques for examining population trends. It is also important to have accurate trend data to gauge the effectiveness of management activities (Lancia et al. 2005). Road-based distance sampling is an efficient and cost-effective technique that alleviates some of the problems associated with indices (e.g., accounts for incomplete detectability); and it may be effectively applied to ecoregion-scale monitoring programs for wild turkey populations (Butler 2006, Butler et al. 2007*a*).

The goal of this research effort was to evaluate a population density estimation technique based on distance sampling from roads in Texas. We evaluated line transect-based distance sampling for RGWT populations in 4 ecological regions of Texas: the southern portion of the Rolling Plains, the Cross-Timbers, the Edwards Plateau, and South Texas (Gould 1962). Our objectives were to: (1) quantify the association of male and female Rio Grande wild turkeys to roads, according to ecoregion, season, and time of day; and examine potential biases associated with using roads as transects for distance sampling; (2) determine encounter rates of wild turkeys during road-based surveys in each ecoregion and determine the amount of survey effort (i.e., km of roads) required to obtain adequate sample sizes for distance sampling; and (3) conduct distance sampling field simulation surveys using inflatable turkey decoys to determine flock detection and evaluate factors affecting flock detectability.

Chapter II examines the association of Rio Grande wild turkeys to roads in the Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas. We conducted habitat use and availability analyses of radio-marked birds by ecoregion, sex, season, and time of day (morning or afternoon), to determine when wild turkey populations are distributed randomly across the landscape in relation to roads. We then used that information to determine if and when road-based surveys would produce unbiased results in each ecoregion.

Chapter III describes the methodology and results obtained from use of road-based distance sampling surveys to determine wild turkey flock encounter rates in 4 ecoregions of Texas. Chapter III also explains use of field simulation surveys for determining flock detection probabilities, and for evaluating the effects of distance to a flock, flock size, and vegetative cover on flock detectability. Chapters II and III are formatted for submission to *The Journal of Wildlife Management* and include co-authors that made substantial contributions to the research. Authorship is as follows:

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CHAPTER II

RIO GRANDE WILD TURKEY HABITAT USE AROUND ROADS IN TEXAS

Abstract

Road-based distance sampling is a common technique used to estimate the density of many wildlife species but potential biases exist unless the target population is randomly distributed around roads. Our objective was to determine if and when Rio Grande wild turkeys (*Meleagris gallopavo intermedia*; RGWT) were randomly distributed around roads to identify time periods in which road-based surveys would be most appropriate. We used triangulated locations obtained from radiotelemetry in RGWT studies in the Edwards Plateau (2001–2003), Rolling Plains (2000–2006), and South Texas (2003–2006) ecoregions. Using a geographic information system (GIS), we conducted use and availability analyses by sex, season, and time of day for each ecoregion to determine wild turkey use of areas near roads (<200 m). We found the most appropriate time to conduct road-based distance sampling was from 1 December–15 March. Our results suggested road-based surveys conducted during these periods should yield generally unbiased results in the Rolling Plains and Edwards Plateau ecoregions.

Introduction

Distance sampling from roads is a common technique for surveys of avian species such as mountain quail (*Oreortyx pictus*), red-legged partridge (*Alectoris rufa*), wild turkeys (*Meleagris gallopavo*), and red-tailed hawks *(Buteo jamaicensis)* (Brennan and

Block 1986, DeYoung and Priebe 1987, Millsap and LeFranc 1988, Borralho et al. 1996, Butler et al. 2007). Unlike many of the traditional index-based techniques, road-based distance sampling is an effective and efficient technique for monitoring populations across large ecoregion scales (Butler et al. 2007). However, to achieve reliable estimates of population density from line-transect–based distance sampling, several assumptions must be met. These assumptions include (1) all animals on the transect are observed, (2) animals are not frightened away from or attracted to the transect before being detected, (3) distance and angle measurements are accurate, (4) the distribution of animals is not influenced by the transect, (5) animals are not counted twice during a survey, and (6) sighting events are independent (Burnham et al. 1980, Verner 1985, Thompson et al.1998, Bibby et al. 2000, Buckland et al. 2001).

One critical assumption, the distribution of animals is not influenced by the transect, may be violated if the transect is a road (Buckland et al. 2001). The attraction of animals to transects biases density estimates high, and avoidance of transects biases estimates low (Verner 1985, Thompson et al. 1998, Buckland et al. 2001). To obtain reliable density estimates, researchers suggested that transects should not be positioned on roads unless the target population is randomly distributed across the landscape in relation to roads (Burnham et al. 1980, Buckland et al. 2001, Butler et al. 2007).

DeYoung and Priebe (1987) compared inventory methods for Rio Grande wild turkeys (*M. g. intermedia*; RGWT) in South Texas and suggested males used roads as display sites during the breeding season. Thus, conducting road-based distance sampling during the breeding season would likely bias density estimates high. Based on the reproductive phenology of RGWTs in the Texas Rolling Plains (Gould 1962) and southwestern Kansas, nest initiation occurred from 1 April–3 July with a peak during 13 April–26 April (Hall 2005). In the Edwards Plateau, nest initiation occurred from 2 April–2 July (Melton 2007). Conducting road-based distance sampling during nesting would likely bias density estimates low because a portion of the population would be unavailable for detection.

Butler et al. (2005) examined the relationship of RGWT distributions to roads in the southern Great Plains during 2000–2003. They found areas <100 m from roads were used in proportion to availability by RGWTs during autumn-midday and winter-morning. Their results suggested that surveys conducted in the southern Great Plains during these 2 periods would generally be unbiased. In north-central Arizona, Rogers et al. (1999) studied male Merriam's turkey (*M. g. merriami*) distribution around roads and found turkeys avoided habitat <200 m from roads. However, research on eastern wild turkeys (*M. g. silvestris*) in Virginia suggested turkeys used areas <150 m from roads in proportion to availability and areas >450 m from roads more than expected (McDougal et al. 1990).

Our objective was to identify the appropriate seasons and time periods to conduct road-based surveys for RGWTs. We quantified the association of RGWTs to roads according to ecoregion, sex, season, and time of day (morning or afternoon). We examined the potential biases involved with sampling from roads and determined when road-based surveys would produce unbiased results based on wild turkey distributions. This information is needed to develop a survey protocol for an evaluation of road-based distance sampling of RGWTs in Texas.

Study Area

We gathered triangulated locations of Rio Grande wild turkeys derived from radio telemetry used in recent research at Texas A&M University, and Texas A&M University–Kingsville, and Texas Tech University. Telemetry locations were collected from March 2001–August 2003 on 4 study sites in the Edwards Plateau. These sites were located on private ranches in Kerr, Real, Bandera, and Medina counties. The vegetation and topography for each site was characteristic of the Edwards plateau region (Collier et al. 2007*a*). All 4 sites were a combination of brushland and open woodland dominated by live oak (*Quercus virginiana*) and Ashe juniper (*Juniperus ashei*) (Collier et al. 2007*a*).

Telemetry locations were collected from January 2000–March 2006 on 3 study sites in the Texas Rolling Plains. These study sites were centered on the Gene Howe Wildlife Management Area (WMA) in Hemphill County; the Matador WMA in Cottle County; and private ranches surrounding the Salt Fork of the Red River in eastern Donley and western Collingsworth counties. Vegetation in the riparian areas of these sites was dominated by cottonwood (*Populus deltoids*), hackberry (*Celtis occidentalis*), and elms (*Ulmus* spp.*)* but vegetation in the upland areas was dominated by honey mesquite (*Prosopis glandulosa*), sand sagebrush (*Artemisia filifolia*), redberry juniper (*Juniperus pinchotii*), and sand plum (*Prunus angustifolia*) (Spears 2002, Spears et al. 2002, Butler et al. 2005, Holdstock et al. 2006).

Telemetry locations were collected from November 2003–June 2006 on 3 study sites in South Texas. These study sites were located on private lands in Kenedy, Brooks, and Kleberg Counties. The vegetation from these study sites consisted of coastal prairie, oak (*Quercus* spp.) woodland, mesquite (*Prosopis* spp.) brushland, and thorn scrub (Collier et al. 2007*b*).

Methods

We captured RGWTs using rocket nets, drop nets, and walk-in traps (Glazener et al. 1964, Bailey et al. 1980, Davis 1994, Peterson et al. 2003). We outfitted 285 wild turkeys in the Edwards Plateau, 1,207 wild turkeys in the Rolling Plains, and 171 wild turkeys in South Texas with 95-g, mortality-sensitive, backpack-style radiotransmitters (Advanced Telemetry Systems, Isanti, MN). We triangulated locations 1–5 times per week using null-peak receiver systems with a truck-mounted 4-element Yagi antenna or a handheld 3-element Yagi antenna (Holdstock et al. 2006, Collier et al. 2007*a*, Hall et al. 2007). Telemetry bearings were imported into Location of a Signal (LOAS, Ecological Software Solutions, Sacramento California) software to generate turkey locations and related error polygons (Swearingin 2007). We removed any locations with error polygons >0.16 km^2 to be certain that the locations we analyzed were either near (<200 m) or far ($\geq$200 m) from roads. We categorized telemetry locations by ecoregion (Edwards Plateau, Rolling Plains, South Texas; Gould 1962), sex, season (winter = 1 Dec–15 Mar, nesting = 16 Mar–15 Aug, and autumn = 16 Aug–30 Nov) and time period (morning = first half of daylight hours, afternoon = last half of daylight hours).

We displayed telemetry locations along with county roads and Farm to Market (FM) highways, obtained from Texas Department of Transportation (TxDOT), in a geographic information system (GIS) using ArcMap™ Version 9.2. The South Texas study sites did not contain county roads or FM highways, so we used paved and caliche ranch roads instead. These roads were either surveyed or digitized from orthoimagery (2004 National Agriculture Imagery Program, U.S. Department of Agriculture) by private ranch staff or Texas Tech University personnel. State and federal highways were excluded from analysis due to their lack of feasibility for distance sampling because of traffic volume. Using Hawth's Analysis tools (Beyer 2004), we created a minimum convex polygon (MCP) around all locations from each study population to determine the available habitat (i.e., the landscape that is available for use to the population) at each study site. In the Rolling Plains ecoregion, we created 3 MCPs (Gene Howe, Salt Fork, and Matador), in the Edwards Plateau we created 2 MCPs (Kerr-Real and Bandera), and in South Texas we created 3 MCPs (Kleberg, Brooks, and Kenedy) (Fig. 2.1). Within each MCP, we created a 200-m buffer on each side of roads to represent available habitat near roads. A 200-m buffer was used because previous research indicated that turkey flock detection is unlikely at distances ≥200 m from roads (Butler et al. 2007). Using the MCP and road buffers at each study site, we were able to determine the total available habitat and the percent of available habitat near roads. We determined the percent of locations within 200 m of roads (e.g., percent use near roads). We then obtained 95% binomial confidence intervals (Conover 1999) to determine if RGWTs used road buffer areas more, less, or in proportion to availability.

We conducted a priori power analyses for a 2-sided exact binomial test (Appendix A) using PROC POWER in SAS 9.1.3 (SAS Institute, Cary, NC). We determined the number of RGWT locations needed to detect a 10% difference in observed and expected habitat use with ≥0.80 power at each study site. The number of locations needed was different at each study site because the amount of available habitat within 200 m of roads (i.e., the null proportion) differed by study site.

Results

We obtained 4,980 (female = 3,571, male = 1,409) RGWT locations from the Edwards plateau, 12,587 (female = 7,953, male = 4,634) locations from the Rolling Plains, and 1,827 female locations from South Texas (data were inadequate to analyze male wild turkey locations for South Texas study sites). The amount of available habitat at each study site ranged from 143.1 to 1,354.1 km^2 (Table 2.1). The density of county roads and FM highways at each study site ranged from 159.0–632.7 m/km^2; and the percent of available habitat within 200 m of roads at each study site ranged from 5.8 to 22.5% (Table 2.1). To detect a 10% difference in observed and expected habitat use with ≥0.80 power, 62 RGWT locations were needed at Kerr-Real and 48 locations were needed at Bandera. Forty-five locations were needed at Gene Howe and 33 locations were needed at Salt Fork and Matador. One hundred sixteen locations were needed at Brooks, 81 were needed at Kleberg, and 56 were needed at Kenedy (Appendix A).

In the Edwards Plateau, RGWTs used areas near roads (<200 m) in proportion to availability during most seasons and time periods. However, at the Kerr-Real study site, female RGWTs used areas near roads less than expected during winter mornings (Table 2.2). At the Bandera study site, female RGWTs used areas near roads more than expected during the nesting morning and afternoon periods, but our sample sizes were too small to adequately determine habitat use near roads during autumn and winter (Table 2.2).

In the Rolling Plains, wild turkey habitat use around roads varied among study sites. At the Gene Howe, RGWTs used areas near roads more than expected in most seasons and time periods. However, females used areas near roads in proportion to availability during winter mornings and males used areas near roads in proportion to availability during the winter morning and afternoon periods (Table 2.3). At the Matador, RGWTs used areas near roads more than expected during all seasons and time periods (Table 2.3). At the Salt Fork, RGWTs used areas near roads less than expected except during autumn mornings and afternoons and winter afternoons. During those periods, females used areas near roads in proportion to availability (Table 2.3).

Discussion

Our analyses identified seasons and time periods during which RGWTs used areas near roads in proportion to availability in the 3 ecoregions where most RGWTs in Texas occur. However, our results varied among ecoregions and even study sites within each ecoregion.

We had insufficient data to definitely determine why habitat use around roads differed among study sites. It is likely, however, that human disturbance and land use patterns affected RGWT distributions around roads (e.g., Wright and Speake 1975, McDougal et al. 1990). In the Rolling Plains, RGWTs used areas near roads more than expected at the Gene Howe and Matador, but less than expected at the Salt Fork (Table 2.3). The Gene Howe and Matador study sites were on limited-access Wildlife Management Areas operated by Texas Parks and Wildlife and Department, while the Salt Fork was located on privately owned ranches. Though the Salt Fork had a similar public road density to the Matador and Gene Howe (Table 2.1), it is likely the Salt Fork had more human disturbance than those study sites on the limited-access, state managed lands. It is difficult to make comparisons across ecoregions because we were limited to smaller sample sizes in the Edwards Plateau and South Texas; and those study sites were located on private land (Collier et al. 2007*a*). However in South Texas, many of the roads at Brooks, Kenedy, and Kleberg are limited-access. At those study sites, RGWTs did not appear to avoid roads during most periods (Table 2.4).

Our results are consistent with data obtained for eastern wild turkeys. In Kentucky, Wright and Speake (1975) found that wild turkeys avoided areas with higher human activity. Additionally, McDougal et al. (1990) found that radio-marked wild turkeys in Virginia avoided areas near roads where traffic rates were >70 vehicles/hr. Unfortunately, we did not have traffic volume data from our study sites to conduct a similar analysis.

Another factor that might influence RGWT distributions is road baiting. Baiting roads with milo (*Sorghum* spp.) and corn (*Zea mays*) has become common in Texas during certain periods of the year to facilitate game harvest. In South Texas, baiting roads for northern bobwhite (*Colinus virginianus*) has become popular not only to facilitate harvest, but also to provide nutrition during winter stress periods (Haines et al. 2004). In South Texas, RGWTs used areas near roads more than expected at those study sites in which we could determine habitat use. Additional research on the effects of road baiting, human disturbance, and vehicle traffic volume on RGWT distributions around roads is needed to further our understanding of when it is appropriate to use road-based distance sampling to estimate RGWT density in Texas.

Management Implications

Our analyses suggested that Rio Grande wild turkeys use areas near roads in proportion to availability in the Edwards Plateau and Rolling Plains during certain time periods (Tables 2.2–2.3). In those ecoregions, the most appropriate time to conduct road-based surveys is from 1 December–15 March during morning or afternoon. Surveys conducted during other times may produce biased estimates. For example, conducting surveys in the Rolling Plains from 16 August–30 November would produce inflated population estimates because both sexes used areas near roads more than expected during those periods (Table 2.3).

The results from our analyses should act as a guide for determining when to conduct road-based surveys for wild turkeys. However, other factors such as flocking behavior and vegetative cover also should be considered. For example, vegetative cover may affect flock detectability, so knowledge of annual leaf fall dates would be helpful in designing survey protocols.

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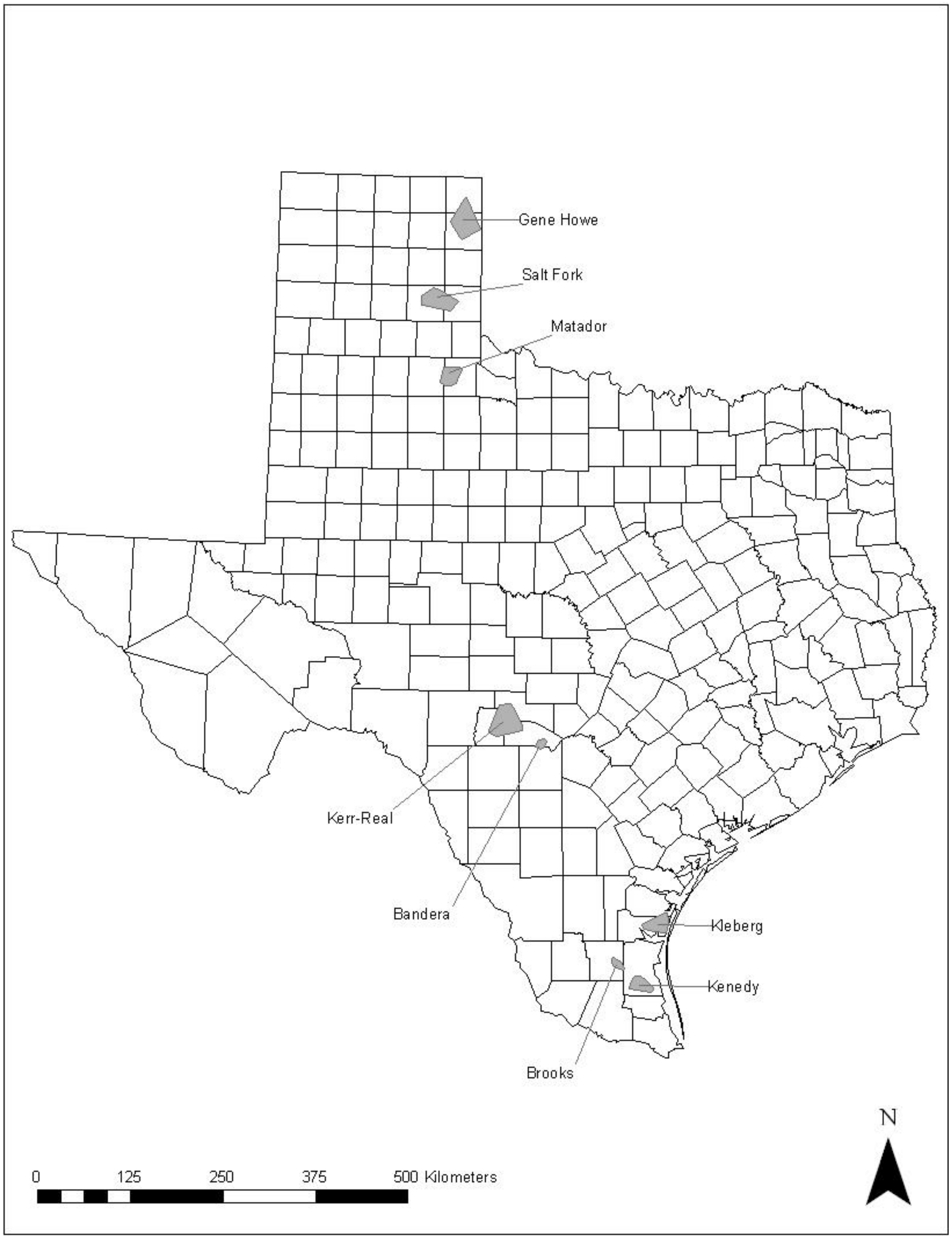

Figure 2.1. Map of Texas denoting minimum convex polygons used to determine available habitat for Rio Grande wild turkeys in the Edwards Plateau, Rolling Plains, and South Texas ecoregions; obtained from radiotelemetry data collected during 2000–2006.

Table 2.1. Summary of available habitat and road density in the Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas, 2000–2006.

		Habitat		
Ecoregion	Study site	Available (km^2)[a]	Near roads (%)[b]	Road density (m/km^2)[c]
Rolling Plains	Gene Howe	1,228.8	8.0	230.7
	Salt Fork	984.5	10.7	315.1
	Matador	583.4	10.7	311.0
Edwards Plateau	Kerr-Real	1,354.1	5.8	159.0
	Bandera	143.1	11.2	315.4
South Texas	Kleberg	623.3	15.6	429.8
	Brooks	169.6	22.5	632.7
	Kenedy	464.0	12.5	340.0

[a] Available habitat inside each minimum convex polygon (MCP).

[b] Percent of available habitat within 200 m of roads inside each MCP.

[c] Density of Farm to Market highways and county roads inside each MCP.

Table 2.2. Rio Grande wild turkey use of habitat within 200 m of roads by site, sex, season, and time period in the Edwards Plateau ecoregion of Texas, 2001–2003.

					Estimated 95% CI[a]			
Site	Sex	Season	Period	n[b]	Lower	p	Upper	Use[c]
Kerr-Real	female	autumn	afternoon	315	5.7	8.6	12.2	o
			morning	511	3.5	5.3	7.6	o
		nesting	afternoon	544	3.6	5.3	7.6	o
			morning	1,472	4.2	5.3	6.6	o
		winter	afternoon	112	3.1	7.1	13.6	o
			morning	344	1.0	2.3	4.5	-
	male	autumn	afternoon	117	4.8	9.4	16.2	o
			morning	156	2.7	5.8	10.7	o
		nesting	afternoon	191	3.7	6.8	11.4	o
			morning	495	4.3	6.3	8.8	o
		winter	afternoon	101	1.6	5.0	11.2	o
			morning	115	1.4	4.4	9.9	o
Bandera	female	autumn	afternoon	23	1.1	8.7	28.0	*
			morning	25	1.0	8.0	26.0	*
		nesting	afternoon	120	13.3	20.0	28.3	+
			morning	76	12.5	21.1	31.9	+
		winter	afternoon	19	9.2	26.3	51.2	*
			morning	9	0.3	11.1	48.3	*

Table 2.2. Continued.

					Estimated 95% CI[a]			
Site	Sex	Season	Period	*n*[b]	Lower	*p*	Upper	Use[c]
	male	autumn	afternoon	18	1.4	11.1	34.7	*
			morning	28	13.2	28.6	48.7	*
		nesting	afternoon	94	5.2	10.6	18.7	o
			morning	49	3.4	10.2	22.2	o
		winter	afternoon	30	5.6	16.7	34.7	*
			morning	15	7.8	26.7	55.1	*

[a] 95% binomial confidence intervals of the percent of locations (*p*) within areas <200 m from roads.

[b] Number of Rio Grande wild turkey locations.

[c] Symbols indicate areas <200 m from roads were used more (+), less (-), or in proportion to availability (o). The asterisk (*) indicates the sample size was too small to determine habitat use near roads. At Kerr-Real, 5.8% of available habitat was near roads. At Bandera, 11.2% of available habitat was near roads.

Table 2.3. Rio Grande wild turkey use of habitat within 200 m of roads by site, sex, season, and time period in the Rolling Plains ecoregion of Texas, 2000–2006.

					Estimated 95% CI[a]			
Site	Sex	Season	Period	*n*[b]	Lower	*p*	Upper	Use[c]
Gene Howe	female	autumn	afternoon	207	19.8	25.6	32.1	+
			morning	270	10.2	14.1	18.8	+
		nesting	afternoon	1,374	19.2	21.3	23.6	+
			morning	1,250	20.0	22.2	24.7	+
		winter	afternoon	194	10.7	15.5	21.3	+
			morning	133	7.6	12.8	19.7	o
	male	autumn	afternoon	162	18.8	25.3	32.7	+
			morning	217	11.1	15.7	21.2	+
		nesting	afternoon	900	24.3	27.2	30.3	+
			morning	745	32.0	35.4	39.0	+
		winter	afternoon	136	6.9	11.8	18.4	o
			morning	87	6.5	12.6	21.5	o
Matador	female	autumn	afternoon	157	36.7	44.6	52.7	+
			morning	114	43.1	52.6	62.1	+
		nesting	afternoon	625	48.6	52.6	56.6	+
			morning	701	41.4	45.1	48.9	+
		winter	afternoon	194	45.8	53.1	60.3	+
			morning	169	53.8	61.5	68.9	+

Table 2.3. Continued.

Site	Sex	Season	Period	n[b]	Estimated 95% CI[a] Lower	p	Upper	Use[c]
	male	autumn	afternoon	38	26.3	42.1	59.2	+
			morning	55	25.4	38.2	52.3	+
		nesting	afternoon	533	30.3	34.3	38.5	+
			morning	440	31.4	35.9	40.6	+
		winter	afternoon	60	21.7	33.3	46.7	+
			morning	57	18.4	29.8	43.4	+
Salt Fork	female	autumn	afternoon	227	4.1	7.1	11.2	o
			morning	132	5.9	10.6	17.2	o
		nesting	afternoon	949	5.1	6.5	8.3	-
			morning	1,066	6.4	8.0	9.8	-
		winter	afternoon	85	1.9	5.9	13.2	o
			morning	94	0.7	3.2	9.0	-
	male	autumn	afternoon	122	1.3	4.1	9.3	-
			morning	76	0.3	2.6	9.2	-
		nesting	afternoon	398	3.3	5.3	8.0	-
			morning	499	2.6	4.2	6.4	-
		winter	afternoon	59	0.0	0.0	5.0	-
			morning	50	0.1	2.0	10.7	-

[a] 95% binomial confidence intervals of the percent of locations (p) within areas <200 m from roads.

[b] Number of Rio Grande wild turkey locations.

[c] Symbols indicate areas <200 m from roads were used more (+), less (-), or in proportion to availability (o). At Gene Howe, 8% of available habitat was near roads. At Matador, 10.7% of available habitat was near roads. At Salt Fork, 10.7% of available habitat was near roads.

Table 2.4. Rio Grande wild turkey use of habitat within 200 m of roads by site, sex, season, and time period in the South Texas ecoregion of Texas, 2003–2006.

					Estimated 95% CI[a]			
Site	Sex	Season	Period	n[b]	Lower	p	Upper	Use[c]
Brooks	female	autumn	afternoon	105	8.2	14.3	22.5	*
			morning	30	7.7	20.0	38.6	*
		nesting	afternoon	102	12.4	19.6	28.7	*
			morning	80	15.0	23.8	34.6	*
		winter	afternoon	12	2.1	16.7	48.4	*
			morning	28	2.3	10.7	28.2	*
Kleberg	female	autumn	afternoon	22	17.2	36.4	59.3	*
			morning	44	30.4	45.5	61.2	*
		nesting	afternoon	224	31.1	37.5	44.2	+
			morning	438	37.1	41.8	46.6	+
		winter	afternoon	116	44.0	53.5	62.8	+
			morning	154	36.2	44.2	52.4	+
Kenedy	female	autumn	afternoon	5	0.0	0.0	45.1	*
			morning	14	12.8	35.7	64.9	*
		nesting	afternoon	220	13.7	18.6	24.4	+
			morning	217	23.5	29.5	36.0	+
		winter	afternoon	7	3.7	28.6	71.0	*
			morning	4	0.0	0.0	52.7	*

[a] 95% binomial confidence intervals of the percent of locations (p) within areas <200 m from roads.

[b] Number of Rio Grande wild turkey locations.

[c] Symbols indicate areas <200 m from roads were used more (+), less (-), or in proportion to availability (o). The asterisk (*) indicates the sample size was too small to determine habitat use near roads. At Brooks, 22.5% of available habitat was near roads. At Kleberg, 15.6% of available habitat was near roads. At Kenedy, 12.5% of available habitat was near roads.

CHAPTER III

ENCOUNTER RATES FROM ROAD-BASED SURVEYS OF RIO GRANDE WILD TURKEYS IN TEXAS

Abstract

Research on line-transect–based distance sampling, has indicated road-based surveys may be an efficient and cost-effective technique for monitoring wild turkey (*Meleagris gallopavo*) populations on an ecoregion level. Our goal was to evaluate the applicability of road-based distance sampling in the Cross Timbers, Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas. We conducted road-based surveys in each ecoregion during 2007–2008 to estimate Rio Grande wild turkey (*M. g. intermedia*) flock encounter rates and to determine the amount of survey effort (i.e., km of roads) needed to obtain adequate sample sizes for distance sampling in each ecoregion. Using simulation data based on inflatable turkey decoys, we evaluated the effects of distance to a flock, flock size, and vegetative cover on turkey flock detectability. Encounter rates of wild turkey flocks obtained from road-based surveys varied from 0.1 (0.0–0.6; 95% CI) to 2.2 (0.8–6.0) flocks/100 km surveyed. Encounter rates from surveys restricted to riparian communities varied from 0.2 (0.1–0.6; 95% CI) to 2.9 (1.5–6.7) flocks/100 km surveyed. Flock detection probabilities obtained from field simulations ranged from 22.5% (16.3–29.8%; 95% CI) to 25.0% (13.6–39.6%). Flock detection probabilities were lower than expected in all 4 ecoregions, which resulted in low encounter rates. Estimated survey effort required to obtain adequate sample sizes for distance sampling ranged from 2,765 km (2,597–2,956 km; 95% CI) in the Edwards

Plateau to 37,500 km (33,333–42,857 km) in South Texas. When road-based surveys were restricted to riparian communities, estimated survey effort ranged from 2,222 km (2,092–2,370 km; 95% CI) in the Edwards Plateau to 22,222 km (19,782–25,349 km) in South Texas. We found that distance to the flock and vegetative cover both played important roles in wild turkey flock detectability. Our results indicated that too much survey effort was required to make road-based surveys a feasible technique for monitoring wild turkey populations in most ecoregions of Texas. However, when surveys were restricted to areas ≤1 km from a river or stream, the technique was feasible for monitoring wild turkey populations in the Edwards Plateau and Rolling Plains ecoregions.

Introduction

Wild turkey (*Meleagris gallopavo*) populations have been increasing for most of the 20th century and therefore, few studies have focused on developing rigorous techniques for estimating abundance, density, and trends in population size (Butler 2006, Butler et al. 2007*a*). Recently, however, biologists in Texas have become concerned that Rio Grande wild turkey (*M. g. intermedia*; RGWT) populations have begun to decline across much of the state (Brunjes 2005). Texas Parks and Wildlife Department (TPWD) personnel have conducted hen-poult counts (Schwertner 2003, Butler et al. 2007*b*, Appendix B), winter roost counts (Butler et al. 2006, Thomas et al. 1966), and harvest surveys (Cook 1973) to monitor population trends; however, these index-based techniques lack power to detect anything but drastic changes in populations (Butler et al. 2007*a*). An evaluation of brood count data collected by TPWD in 5 ecoregions of Texas, indicated that brood counts had <0.50 power to detect long term changes of <0.20% (Schwertner et al. 2003). Poult-hen counts have the ability to index reproduction and recruitment on localized levels, but they do not estimate actual population abundance (Butler et al. 2007*b*). Winter roost counts have the ability to estimate abundance on a localized level (Butler et al. 2006), but far too much effort would be needed to make it a useful technique for monitoring populations on an ecoregion level.

Road-based distance sampling is a common technique that has been used for surveys of avian species such as mountain quail (*Oreortyx pictus*), red-legged partridge (*Alectoris rufa*), wild turkeys, and red-tailed hawks *(Buteo jamaicensis)* (Brennan and Block 1986, DeYoung and Priebe 1987, Millsap and LeFranc 1988, Borralho et al. 1996, Butler et al. 2007*a*). Distance sampling is popular because it alleviates problems associated with indices such as incomplete detectability (Anderson 2001, Rosenstock et al. 2002, Butler 2006). Butler et al. (2007*a*) evaluated distance sampling as a method to survey RGWTs in the Texas Rolling Plains and found that road-based surveys can provide sufficient power (≥0.80) to detect a 10 to 12% change in turkey populations in an 8 to 12 year period; more drastic changes can be detected in shorter periods. That study suggested that road-based distance sampling may be effective for monitoring wild turkey populations on ecoregion scales at a lower cost than other methods (e.g., aerial surveys, mark-resight) (Butler 2006, Butler et al. 2007*a*).

To obtain reliable density estimates, researchers suggested that transects should not be positioned on roads unless the target population was randomly distributed across the landscape in relation to roads (Burnham et al. 1980, Buckland et al. 2001, Butler et al. 2005). The attraction of animals to transects biases density estimates high, and avoidance of transects biases estimates low (Verner 1985, Thompson et al. 1998, Buckland et al. 2001). Butler et al. (2005) examined the relationship of RGWT distributions to roads in the Southern Great Plains during 2000–2003, and found areas <100 m from roads were used in proportion to availability during autumn-midday and winter-morning. We conducted similar analyses (Chapter II) for the Edwards Plateau, Rolling Plains and South Texas, and found that RGWTs tended to use areas <200 m from roads in proportions to availability during 1 December–15 March. Those results suggested that road-based surveys conducted during that period should yield generally unbiased results.

We evaluated the use of road-based surveys for RGWTs in the Cross Timbers, Edwards Plateau, the southern portion of the Rolling Plains (hereafter, Rolling Plains), and the South Texas ecoregions of Texas (Gould 1962). Our goal was to evaluate line-transect–based distance sampling from roads and determine flock encounter rates in each ecoregion. We used those encounter rates to determine the amount of effort (i.e., km of roads) needed to obtain adequate sample sizes for distance sampling in each ecoregion. We also conducted field simulations using inflatable wild turkey decoys to determine wild turkey flock detectability and factors influencing their detectability in each ecoregion.

Study Area

The Cross Timbers ecoregion (Fig. 3.1) separates the plains region in the west from the forested hills region of eastern Texas (Griffith et al. 2004). Elevation ranged from 366–596 m above sea level (ASL) and the area received an average of 73 cm of rainfall per year (Hohensee 1999). Common grasses for the region included little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), and Texas wintergrass (*Nassella leucotricha*). Common woody species included honey mesquite (*Prosopis glandulosa*) and post oak (*Quercus stellata*) (Griffith et al. 2004, Hohensee 1999).

The Edwards Plateau ecoregion (Fig. 3.1) is a limestone plateau that is primarily vegetated by juniper-oak (*Juniperus-Quercus* spp.) savannah and mesquite-oak savannah (Griffith et al. 2004). The area contained many perennial streams (Griffith et al. 2004) and received approximately 38–84 cm of rainfall per year. Elevation ranged from approximately 305–915 m ASL (Randel 2003, Texas Economic Development and Tourism 2003). Common grasses for the region included switchgrass (*Panicum virgatum*), indiangrass (*Sorghastrum nutans*), and buffalograss (*Buchloe dactyloides*). Common woody species included ashe juniper (*J. ashei*) and live oak (*Q. fusiformis*) (Randel 2003).

The Rolling Plains ecoregion (Fig. 3.1) encompasses mostly smooth to irregular plains with a large percentage of cropland and oil and gas production (Griffith et al. 2004). The region has many small stream valleys that flow east to southeast (Spears et al. 2002). Elevation ranged from approximately 240–910 m ASL and the area received an average of 55–76 cm of rainfall per year (Spears 2002). The vegetation was mostly honey mesquite-dominated grasslands with presence of sand sagebrush (*Artemesia filifolia*), sand shinnery oak (*Q. havardii*), and acacia (*Acacia* spp.). Bluestems (*Schizachyrium* spp.) and gramas (*Bouteloua* spp.) are the dominant grasses of the ecoregion (Spears 2002).

The South Texas ecoregion (Fig. 3.1) was once a rolling grassland but due to extensive cattle grazing, the vegetation is now primarily honey mesquite-scrub oak (*Quercus* spp.) shrubland (Griffith et al. 2004). Elevation ranged from 0–305 m ASL and average precipitation for the area was about 65 cm per year (Hernandez et al. 2005, Texas Economic Development and Tourism 2003). Common woody species for the region included honey mesquite, huisache (*A. farnesiana*), granjeno (*Celtis pallida*), and live oak (Hernandez et al. 2005). Some of the common grasses and forbs included doveweed (*Croton* spp.), annual sunflower (*Helianthus annus*), little bluestem, and three-awns (*Aristida* spp.) (Hernandez et al. 2005). Cattle grazing, hunting, and oil production was widespread across the ecoregion (Griffith et al. 2004).

Methods

We randomly established ≥100 16-km survey transects on county roads or Farm to Market highways in each ecoregion as suggested by Butler et al. (2007*a*). We excluded all state and federal highways due to their lack of feasibility for distance sampling because of traffic volume and we excluded all private roads because of land access limitations. We used ArcMap^{TM} version 9.2 and Hawth's Analysis Tools (Beyer 2004) to generate random transect start points located on roads in each ecoregion. We used a global positioning system (GPS) to record each survey transect (Universal Transverse Mercator [UTM], North American Datum 1983). We drove each transect until we mapped a 16-km route. If we came to a road intersection, we randomly chose the path that would allow us to complete a 16-km transect without allowing the transect to intersect itself or any other transects, as this could bias density estimates when conducting surveys. If we arrived at an intersection and more than one possible route met those conditions, we flipped a coin to determine which direction to proceed. While creating the transects, we also recorded a set of transect descriptions (Appendix C) for each transect so that the observer could easily navigate the transects during surveys. To help locate survey transects during the survey period, we used ArcMap™ Version 9.2 to create county maps showing all public roads and survey transects (Appendix C).

Road-based distance sampling surveys

With the help of TPWD personnel, we conducted road-based surveys from 1 December 2007–15 March 2008 in the Cross Timbers, Edwards Plateau, Rolling Plains, and South Texas ecoregions. Prior to conducting surveys, we trained each observer to identify wild turkeys by sex class as well as, gather distance and angle measurements. We surveyed all transects at least once, some transect were surveyed again if time permitted. To ensure we did not conduct surveys during RGWT roosting activities, we began surveys 30 minutes after sunrise and finished surveys 1 hour before sunset. All surveys were conducted during clear weather so precipitation or fog would not affect flock detectability. We conducted surveys from a 4-wheel drive pickup truck with a single observer traveling at 16–32 km/hour. Distance sampling requires complete detectability near transects; therefore, the observer was instructed to focus their attention near the road (Buckland et al. 2001). Once a flock was detected, we recorded an observation number for each flock so that sightings remained independent. We used a Bushnell® Yardage Pro Scout rangefinder (Bushnell Performance Optics, Bausch & Lomb, Inc., Overland Parks, KS) and compass bearings to estimate the perpendicular sighting distance to the center of each observed flock. To help minimize measurement error, each observer was trained to use the rangefinder and compass prior to surveys. For each observation, we collected a perpendicular sighting distance, a sighting bearing, and the UTM coordinate on the transect at the point where the measurements were collected. We also recorded flock size and flock composition and any flushing responses for each observation. When an observed flock flushed, we recorded all measurements to the location of the flock prior to flushing. To assess the amount of vegetative cover for each observation, we classified vegetation as grassland, low density understory (<50%), or high density understory (>50%). The purpose of the vegetative cover classifications was not to describe the overall landscape, but rather to describe the vegetation growing in sight of the observed flock. We did not classify overstory vegetation because it did not affect flock detectability. A detailed survey protocol is included in Appendix C.

To determine flock encounter rates, we divided data into surveys conducted during the first half of daylight hours (AM) and surveys conducted during the last half of daylight hours (PM), and then used DISTANCE 5.0 (Thomas et al. 2005) to calculate AM, PM, and combined encounter rates for each ecoregion. We were interested in determining an AM, PM, and combined encounter rate for each ecoregion to determine when road-based surveys would be most appropriate. Butler et al. (2007*a*) found that a sample size of ≥60–70 flock detections was necessary to detect a 10–25% change in population density in 8–12 years; therefore, we used estimated encounter rates to determine how many km of roads would need to be surveyed to detect 60 flocks within each ecoregion.

Butler et al. (2007*a*) used a similar methodology to evaluate road-based surveys in the Texas Rolling Plains, but they restricted survey transects to areas ≤1 km from riparian vegetative communities because RGWTs are dependent on riparian communities in the Rolling Plains (Brunjes 2005). We were interested in comparing encounter rates obtained from surveys conducted in both riparian and non-riparian communities, to encounter rates obtained from surveys conducted solely in riparian communities (hereafter riparian surveys). Using ArcMap™ version 9.2 and Hawth's Analysis Tools (Beyer 2004), we created a 1-km buffer around rivers, major streams, and minor streams (Texas Commission on Environmental Quality 2008). To determine the appropriate riparian buffer, we calculated distances from radiotelemetry locations of RGWTs in the Edwards Plateau (n = 4,979) and Rolling Plains (n = 47,472) to the nearest river or stream. In the Edwards Plateau, 90% of locations were ≤998 m from a river or stream and in the Rolling Plains, 90% of locations were ≤824 m from a river or stream. Using the riparian buffers and data from road-based surveys of both riparian and non-riparian communities, we determined encounter rates from those portions of surveys conducted in riparian communities. The riparian encounter rates were then used to determine how many km of roads would need to be surveyed to detect 60 flocks within each ecoregion if surveys were restricted to riparian communities (i.e., within 1 km of rivers and streams).

Decoy simulation surveys

To evaluate flock detectability, we conducted field simulations using inflatable turkey decoys (Sceery Outdoors, Ltd., Santa Fe, NM) during the same period as road-based distance sampling surveys for live birds. Butler et al. (2007*a*) evaluated the use of inflatable decoys to simulate live RGWT flocks in the Rolling Plains and found that detection probabilities were similar to that of wild turkey flocks. We conducted simulation surveys on private and public roads where we had access to set up decoy flocks on both sides of the road. For each simulation, we placed 12–18 decoy flocks at random distances from 0–200 m on either side of the transect. We did not place flocks more than 200 m from the transect because previous research indicates flock detection was unlikely at distances ≥200 m from roads (Butler et al. 2007*a*). We varied the flock size randomly from 1–50 decoys. We used 3–5 observers to survey each simulation; each observer conducted the survey independent of the other observers. When conducting the decoy simulation surveys, the observer followed the same protocol as described for the road-based surveys of live birds (Appendix C).

To evaluate flock detectability, we analyzed the simulation survey data using logistic regression (Hosmer and Lemeshow 2000, Butler et al. 2007*a*) in SPSS® 16 (SPSS Inc., Chicago, Illinois, USA). We created 9 a priori logistic regression models (Table 3.1) and then used second order Akaike's information criterion (AIC_c) weights (Burnham and Anderson 2002) to evaluate effects of distance to a flock, flock size, and vegetative cover on flock detection. We chose to use AIC_c because it performs better than AIC when the ratio of sample size to the number of parameters in the model is <40 (Burnham and Anderson 2002). For the logistic regression models, we used a binary variable for flock detection where 1 was "flock detected" and 0 was "flock not detected" (Butler et al. 2007*a*). We also evaluated the fit of each model using Hosmer and Lemeshow goodness-of-fit tests (Hosmer and Lemeshow 2000).

Results

Road-based distance sampling surveys

In the Cross Timbers, we conducted 154 surveys totaling 2,548.7 km; in the Edwards Plateau, 126 surveys totaling 1,751.4 km; in the Rolling Plains, 107 surveys totaling 1,774.2 km; and in South Texas, 112 surveys totaling 1,874.5 km. The total number of flocks detected in each ecoregion ranged from 3 in South Texas to 38 in the Edwards Plateau (Table 3.2). Encounter rates varied from 0.1 (0.0–0.6; 95% CI) flocks/100 km during AM surveys in South Texas to 2.2 (0.8–6.0) flocks/100 km during PM surveys in Edwards Plateau (Table 3.2). In the Cross Timbers, Edwards Plateau, and South Texas ecoregions, we observed more flocks during PM surveys. More flocks were observed during AM surveys in the Rolling Plains. The amount of survey effort that would be required to obtain 60 flock observations per ecoregion was 12,766 km (11,765–13,954 km; 95% CI) in the Cross Timbers, 2,765 km (2,597–2,956 km) in the Edwards Plateau, 6,250 km (5,941–6,593 km) in the Rolling Plains, and 37,500 km (33,333–42,857 km) in South Texas (Table 3.2).

We surveyed 1,970.7 km in riparian communities (i.e., within 1 km of rivers and streams) in the Cross Timbers; 1,297.0 km in riparian communities in the Edwards Plateau; 1,085.6 km in riparian communities in the Rolling Plains; and 1,124.4 km in riparian communities in South Texas. The total number of flocks detected ≤1 km from a river or stream ranged from 3 in South Texas to 35 in the Edwards Plateau (Table 3.3). Encounter rates in riparian communities varied from 0.2 (0.1–0.6; 95% CI) flocks/100 km during AM surveys in South Texas to 2.9 (1.5–6.7) flocks/100 km during PM surveys in the Edwards Plateau (Table 3.3). The amount of survey effort required to obtain 60 flocks per ecoregion if surveys were restricted to riparian communities, was 9,836 km (8,963–10,897 km; 95% CI) in the Cross Timbers, 2,222 km (2,092–2,370 km) in the Edwards Plateau, 4,348 km (4,135–4,584 km) in the Rolling Plains, and 22,222 km (19,782–25,349 km) in South Texas (Table 3.3).

Decoy simulation surveys

In the Edwards Plateau, we conducted 10 simulation surveys and detected 32 of 130 (24.6%; 17.5–32.9% [95% CI]) decoy flocks; in the Rolling Plains we conducted 10 surveys and detected 36 of 160 (22.5%; 16.3–29.8%) decoy flocks; and in the South Texas ecoregion we conducted 3 surveys and detected 12 of 48 (25.0%; 13.6–39.6%) decoy flocks. Distances from the transect to flock center were underestimated by 4.3 ± 2.2 m (t = 3.813, df = 79, $P < 0.001$). Distance from the transect to detected and undetected decoy flocks were different (mean difference = 54.1 ± 11.2 m, 95% CI; t = 9.492, df = 336, $P < 0.001$) and there was a difference in detected and undetected decoy flock sizes (mean difference = 5.9 ± 3.5; t = 3.301, df = 336, P = 0.001). During simulation surveys, detected decoy flock sizes were also underestimated by observers (3.9 ± 1.4; t = 5.451, df = 79, $P < 0.001$).

To evaluate the effect of distance to a flock, flock size, and vegetative cover on wild turkey flock detectability, we created 9 a priori logistic regression models (Table 3.1) and then used AIC_c weights and goodness-of-fit to determine the best model. The global model contained the majority of the AIC_c weight (w_i = 0.990), but the fit was poor (χ^2 = 17.367, df = 8, P = 0.027). The best model (w_i = 0.010, χ^2 = 8.042, intercept = 2.079, df = 8, P = 0.429) suggested that distance and vegetative cover combined played an important role in flock detectability. Specifically, flock detectability decreased with increased distance (odds ratio = 0.975, $W = 25.611$, df = 1, $P = 0.000$) from roads. Flock detectability in high density understory was lower than that of grassland (odds ratio = 0.014, $W = 43.254$, df = 1, $P = 0.000$) and detectability in low density understory was lower than that of grassland (odds ratio = 0.225, $W = 15.127$, df = 1, $P = 0.000$) (Fig. 3.2).

Discussion

Butler et al (2007*a*) suggested that ≥60–70 flock observations were needed to detect a 10–25% change in population density in 8–12 years. Using the encounter rates from road-based surveys, we calculated the total effort needed (i.e., total km of transects) in each ecoregion to observe 60 wild turkey flocks. Estimated flock encounter rates obtained from surveys in both riparian and non-riparian communities were low, requiring far too much survey effort (2,765–37,500 km) to make road-based distance sampling feasible for monitoring population trends in most ecoregions. The encounter rates obtained from riparian surveys were greater, reducing the amount of survey effort (2,222–22,222 km) required. These results suggested that road-based surveys may prove applicable in the Edwards Plateau and Rolling Plains ecoregions if surveys are restricted to areas ≤1 km from rivers and streams. However, too much survey effort would be required for adequate sample sizes in the Cross Timbers and South Texas ecoregions, even if surveys are restricted to riparian communities.

Flock detection probabilities obtained from road-based simulation surveys were lower than expected, likely explaining why live bird encounter rates were low. Butler et al. (2007*a*), using similar techniques, found that decoy flock detectability in the Rolling

Plains during winter was 67.0 ± 13.0%, but we did not observe detection probabilities >25.0% (13.6–39.6%; 95% CI).

Historically, the study area received an average summer precipitation (May, June, and July combined) of approximately 19 cm in the west to approximately 33 cm in the east (PRISM Group, Oregon State University 2008). During 2007, the average summer precipitation for those areas ranged from 23 cm in the west to 110 cm in the east (PRISM Group, Oregon State University 2008). Accordingly, the summer of 2007 (June–August) was the wettest recorded summer since 1895, with a state-wide average of 36 cm of rain (National Climatic Data Center 2008). This led to a productive growing season in all 4 ecoregions. Based on personal observations of thick stands of annual forbs and dense grasses, as well as the results of our modeling efforts, high density vegetative cover was a likely cause of low detection probabilities in each ecoregion. When Butler et al. (2007*a*) conducted field simulations in the Rolling Plains, they observed a higher detection probability (67.0 ± 13.0%). The summer precipitation prior to their surveys was near or below average each year (15–19 cm) (PRISM Group, Oregon State University 2008). Therefore, during years with average rainfall (67.0 ± 13.0%), detection probabilities were 3 times greater than during years with above average rainfall (22.5%; 16.3–29.8%) in the Rolling Plains. Furthermore, research should be conducted to determine if RGWT flock detection probabilities are higher during years with average precipitation in the other ecoregions.

During simulation surveys, observers underestimated perpendicular distances and flock sizes. Underestimating distances biases density estimates high and underestimating flock sizes biases density estimates low. It is unlikely these biases cancel each other

(Buckland et al. 2001), and therefore more effort should be made during surveys to obtain accurate measurements. If road-based distance sampling surveys are used to monitor RGWT populations, we recommend that all observers undergo adequate training to help maximize the number of flock detections and reduce potential measurement errors during surveys.

Our research indicated that road-based distance sampling was generally infeasible for monitoring RGWT populations on ecoregion scales because of the survey effort required (Table 3.2). However, if surveys were limited to areas ≤1 km from rivers or streams, road-based surveys may prove applicable for monitoring wild turkey populations in the Edwards Plateau and Rolling Plains. Though less survey effort is required in riparian communities, the survey design would likely require access to large tracts of private land making annual surveys difficult.

Management Implications

Concerns about decreasing RGWT populations have encouraged TPWD biologists to conduct annual surveys to monitor population trends. However, techniques used were index-based and do not necessarily relate to population abundance, or are infeasible for monitoring population trends on regional levels because of the survey effort required (Schwertner et al. 2003, Butler et al. 2007*a, b*). Previous research in the Rolling Plains suggested that road-based distance sampling could be an effective method for monitoring population trends on an ecoregion level (Butler et al. 2007*a*). We found that road-based surveys generally required too much survey effort to obtain sample sizes large enough for distance sampling. However when restricted to riparian communities, less survey effort was required allowing feasible effort in the Edwards Plateau and Rolling Plains. If surveys are restricted to riparian communities, 128 16-km surveys during PM in the Edwards Plateau and 245 16-km surveys during AM in the Rolling Plains would be adequate for detecting a 10–25% change in population density in 8–12 years.

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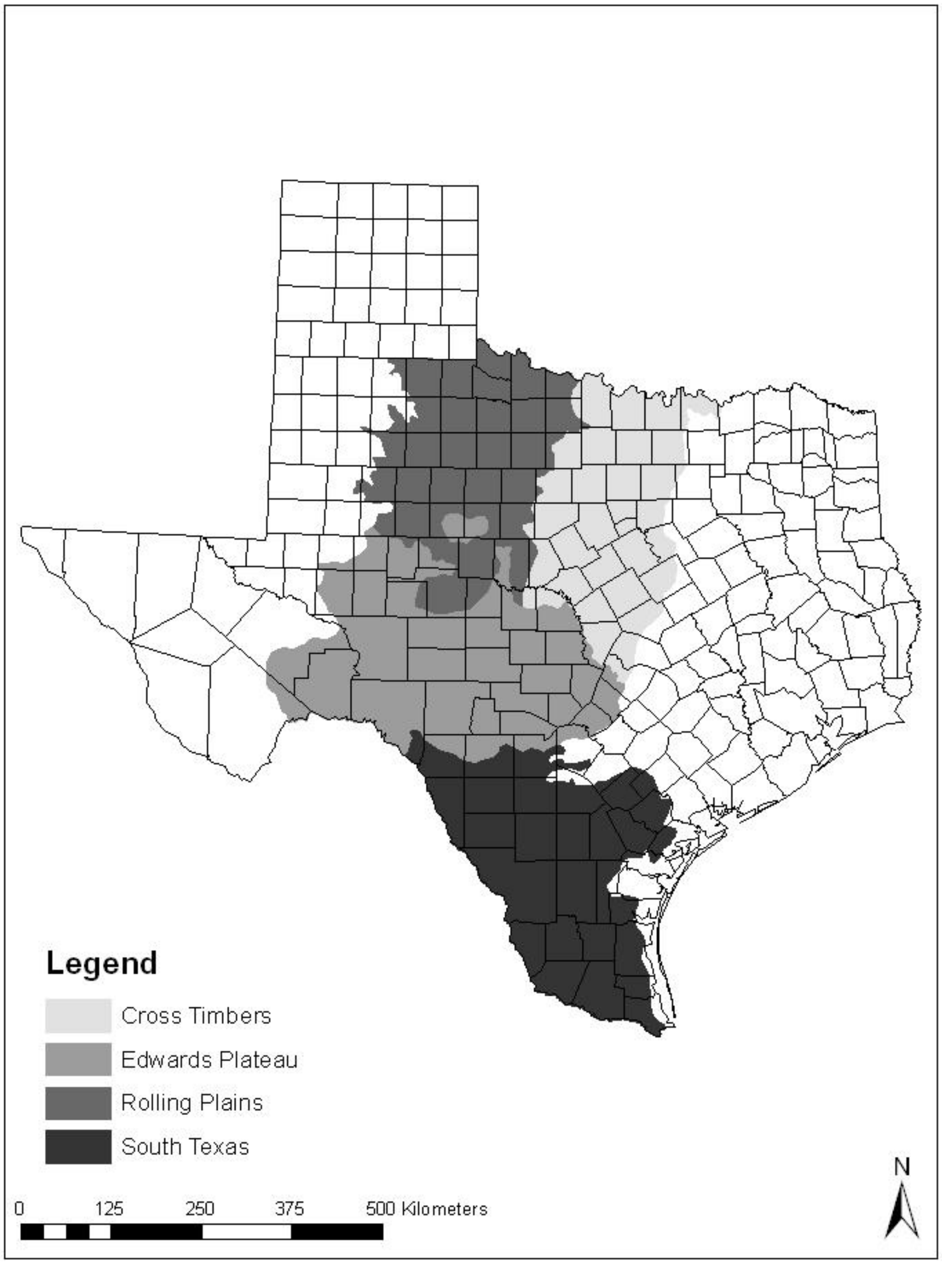

Figure 3.1. Map of Texas denoting 4 ecoregions (Texas Parks and Wildlife Department 2008, Gould 1962) where Rio Grande wild turkey surveys were conducted during 2007–2008.

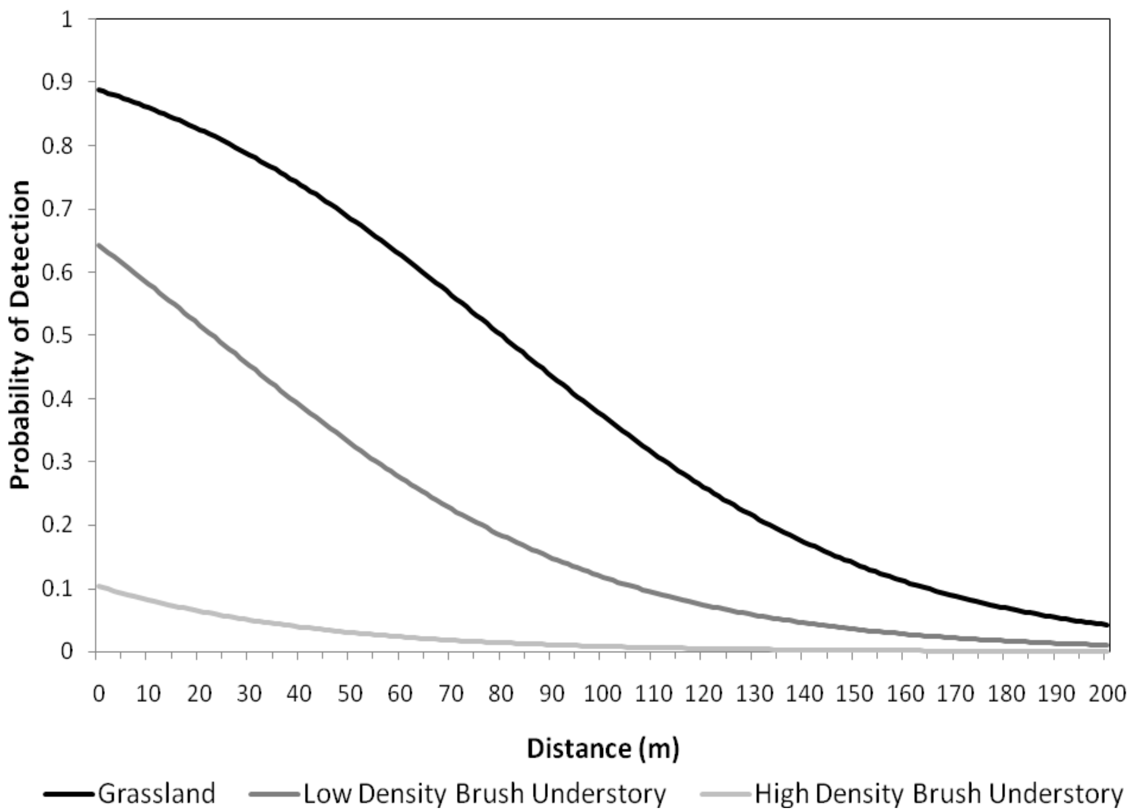

Figure 3.2. Predicted wild turkey flock detection probabilites based on best logistic regression model. Model based on data obtained from road-based surveys of inflatable wild turkey decoys conducted in 3 ecoregions of Texas; 1 December 2007–15 March 2008.

Table 3.1. Flock detectability models for road-based distance sampling surveys of inflatable wild turkey decoys in the Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas; 1 December 2007–15 March 2008 (n = 338). For each logistic regression model, –2*log-likelihood (–2LL), number of parameters (K), second-order Akaike's information criterion (AIC_c), difference in AIC_c compared to lowest AIC_c of the model set (Δ_i), AIC_c weight (w_i), and Hosmer and Lemeshow goodness-of-fit test statistics (GOF) are provided.

						GOF		
Model[a]	–2LL	K	AIC_c	Δ_i	w_i	χ^2	df	p
DIST + FLOCK + VEG	181.8	6	194.0	0.00	0.99	17.367	8	0.027
DIST + VEG	193.1	5	203.2	9.23	0.01	8.042	8	0.429
FLOCK + VEG	222.2	5	232.4	38.37	<0.01	21.873	8	0.005
VEG	226.1	4	234.2	40.20	<0.01	< 0.001	1	1.000
DIST + FLOCK	261.7	3	267.7	73.72	<0.01	10.405	8	0.238
DIST	279.9	2	284.0	89.97	<0.01	41.682	8	<0.001
FLOCK	359.3	2	363.3	169.33	<0.01	57.296	8	<0.001
CONSTANT	369.9	1	371.9	177.88	<0.01	–	–	–
ECOREG	369.6	4	377.8	183.75	<0.01	<0.001	1	1.000

[a] CONSTANT = constant detection rate independent of flock size, distance, vegetative cover, and ecoregion; DIST = distance; ECOREG = ecoregion; FLOCK = flock size; and VEG = vegetative cover.

Table 3.2. Summary of encounter rates of Rio Grande wild turkey flocks during road-based surveys conducted from 1 Dec 2007–15 Mar 2008 in the Cross Timbers, Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas.

					95% CI	
Ecoregion[a]	*n*[b]	ER[c]	Effort[d]	CV(%)	Lower	Upper
Cross Timbers	12	0.47	12,766	37.58	0.43	0.51
Cross Timbers AM	6	0.41	14,634	40.50	0.19	0.89
Cross Timbers PM	6	0.56	10,714	48.24	0.22	1.39
Edwards Plateau	38	2.17	2,765	32.26	2.03	2.31
Edwards Plateau AM	22	2.14	2,804	36.43	1.06	4.34
Edwards Plateau PM	16	2.21	2,715	52.68	0.81	6.00
Rolling Plains	17	0.96	6,250	24.51	0.91	1.01
Rolling Plains AM	9	1.03	5,825	34.50	0.53	2.03
Rolling Plains PM	8	0.89	6,742	32.77	0.47	1.68
South Texas	3	0.16	37,500	62.51	0.14	0.18
South Texas AM	1	0.10	60,000	99.32	0.02	0.56
South Texas PM	2	0.23	26,087	75.36	0.06	0.87

[a] AM represents surveys conducted during the first half of daylight hours. PM represents surveys conducted during the last half of daylight hours.

[b] Number of wild turkey flocks observed.

[c] Encounter rate of wild turkey flocks per 100 km surveyed.

[d] Survey effort (i.e., km of roads) required to observe 60 wild turkey flocks.

Table 3.3. Summary of encounter rates of Rio Grande wild turkey flocks during road-based surveys conducted from 1 Dec 2007–15 Mar 2008 in riparian communities (i.e., areas ≤1 km from a river, major stream, or minor stream) in the Cross Timbers, Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas.

					95% CI	
Ecoregion[a]	*n*[b]	ER[c]	Effort[d]	CV(%)	Lower	Upper
Cross Timbers	12	0.61	9,836	49.82	0.55	0.67
Cross Timbers AM	6	0.52	11,539	52.61	0.30	1.02
Cross Timbers PM	6	0.73	8,219	60.11	0.32	1.49
Edwards Plateau	35	2.70	2,222	31.37	2.53	2.87
Edwards Plateau AM	20	2.54	2,362	35.62	1.46	4.74
Edwards Plateau PM	15	2.94	2,041	51.22	1.54	6.73
Rolling Plains	15	1.38	4,348	26.29	1.31	1.45
Rolling Plains AM	8	1.53	3,927	36.49	1.03	2.54
Rolling Plains PM	7	1.24	4,839	33.36	0.82	2.04
South Texas	3	0.27	22,222	60.15	0.24	0.30
South Texas AM	1	0.18	33,333	96.94	0.10	0.64
South Texas PM	2	0.36	16,667	73.98	0.19	0.92

[a] AM represents surveys conducted during the first half of daylight hours. PM represents surveys conducted during the last half of daylight hours.

[b] Number of wild turkey flocks observed.

[c] Encounter rate of wild turkey flocks per 100 km surveyed in riparian communities.

[d] Survey effort (i.e., km of roads) required to observe 60 wild turkey flocks.

APPENDIX A

A PRIORI POWER ANALYSES FOR HABITAT USE AROUND ROADS IN TEXAS ECOREGIONS

In Chapter II, we evaluated Rio Grande wild turkey (*Meleagris gallopavo intermedia*) habitat use around roads in Texas. We obtained radiotelemetry locations from the Edwards Plateau, Rolling Plains, and South Texas ecoregions, and then conducted habitat use and availability analyses to determine wild turkey use of areas near roads (<200 m). In order to determine the appropriate sample sizes (i.e., the number of wild turkey locations) required to determine habitat use, we conducted a priori power analyses using PROC POWER in SAS 9.1.3 (SAS Institute, Cary, NC). We used PROC POWER (Codes A.1–A.7) to determine the number of locations needed for a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use with ≥0.80 power at each study site. Separate power analyses were needed at each study site because the percent of available habitat near roads (i.e., the null proportion) was different at each site. At a given sample size, power will be different depending on the percent of available habitat near roads.

We plotted power as a function of sample size in order to determine the number of locations needed for ≥0.80 power at each site (Figures A.1–A.7). We observed that power as a function of sample size was saw-toothed for single binomial proportions, meaning that power sometimes decreased with increased sample size (SAS Institute Inc. 2004). An explanation for this saw-toothed behavior was provided by Chernick and Liu (2002). To determine the number of wild turkey locations needed, we used the smallest sample size that produced ≥0.80 power. To accomplish ≥0.80 power, 62 locations were needed at Kerr-Real and 48 locations were needed at Bandera. Forty-five locations were needed at Gene Howe and 33 locations were needed at the Salt Fork and Matador. One hundred sixteen locations were needed at Brooks, 81 were needed at Kleberg, and 56 were needed at Kenedy.

Literature Cited

Chernick, M. R., and C. Y. Liu. 2002. The saw-toothed behavior of power versus sample size and software solutions: single binomial proportion using exact methods. The American Statistician 56:149–155.

SAS Institute Inc. 2004. SAS OnlineDoc®, Version 9. SAS Institute Inc., Cary, North Carolina, USA.

Code A.1. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Kerr-Real study site, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.058
        PROPORTION = 0.001
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 100 by 1
        POWER = .;
    PLOT;
RUN;
```

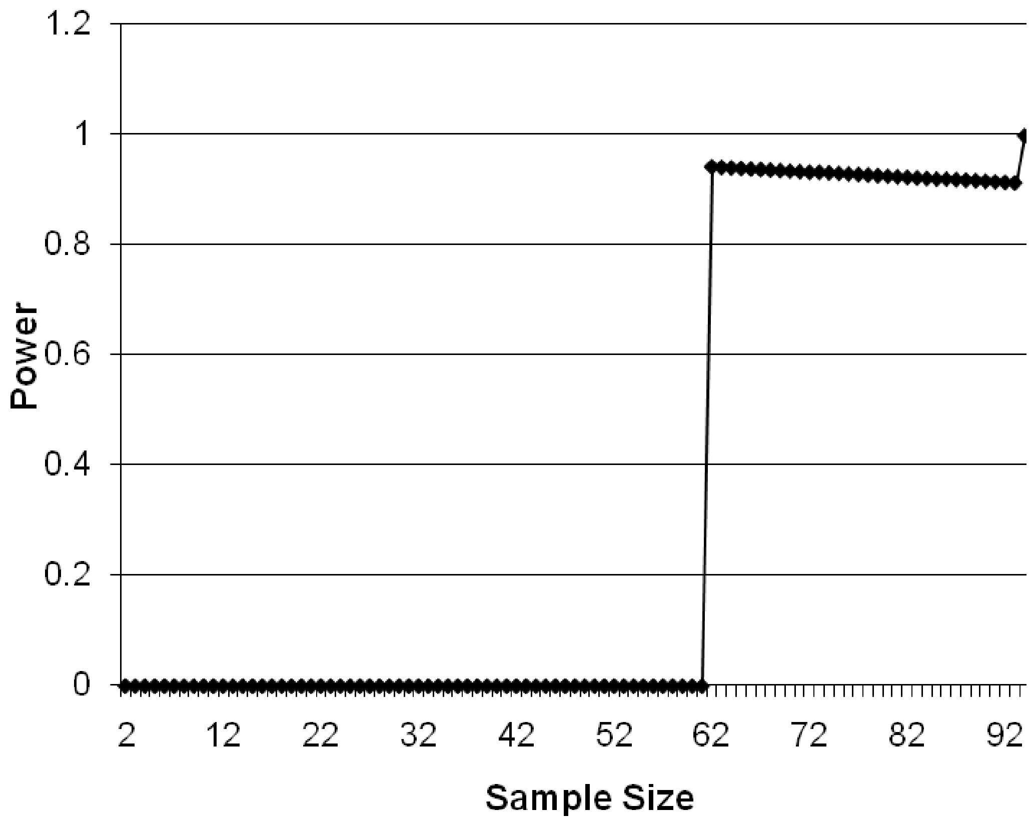

Figure A.1. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Kerr-Real study site, Texas.

Code A.2. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Bandera study site, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.112
        PROPORTION = 0.012
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 100 by 1
        POWER = .;
    PLOT;
RUN;
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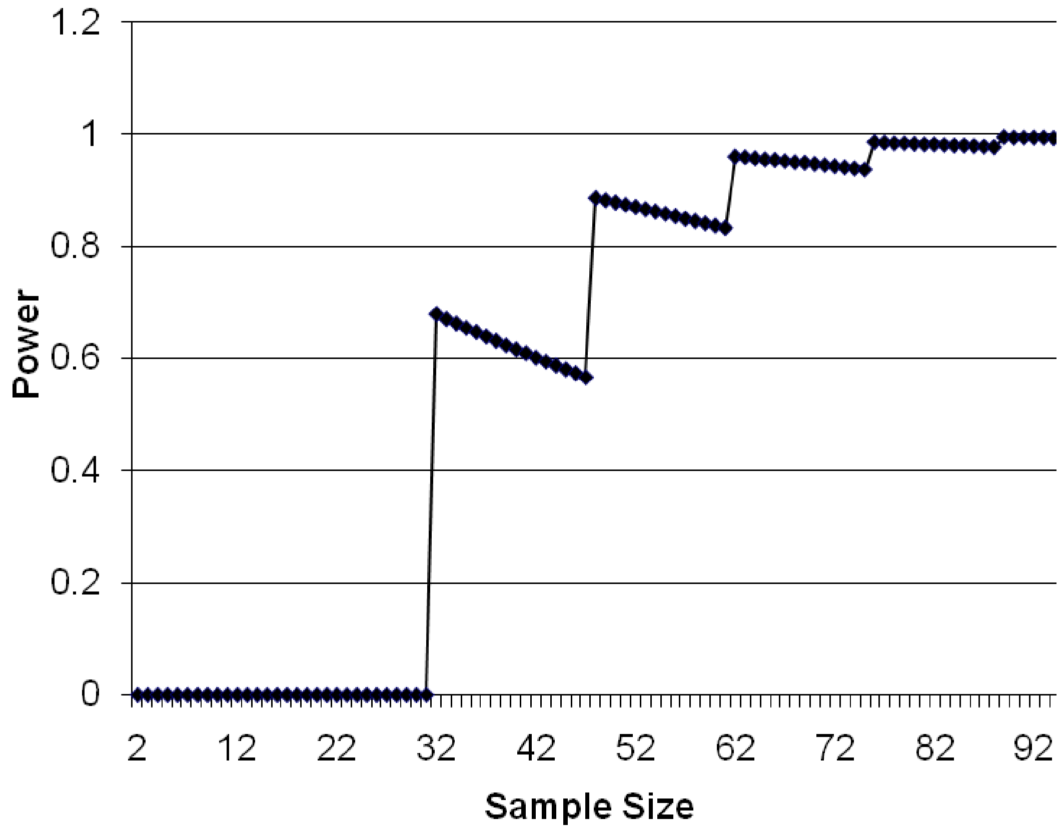


Figure A.2. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Bandera study site, Texas.

Code A.3. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Gene Howe study site, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.08
        PROPORTION = 0.001
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 100 by 1
        POWER = .;
    PLOT;
RUN;
```

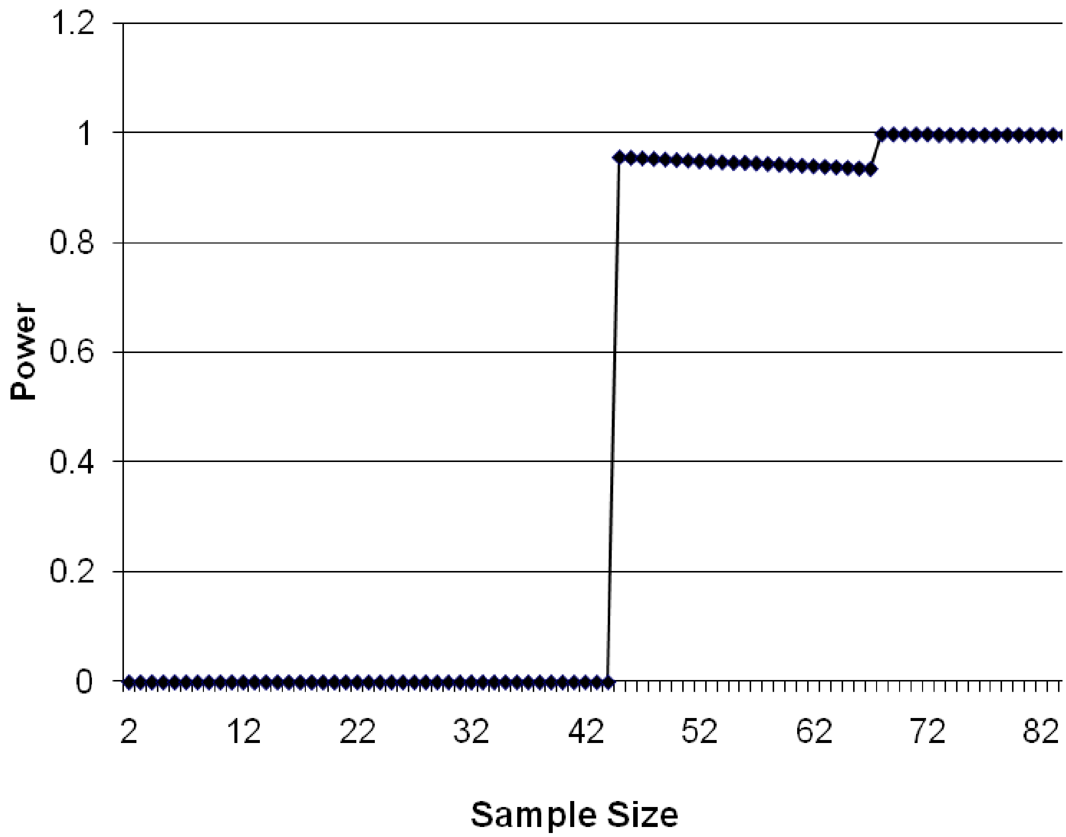


Figure A.3. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Gene Howe study site, Texas.

Code A.4. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Matador and Salt Fork study sites, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.107
        PROPORTION = 0.007
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 100 by 1
        POWER = .;
    PLOT;
RUN;
```

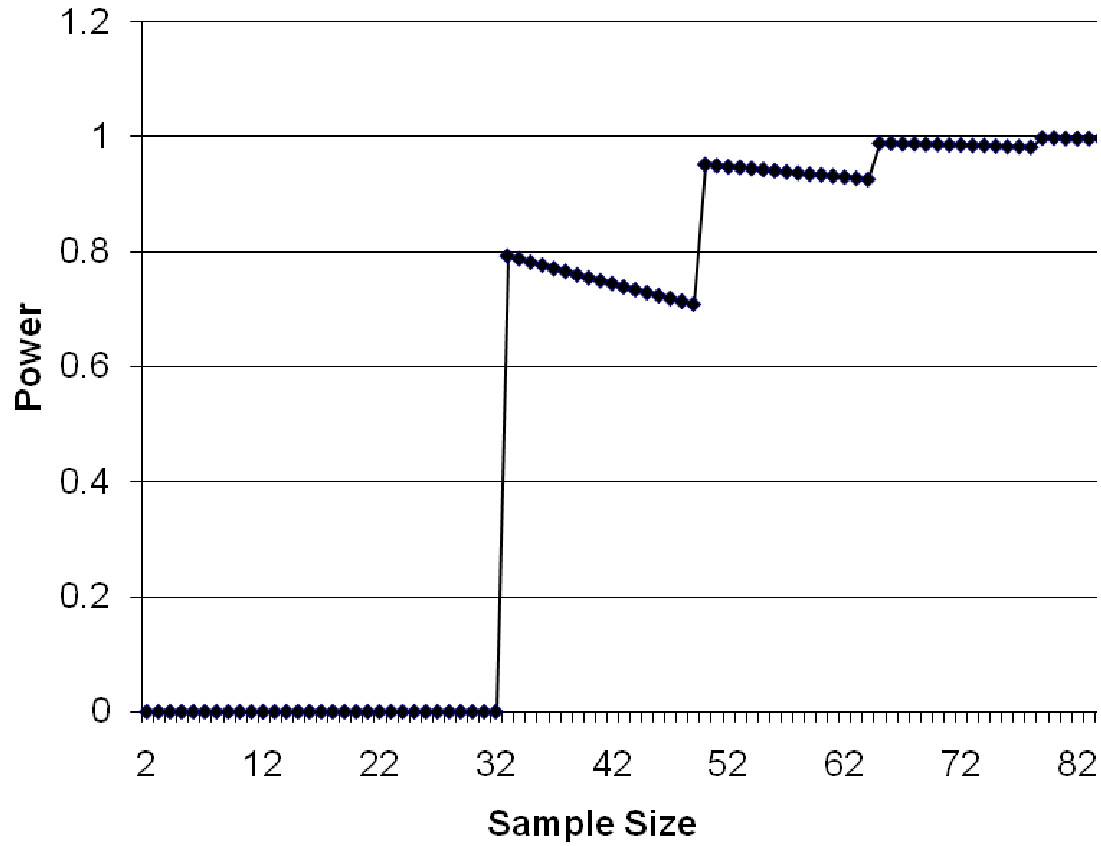


Figure A.4. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Matador and Salt Fork study sites, Texas.

Code A.5. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Brooks study site, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.225
        PROPORTION = 0.125
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 150 by 1
        POWER = .;
    PLOT;
RUN;
```

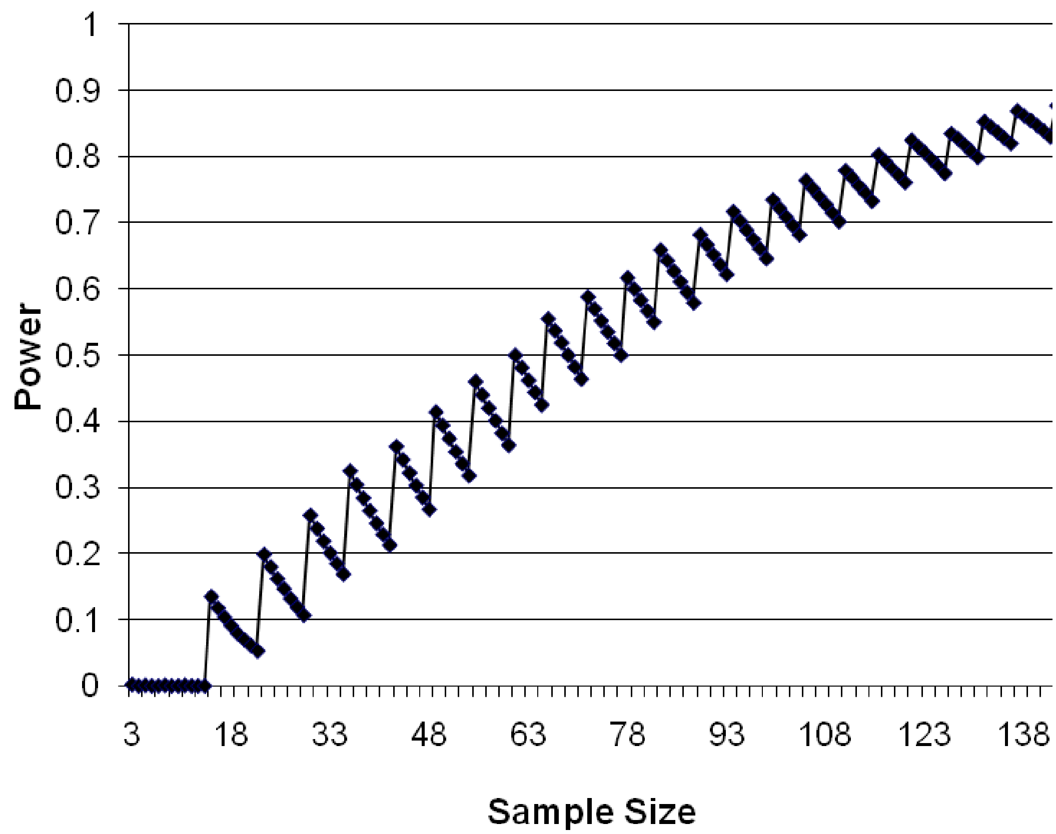


Figure A.5. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Brooks study site, Texas.

Code A.6. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Kleberg study site, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.156
        PROPORTION = 0.056
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 150 by 1
        POWER = .;
    PLOT;
RUN;
```

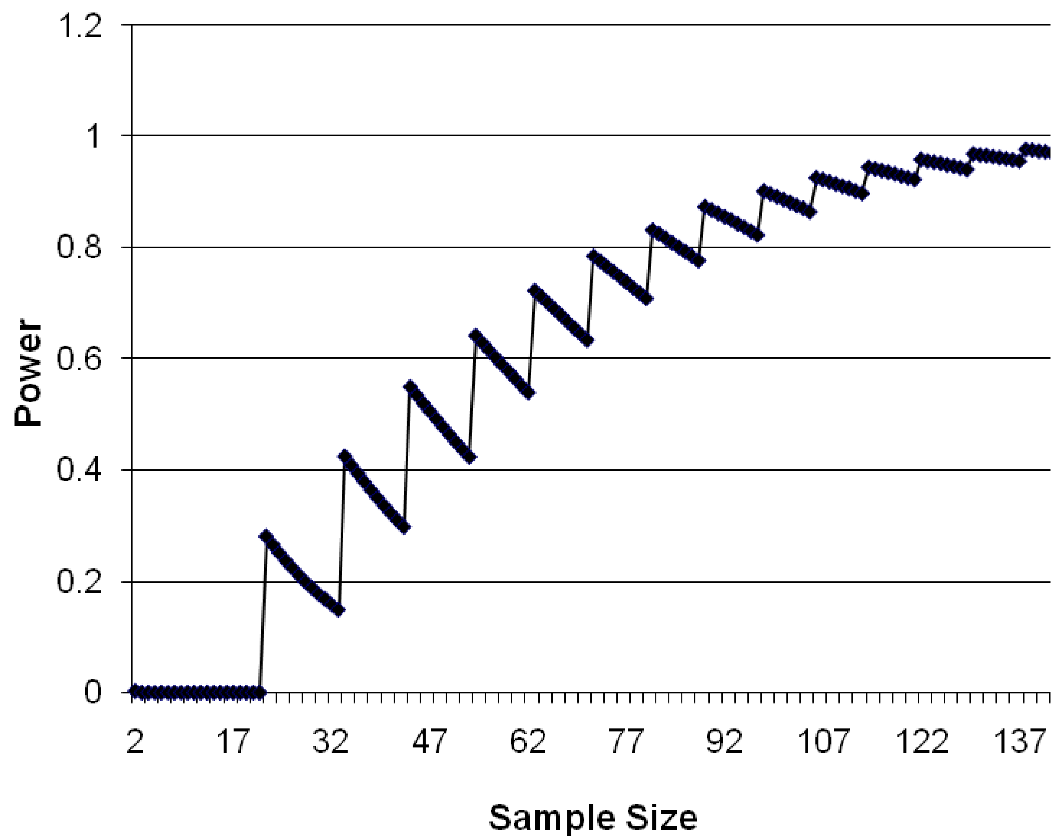


Figure A.6. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Kleberg study site, Texas.

Code A.7. PROC POWER syntax used in SAS 9.1.3 to determine the number of Rio Grande wild turkey locations needed to detect a 10% difference in observed and expected habitat use at the Kenedy study site, Texas.

```
PROC POWER;
    ONESAMPLEFREQ TEST = EXACT
        NULLPROPORTION = 0.125
        PROPORTION = 0.025
        SIDES = 2
        ALPHA = 0.05
        NTOTAL = 2 to 150 by 1
        POWER = .;
    PLOT;
RUN;
```

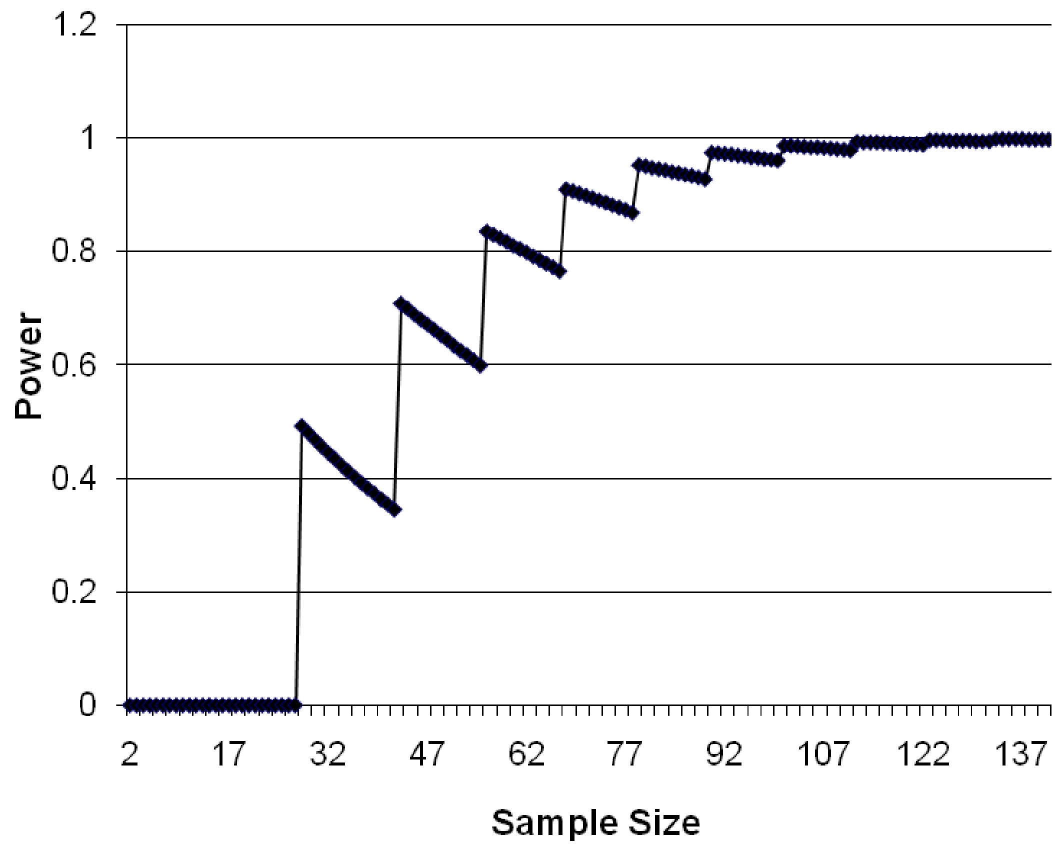


Figure A.7. Estimated power by sample size using a 2-sided exact binomial test to detect a 10% difference in observed and expected habitat use at the Kenedy study site, Texas.

APPENDIX B

SUMMARY OF RIO GRANDE WILD TURKEY FLOCK COUNTS COLLECTED IN TEXAS DURING SUMMER 2007 AND WINTER 2008

Many states have used poult-hen counts or flock counts to index reproduction, recruitment, and population densities of wild turkeys (Bartush et al. 1985, Schwertner et al. 2003, Butler et al. 2007*b*). However, some researchers have questioned the ability of poults/hen estimates to index these population parameters (Caughley 1974, Schwertner et al. 2003, Butler et al. 2007*b*). Texas Parks and Wildlife Department (TPWD) has conducted wild turkey poult-hen counts in Texas since 1978 (Schwertner et al. 2003, Butler et al. 2007*b*). During ongoing research, Texas Tech University has gathered estimates of Rio Grande wild turkey flocks (*Meleagris gallopavo intermedia*) in the Texas Panhandle and southwestern Kansas since 2002. Butler et al. (2007*b*) conducted an evaluation of poult-hen counts as an index of reproduction and recruitment, and found that with adequate sample sizes, poults/hen estimates can be used to detect changes in reproduction and recruitment at local scales. That study suggested that TPWD poult-hen counts could not be used to index reproduction and recruitment because of small sample sizes, and uneven coverage across ecoregions. However, with increased survey efforts distributed more evenly across smaller scales, TPWD poult-hen counts could be of value (Butler et al. 2007*b*). Additionally, estimates of mean flock size have proven valuable in simulations used to evaluate wild turkey abundance or density estimators (Butler 2006, Butler et al. 2007*a*, Butler et al. 2007*b*).

We collected flock counts in the Cross Timbers, Edwards Plateau, Rolling Plains, and South Texas ecoregions of Texas during the establishment of our road-based distance sampling survey transects in June–August 2007, as well as during our survey period from 1 December 2007–15 March 2008. Summer flock counts were collected opportunistically both on and off survey transects. Winter flock counts were collected while conducting distance sampling surveys and traveling among survey transects. Flock counts collected during distance sampling surveys were obtained using the distance sampling survey protocol (Chapter III, Appendix C). Winter flock counts not collected during surveys were obtained opportunistically. We considered ≥ 1 wild turkeys as a flock. When flocks were observed, we recorded date, time, location, weather conditions, habitat type, flock behavior, flock size, sex, and age. We estimated mean flock size by ecoregion and season (Table B.1).

Literature Cited

Bartush, L. H., M. S. Sasser, and D. L. Francis. 1985. A standardized turkey brood survey method for northwest Florida. National Wild Turkey Symposium Proceedings 5:173–181.

Butler, M. J., W. B. Ballard, M. C. Wallace, and S. J. DeMaso. 2007*a*. Road-based surveys for estimating wild turkey density in the Texas Rolling Plains. Journal of Wildlife Management 71:1646–1653.

Butler, M. J., M. C. Wallace, W. B. Ballard, M. C. Wallace, R. S. Phillips, J. H. Brunjes, R. T. Huffman, R. L. Houchin, J. C. Bullock, S. J. DeMaso, R. D. Applegate, M. C. Fisbie. 2007*b*. Utility of poult-hen counts to index productivity of Rio Grande wild turkeys. National Wild Turkey Symposium Proceedings 9:159–168.

Caughley, G. 1974. Interpretation of age ratios. Journal of Wildlife Management 38:557–562.

Schwertner, T. W., M. J. Peterson, N. J. Silvy, and F. E. Smeins. 2003. Brood-count power estimates of Rio Grande turkey production in Texas. Proceedings Annual Conference Southeastern Association of Fish and Wildlife Agencies 57:213–221.

Table B.1. Observed mean Rio Grande wild turkey flock size in 4 ecoregions of Texas, during summer 2007 and winter 2008.

			Flock size	
Ecoregion	Season[a]	*n*[b]	μ	S. D.
Cross Timbers	winter	13	13.8	10.1
	summer	10	2.1	2.1
Edwards Plateau	winter	54	21.6	24.6
	summer	5	2.0	2.2
Rolling Plains	winter	21	17.0	11.3
	summer	1	21.0	–
South Texas	winter	3	24.3	4.0
	summer	3	2.0	1.7

[a] Winter flock data were collected from 1 December 2007–15 March 2008, while conducting road-based distance sampling surveys or traveling to surveys. Summer flock data were collected from June–August 2007 during the establishment of road-based distance sampling survey transects.

[b] Number of observed Rio Grande wild turkey flocks.

APPENDIX C

SURVEY PROTOCOL, TRANSECT MAPS, AND TRANSECT DESCRIPTIONS USED IN ROAD-BASED DISTANCE SAMPLING SURVEYS OF RIO GRANDE WILD TURKEYS IN TEXAS, 1 DECEMBER 2007–15 MARCH 2008

Distance Sampling Protocol

For our evaluation of road-based distance sampling of Rio Grande wild turkeys, we created the following protocol to be used during surveys. It is important that the observer always follow the proper protocol so that biases are eliminated from the survey technique.

When conducting distance sampling, it is important to keep in mind the associated assumptions. These assumptions include (1) all animals on the transect are observed, (2) animals are not frightened away from or attracted to the transect before being detected, (3) distance and angle measurements are accurate, (4) the distribution of animals is not influenced by the transect, (5) animals are not counted twice during a survey, and (6) sighting events are independent. The observer conducting the survey must stay alert at all times and it is very important that all turkeys on or near the transect are observed. It is most common for turkeys to flush once being spotted. When this occurs, it is important that the observer record the distance and angle measurements to the original location in which the turkeys were located before they began to flush. If this rule is followed, it will help to reduce the impact of violation of the second assumption. The accuracy of the distance and angle measurements are in complete control of the observer. It is important to be aware of how the rangefinder works in different conditions and therefore it is recommended to quickly test it before each survey is conducted. It is also important for the observer to step away from the vehicle before using the compass so that the metal of the vehicle does not affect the bearing readings. It is not likely to occur but it is possible to double count a turkey flock. The observer should use their best judgment to make sure this does not happen. In order to maintain independence of sighting events, each flock of wild turkeys will be recorded as an individual observation, not each bird.

Survey Schedule

We have established approximately 100 road-based transects in each ecoregion. Each transect will be surveyed at least once during the survey period (1 December-15 March). The surveys may only be conducted 30 minutes after official sunrise until 60 minutes before official sunset. The official sunrise/sunset times can be found at:

<http://aa.usno.navy.mil/data/docs/RS_OneYear.php>.

Surveying during other times may bias the results because turkeys could be located on the roost. Additionally, surveys will only be conducted during times of no precipitation or fog. Before beginning each survey, the start time, percentage of cloud cover, and wind speed should be recorded in the appropriate places on the data sheet. Wind speed will be recorded from the Beaufort modified wind scale: 0 = 0–1 mph, calm, smoke rises vertically; 1 = 1-3 mph, light air, smoke drifts; 2 = 4–7 mph, light breeze, wind felt on face, leaves rustle; 3 = 8–12 mph, gentle breeze, leaves and small twigs in motion; 4 = 13–18 mph, moderate breeze, dust, small branches move; 5 = 19–24 mph, fresh breeze, small trees begin to sway; 6 = 25–31 mph, strong breeze, large branches begin to move; 7 = 32–38 mph, near gale, whole trees in motion, inconveniences walking; 8 = 39–46 mph, gale, breaks twigs off trees, impedes walking; 9 = >46 mph, severe wind.

Survey Speed

The observer should drive the transect at a speed of 16–32 km/h (16 km/h preferred). Some of the transects use poor quality roads and the observer should use their best judgment for when these speeds are not adequate. Some of the transects may require

4-wheel drive. Extreme caution should be used when approaching water crossings, intersections, and busy roads.

Recording Data

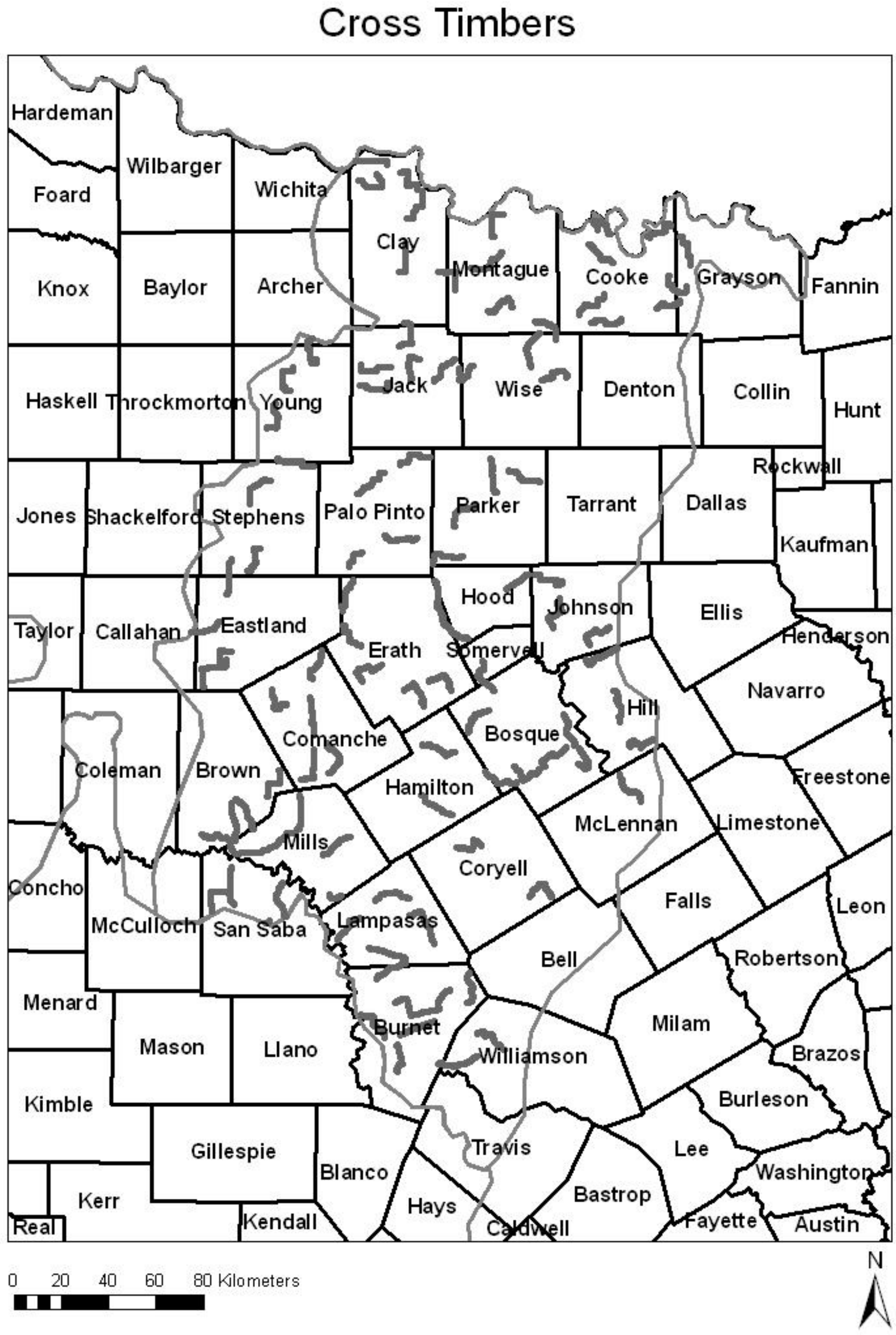
Before a survey is started, the observer must record the transect number, the date, and the observer's name on the data sheet. When a flock is observed, the observer must first record the observation number on the data sheet. For observation number, use a sequential number, starting with 1 for each transect. Each flock is an observation, not each turkey. Next, the time should be recorded. To minimize confusion during the data analysis stage, the time should always be recorded on a 24-hour clock. Flock composition is important and therefore the total flock size, the number of males, number of females, and number of unknown sex should be recorded on the data sheet. Turkeys will likely flush once being spotted and their behavior as the vehicle approaches and after the vehicle stops should be recorded on the data sheet. Remember, when a flock of turkeys flush, the observer should record the distance from the transect to the original location of the flock prior to flush. All distance measurements will be made in meters to the center of the flock. The sighting distance, sighting bearing, and the transect bearing will need to be recorded on the data sheet. It is ideal if measurements can be made perpendicular to the transect. After all distance and angle measurements have been gathered, the observer will need to record Universal Transverse Mercator (UTM NAD83 Zone 14) coordinates for the location on the transect from which the measurements were taken. Next, a vegetation class will need to be recorded. To describe vegetative cover, we have created 5 vegetation classifications. One classification will need to be assigned for each flock observation. The descriptor should not describe the overall landscape of the area, but should describe any vegetation between the observer and the observed flock. The vegetation classifications are: 1 = Grassland, 2 = Brushland-low density (<50%), 3 = Brushland-high density (>50%), 4 = Forest-low density understory (<50%), 5 = Forest-high density understory (>50%). If no turkeys were observed on a transect, complete the top of the data sheet and note that no turkeys were observed in the comments section of the data sheet.

Comments

Comments can be very important and therefore should always be included on the data sheet. Space for comments has been reserved at the bottom of the data sheet. Especially note any information concerning assumption violations and problems associated with the technique or transect. After completing the transect, record the end time and then make sure all handwriting is clearly legible and the data sheet is completely filled out as necessary. An incomplete or illegible data sheet is worthless.

Transect Maps

After establishing our road-based survey transects, we used ArcMap™ Version 9.2 to create regional maps and county maps displaying all county roads and highways with the transects numbered and highlighted. We created overview maps of each ecoregion and summary county maps. We organized maps by ecoregion.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Knox
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Young
Jack
Wise
Denton
Collin
Hunt
Rockwall
Jones
Shackelford
Stephens
Palo Pinto
Parker
Tarrant
Dallas
Kaufman
Taylor
Callahan
Eastland
Hood
Johnson
Ellis
Erath
Somervell
Henderson
Navarro
Hill
Comanche
Bosque
Coleman
Brown
Hamilton
Freestone
McLennan
Limestone
Mills
Coryell
Concho
Falls
Leon
McCulloch
San Saba
Lampasas
Bell
Robertson
Menard
Milam
Mason
Llano
Burnet
Williamson
Brazos
Kimble
Burleson
Gillespie
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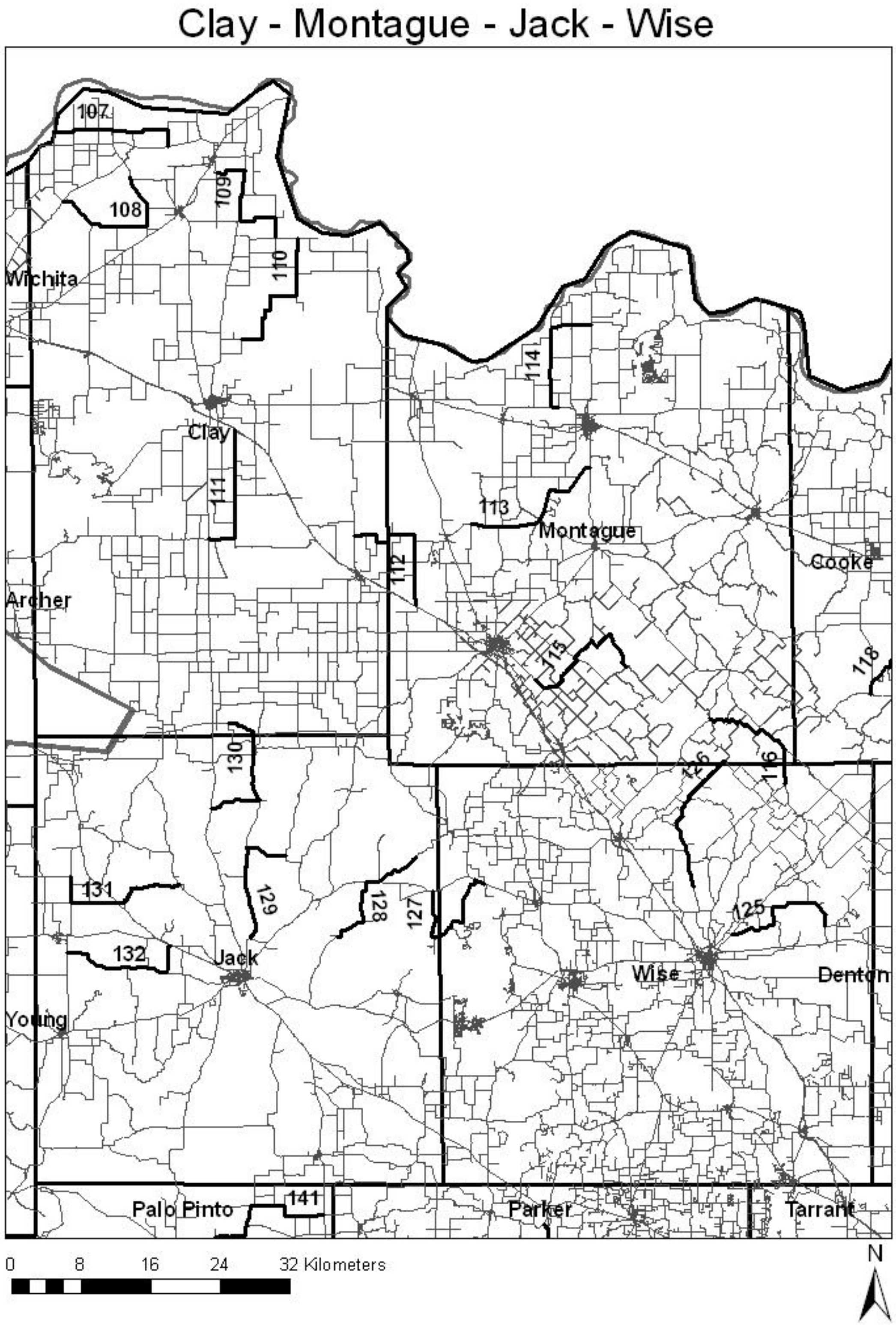
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126
116
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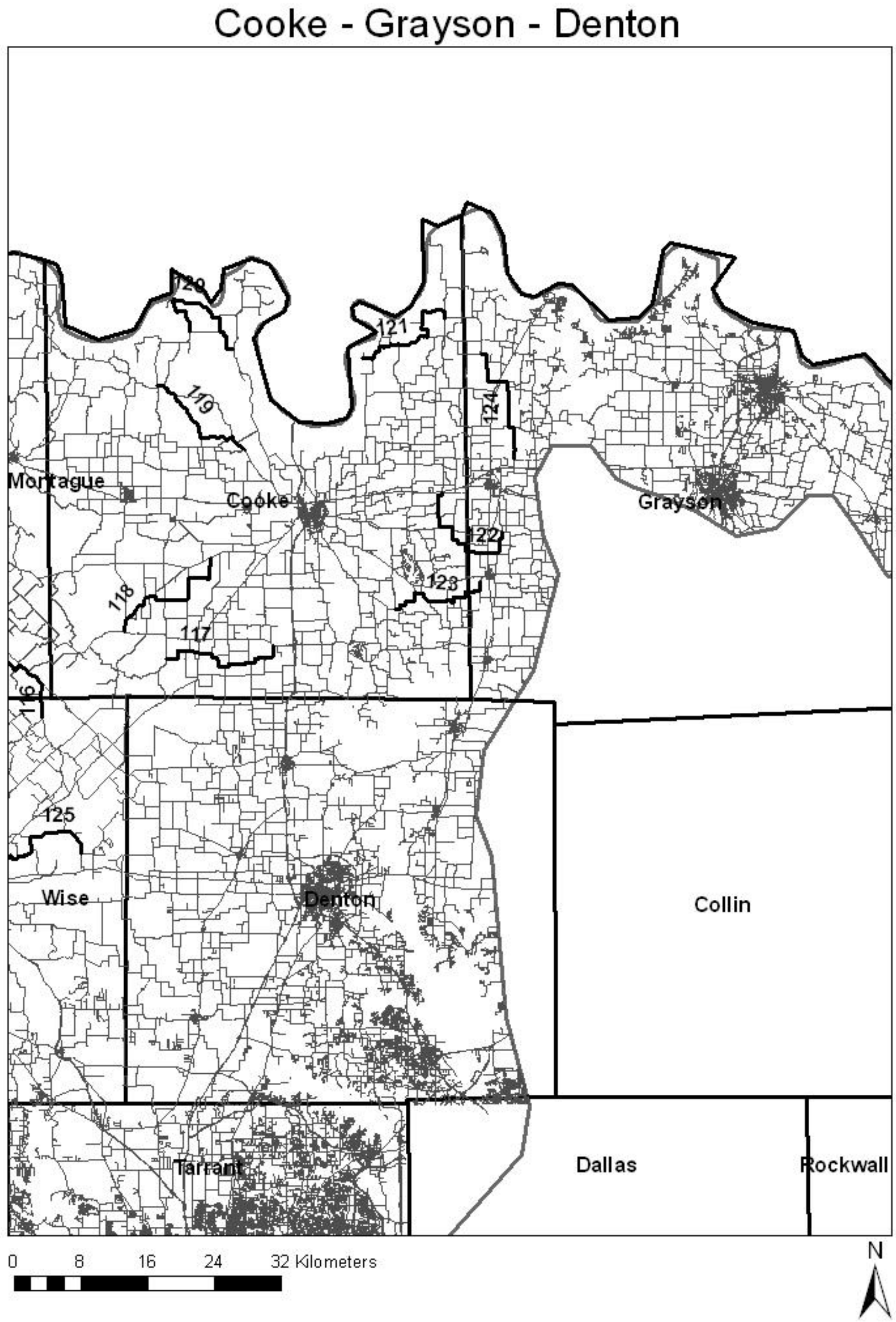
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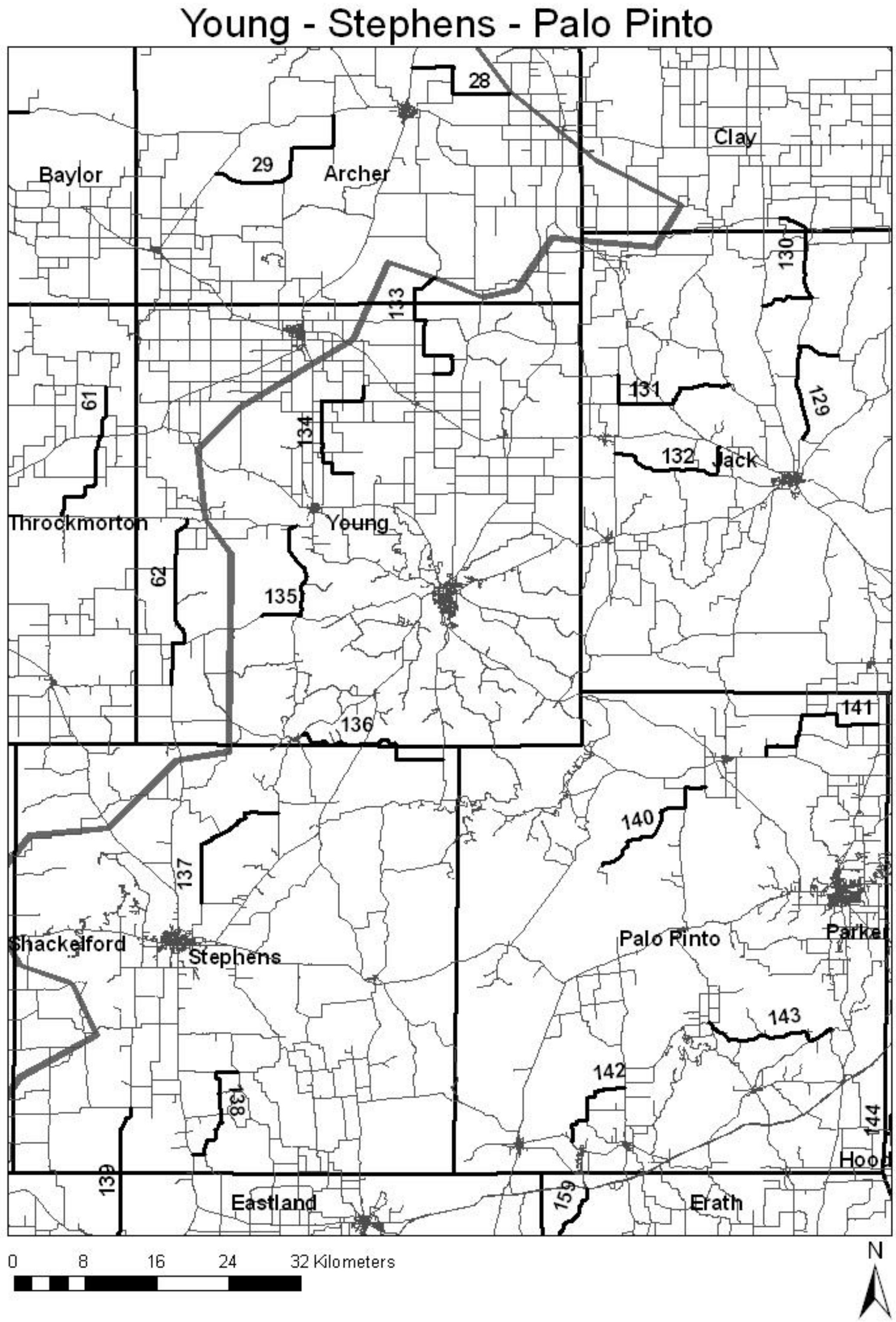
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141
136
140
137
Shackelford
Stephens
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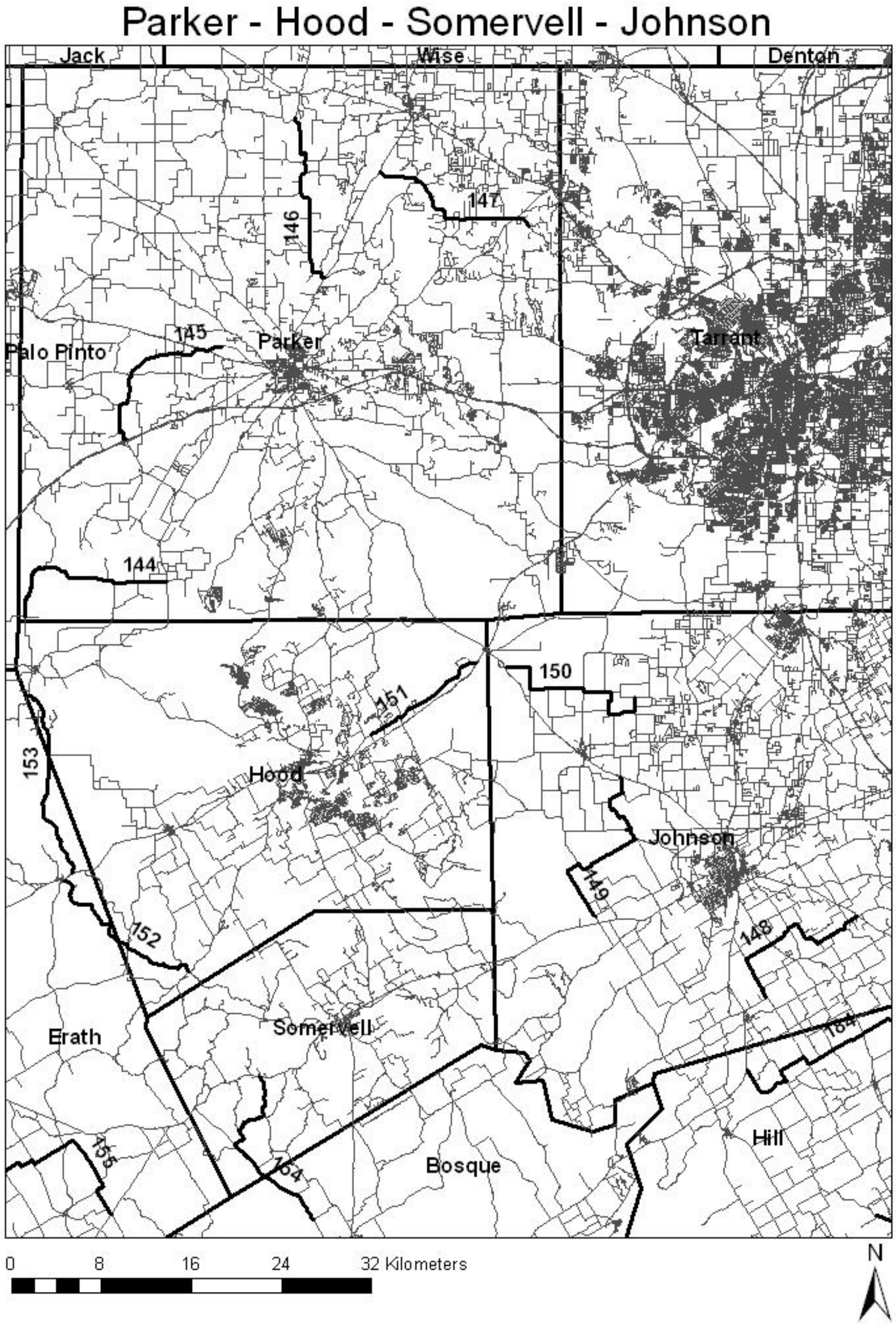
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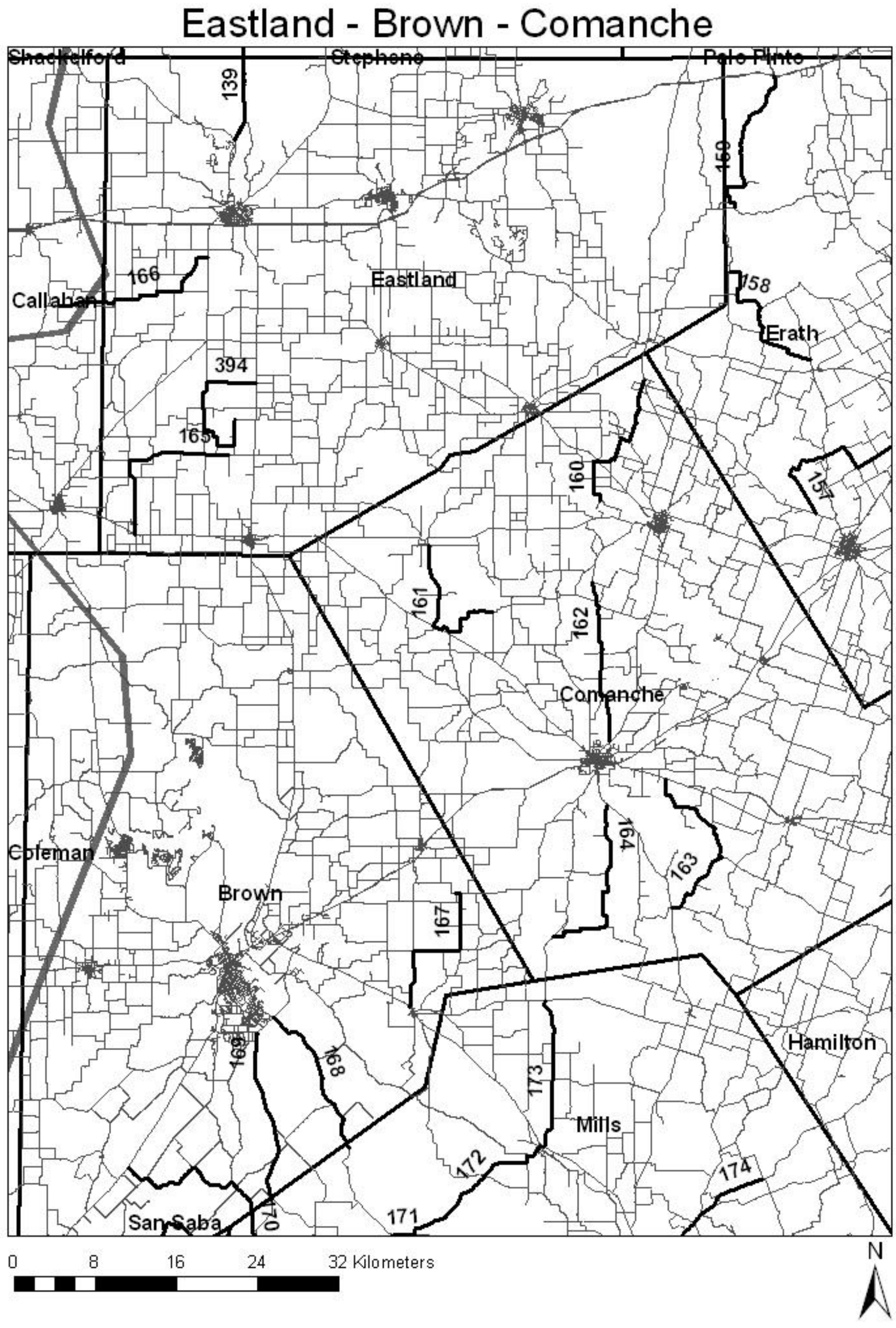
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Comanche
Coleman
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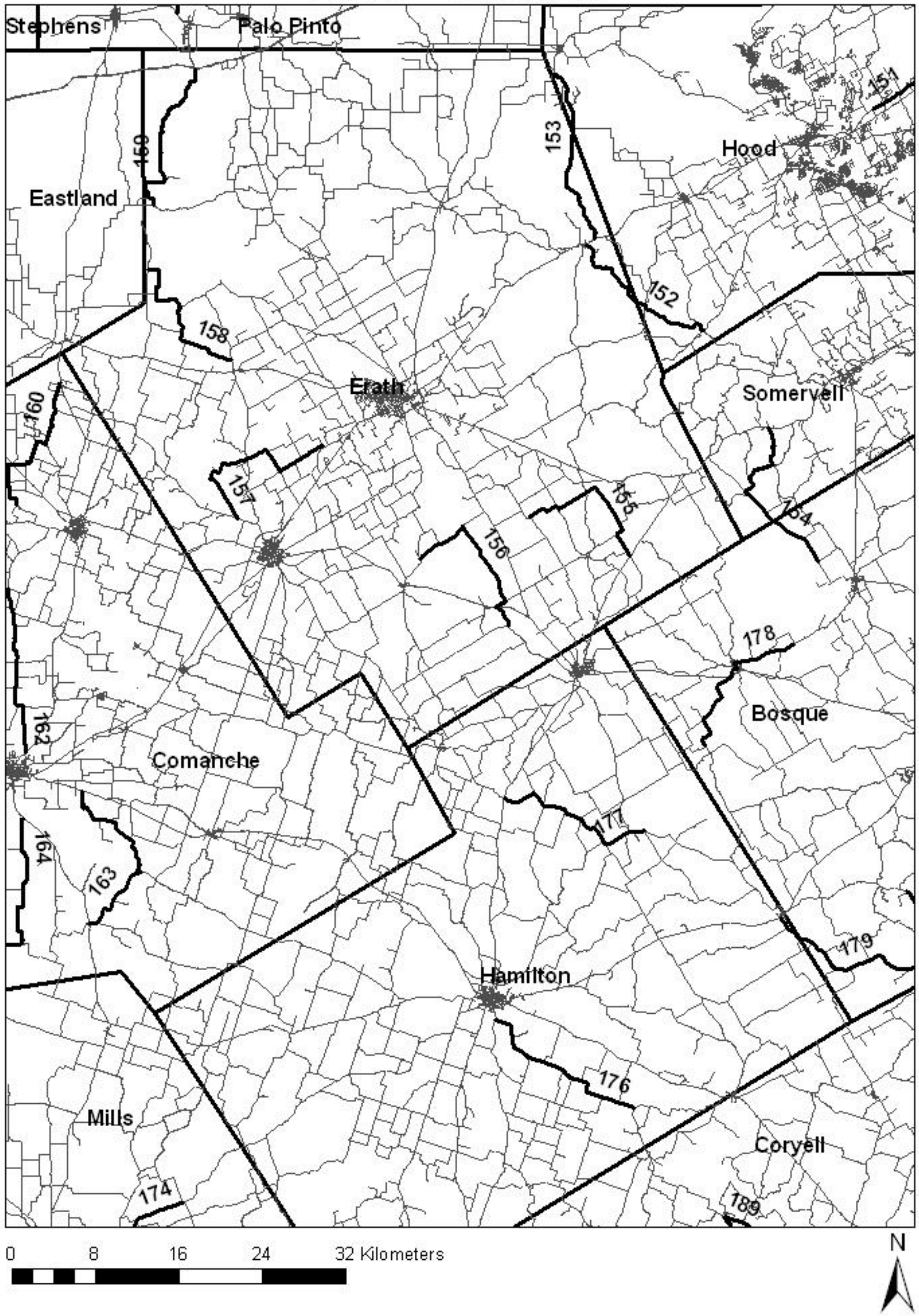
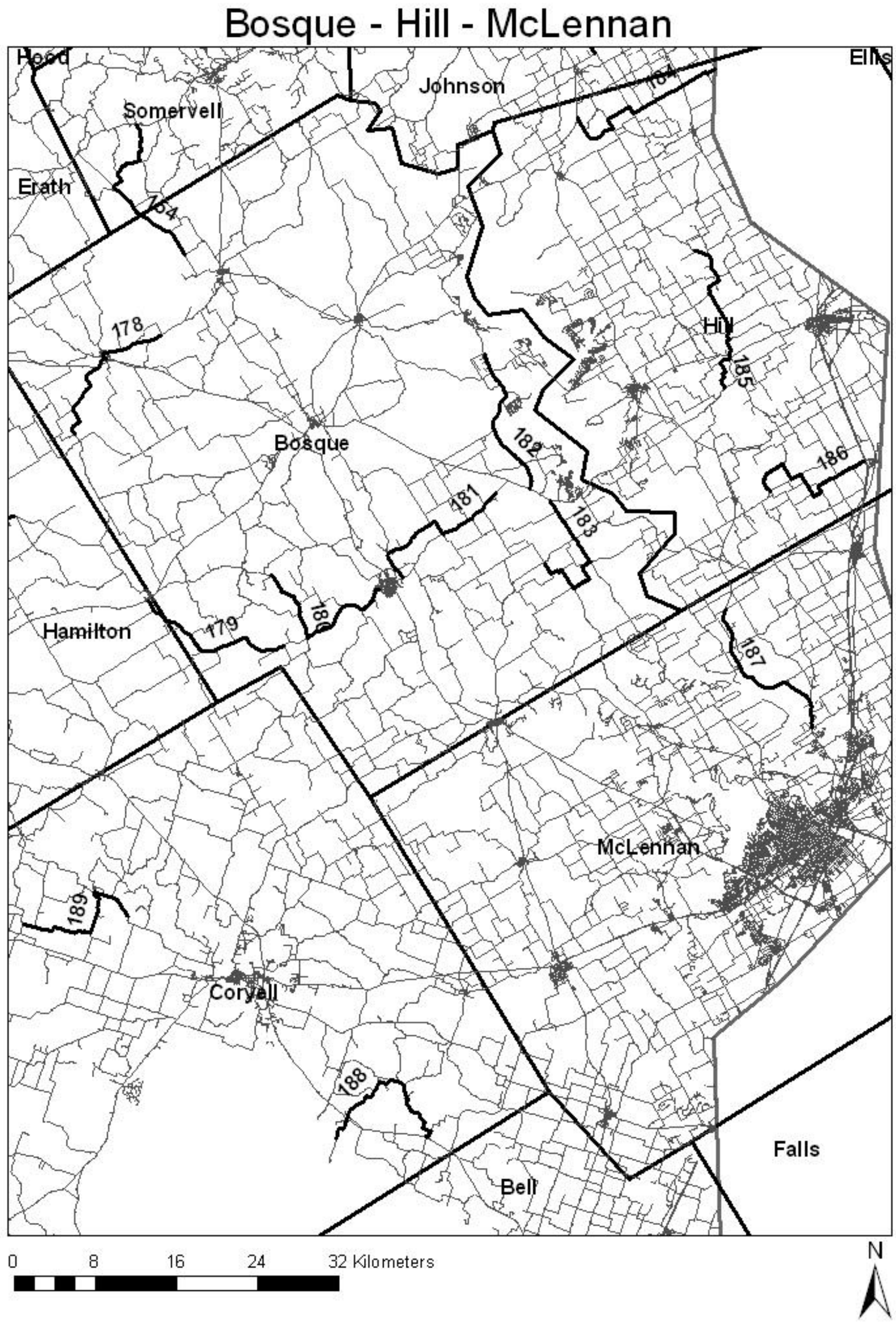
Erath - Hamilton

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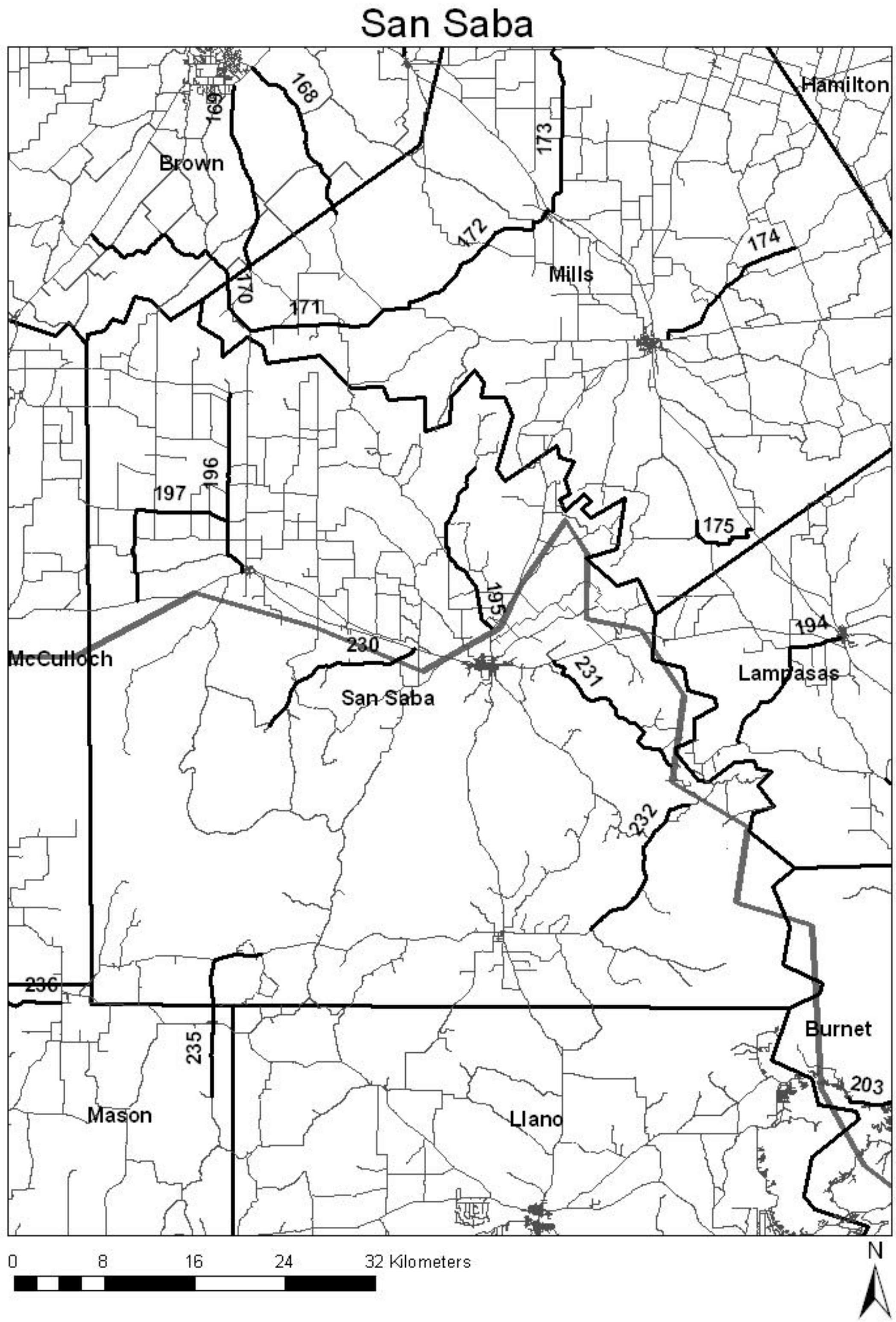
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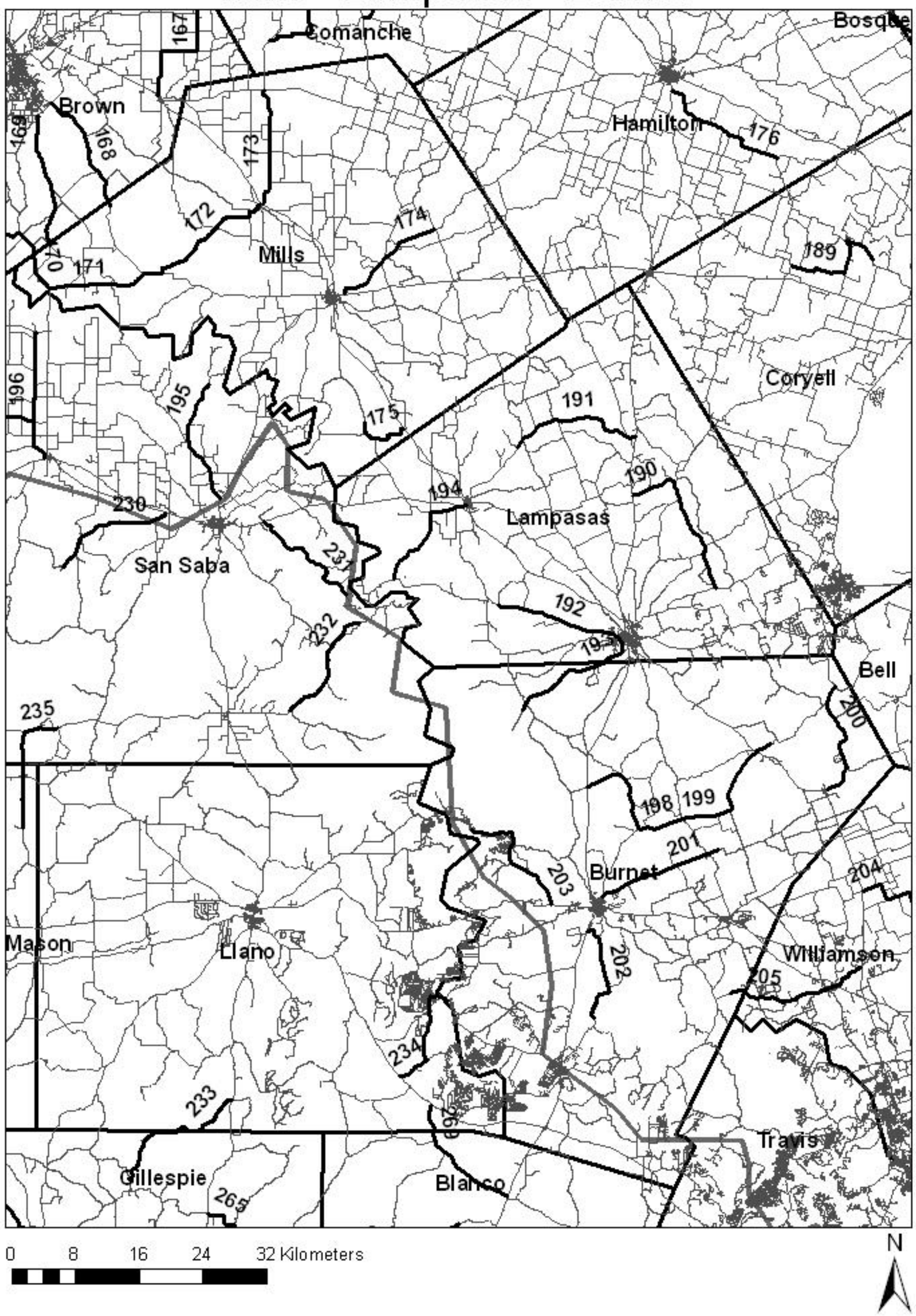
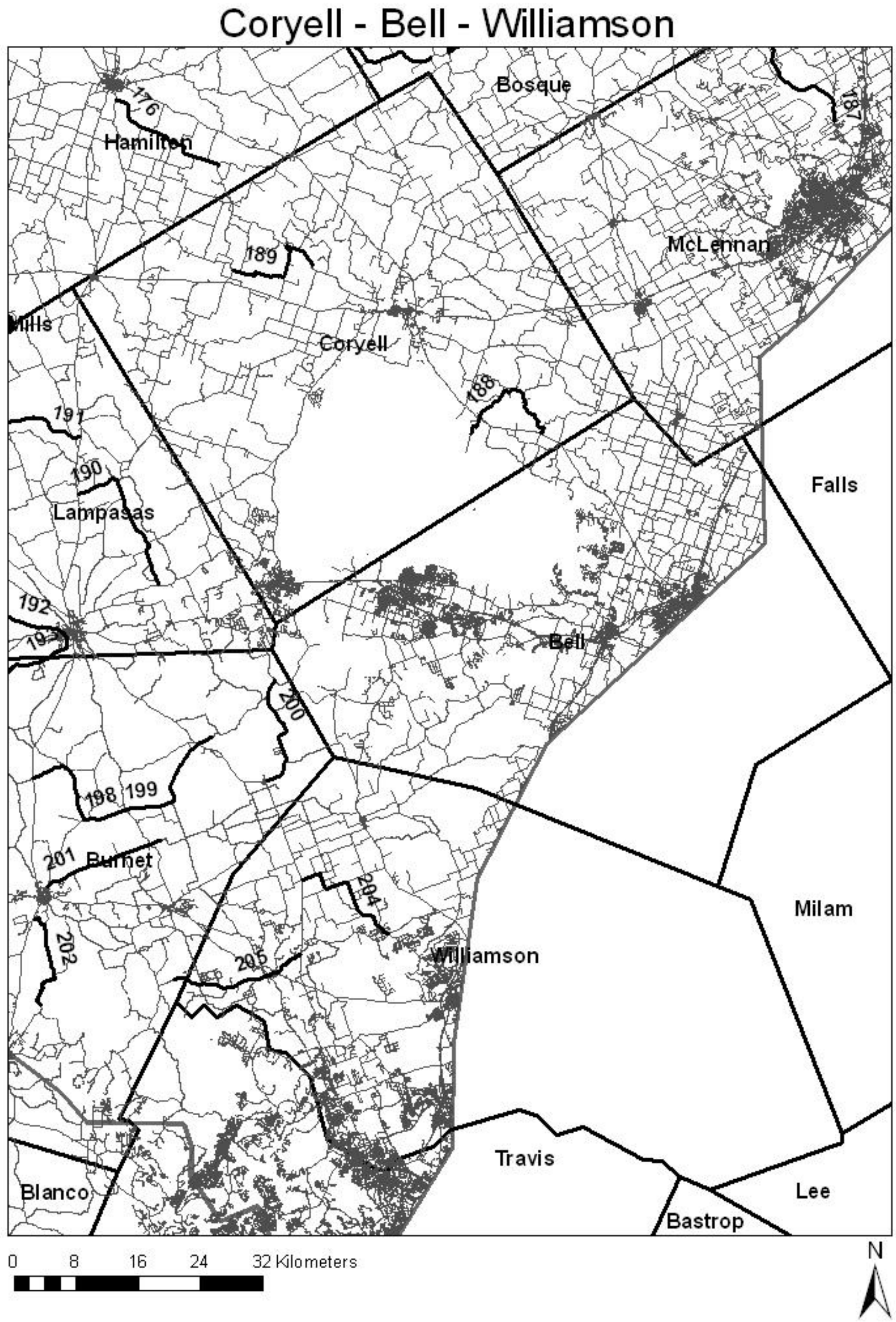
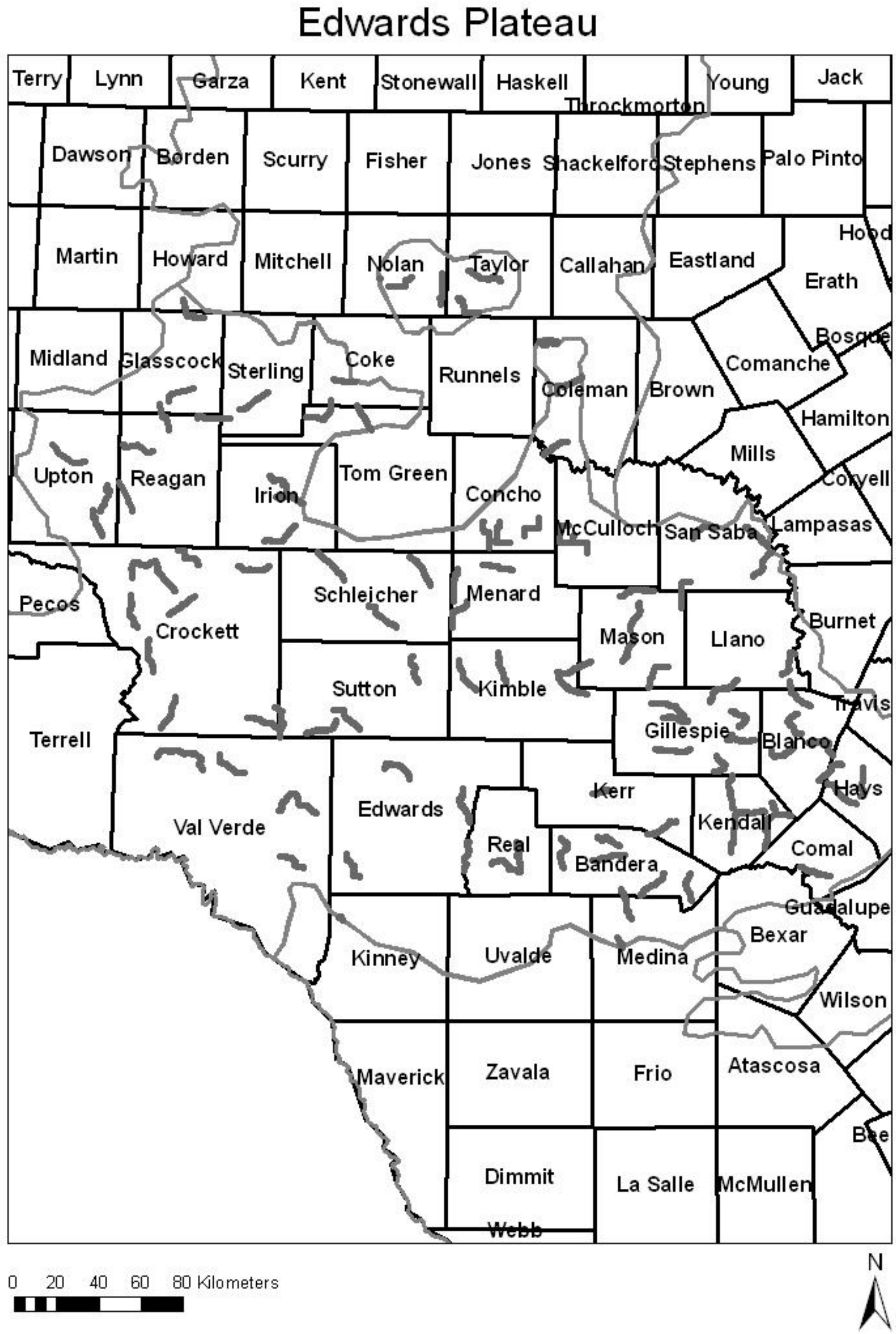
8
16
24
32 Kilometers
N

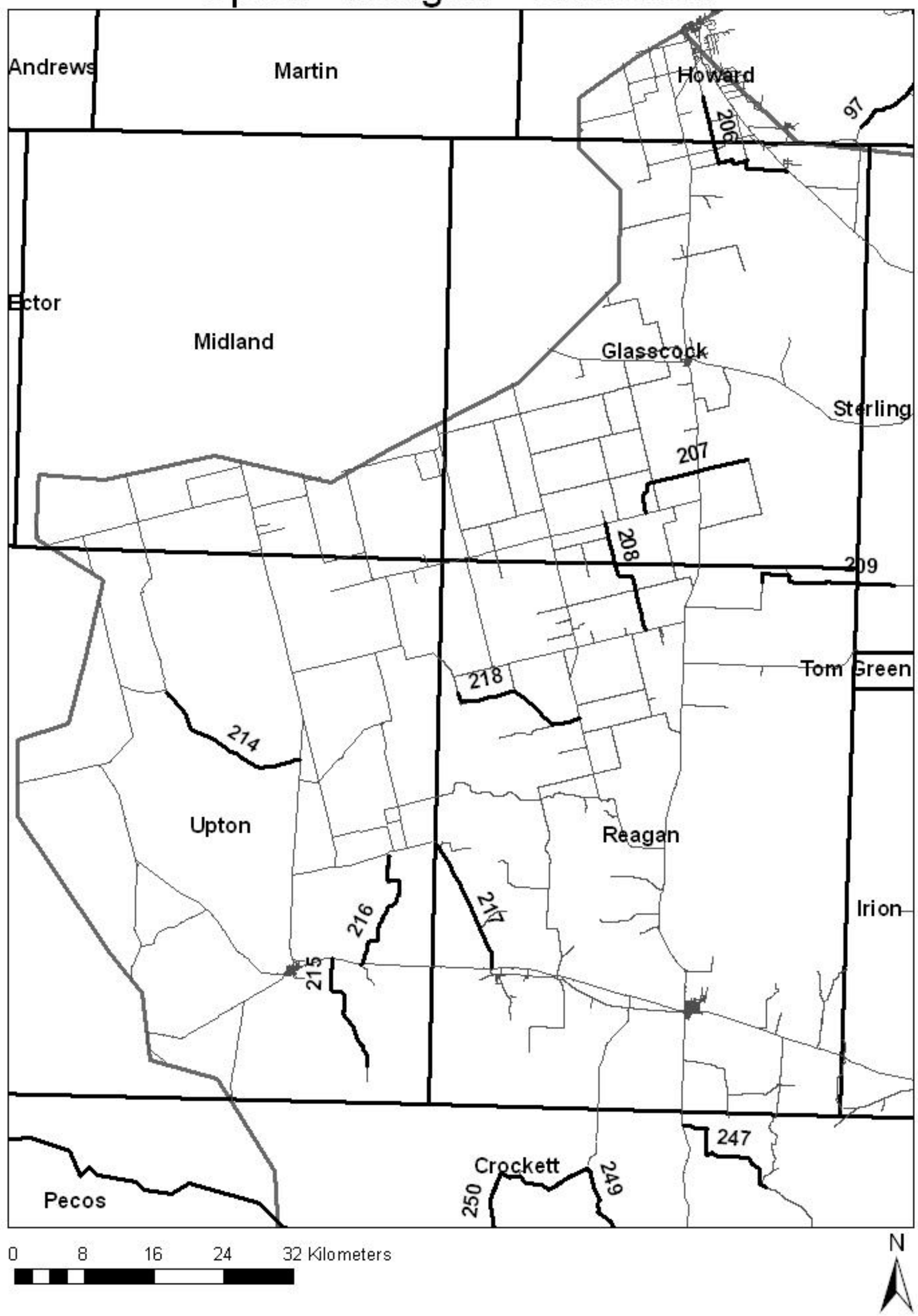
Mills - Lampasas - Burnet



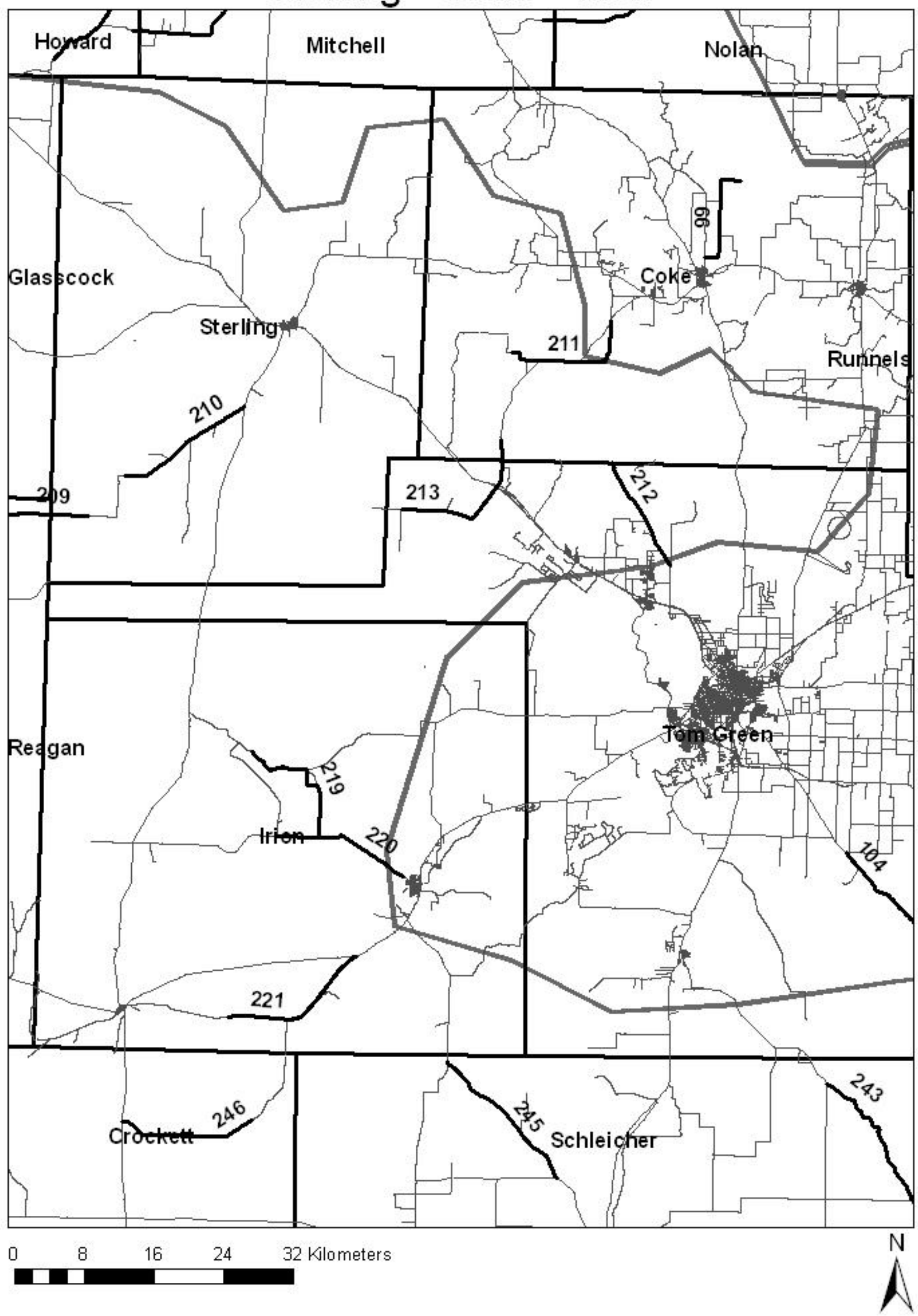

Coryell - Bell - Williamson
Bosque
Hamilton
McLennan
Mills
Coryell
Lampasas
Falls
Bell
Burnet
Milam
Williamson
Travis
Blanco
Lee
Bastrop
176
187
189
188
191
190
192
193
200
198
199
201
204
202
205
0 8 16 24 32 Kilometers
N

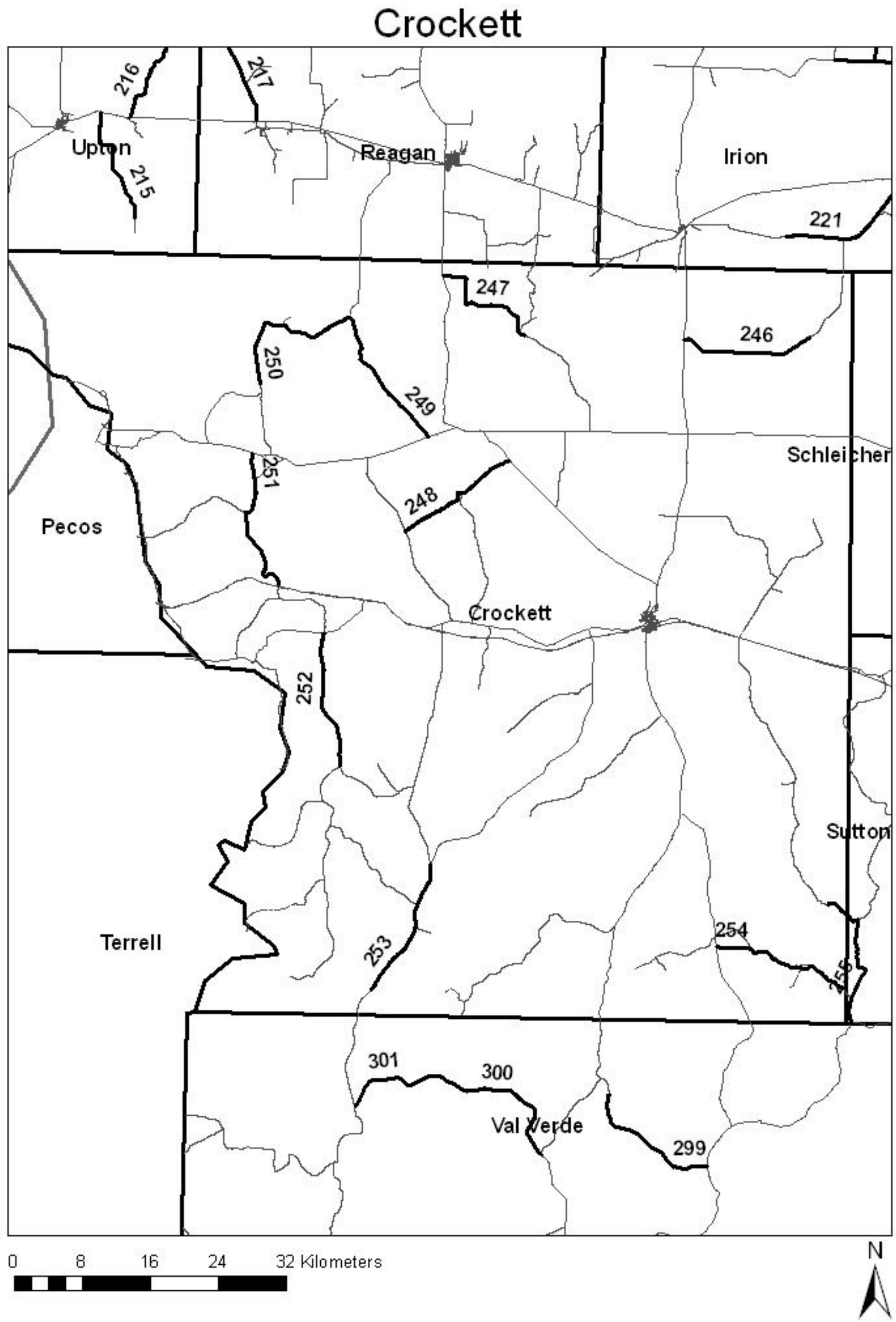

Edwards Plateau
Terry
Lynn
Garza
Kent
Stonewall
Haskell
Throckmorton
Young
Jack
Dawson
Borden
Scurry
Fisher
Jones
Shackelford
Stephens
Palo Pinto
Martin
Howard
Mitchell
Nolan
Taylor
Callahan
Eastland
Hood
Erath
Midland
Glasscock
Sterling
Coke
Runnels
Coleman
Brown
Comanche
Bosque
Hamilton
Upton
Reagan
Irion
Tom Green
Concho
McCulloch
San Saba
Mills
Coryell
Lampasas
Pecos
Crockett
Schleicher
Menard
Mason
Llano
Burnet
Sutton
Kimble
Gillespie
Blanco
Travis
Terrell
Val Verde
Edwards
Real
Kerr
Kendall
Hays
Bandera
Comal
Guadalupe
Kinney
Uvalde
Medina
Bexar
Wilson
Maverick
Zavala
Frio
Atascosa
Dimmit
La Salle
McMullen
Bee
Webb
0 20 40 60 80 Kilometers
N

Upton - Reagan - Glasscock

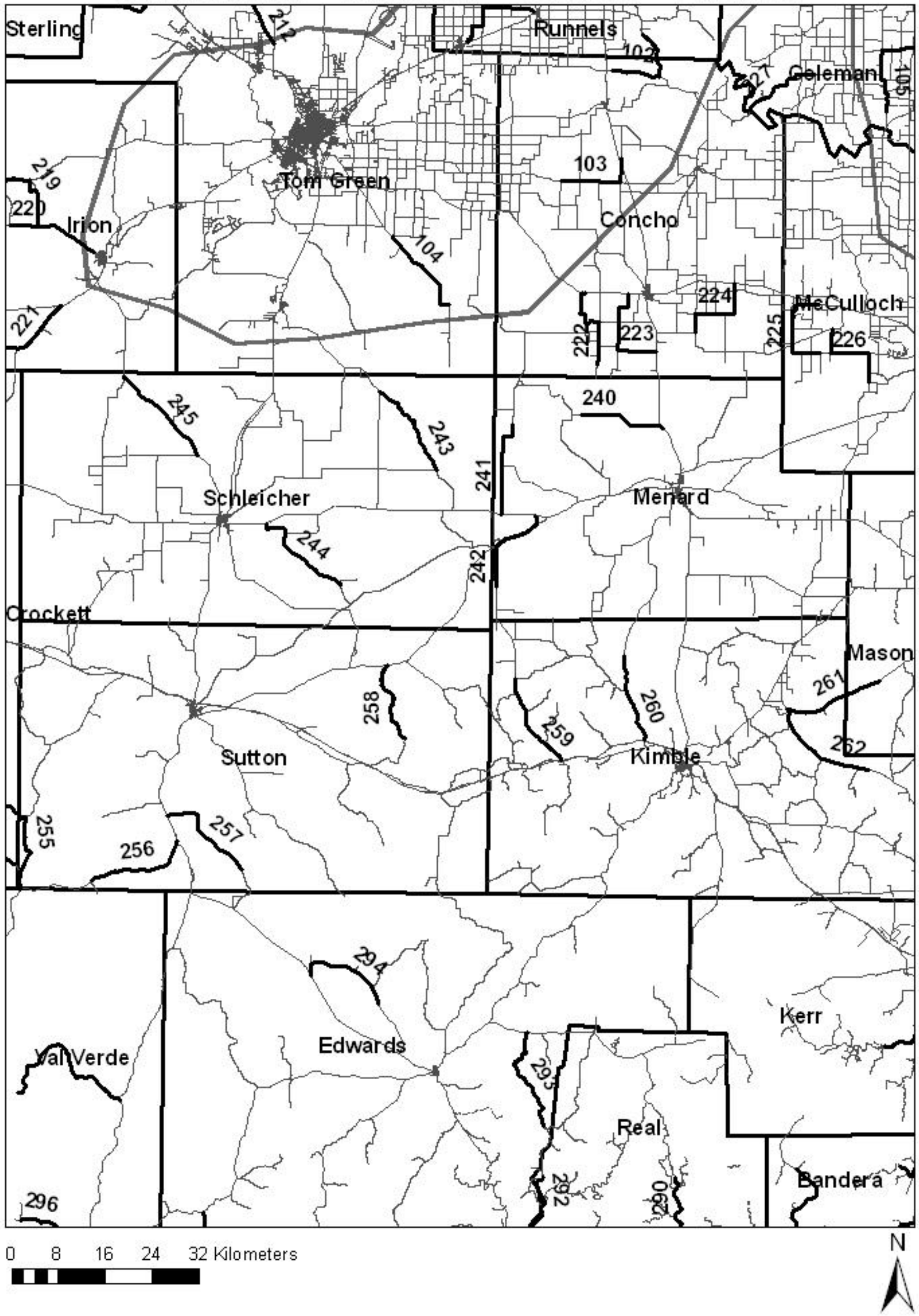


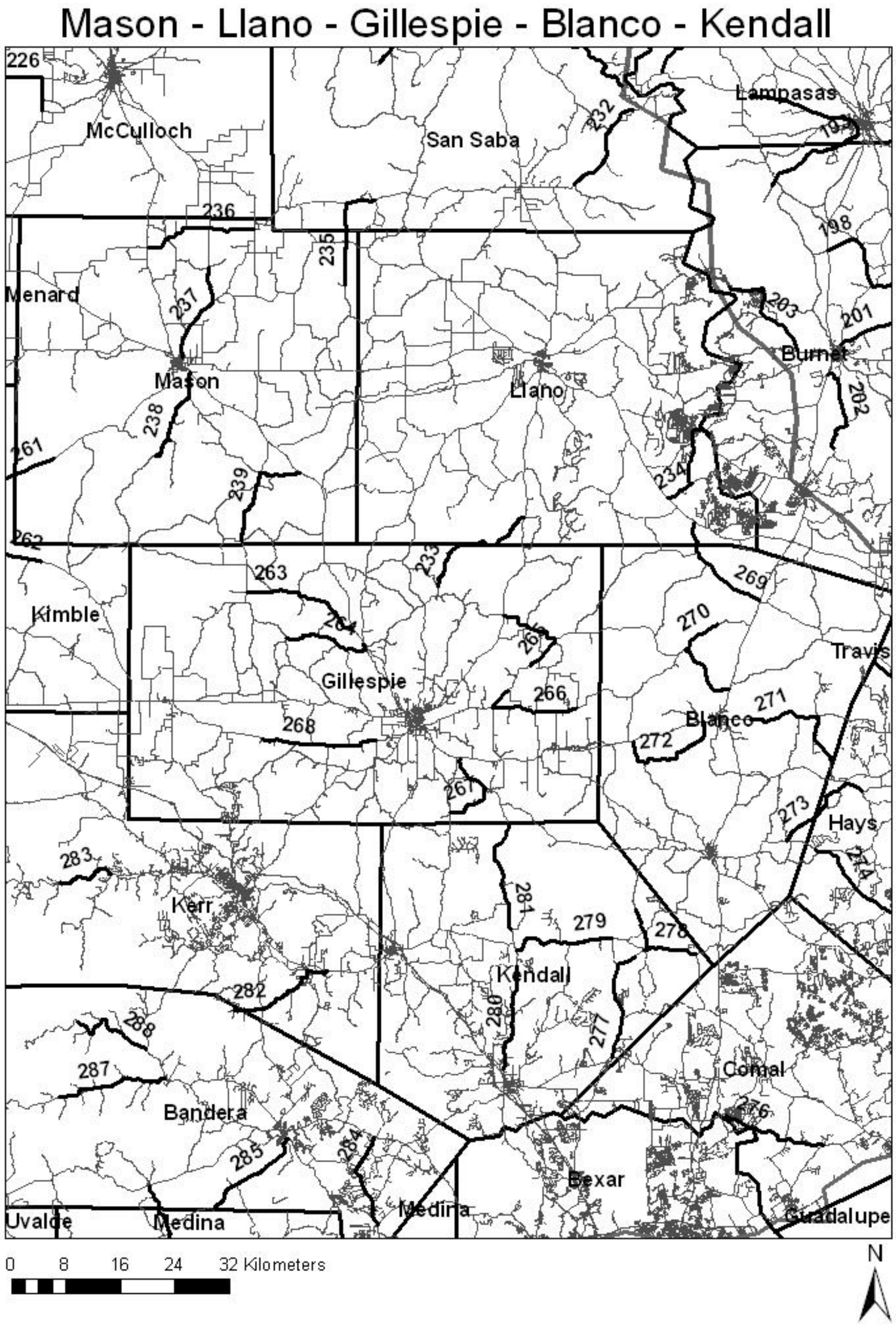
Sterling - Coke - Irion

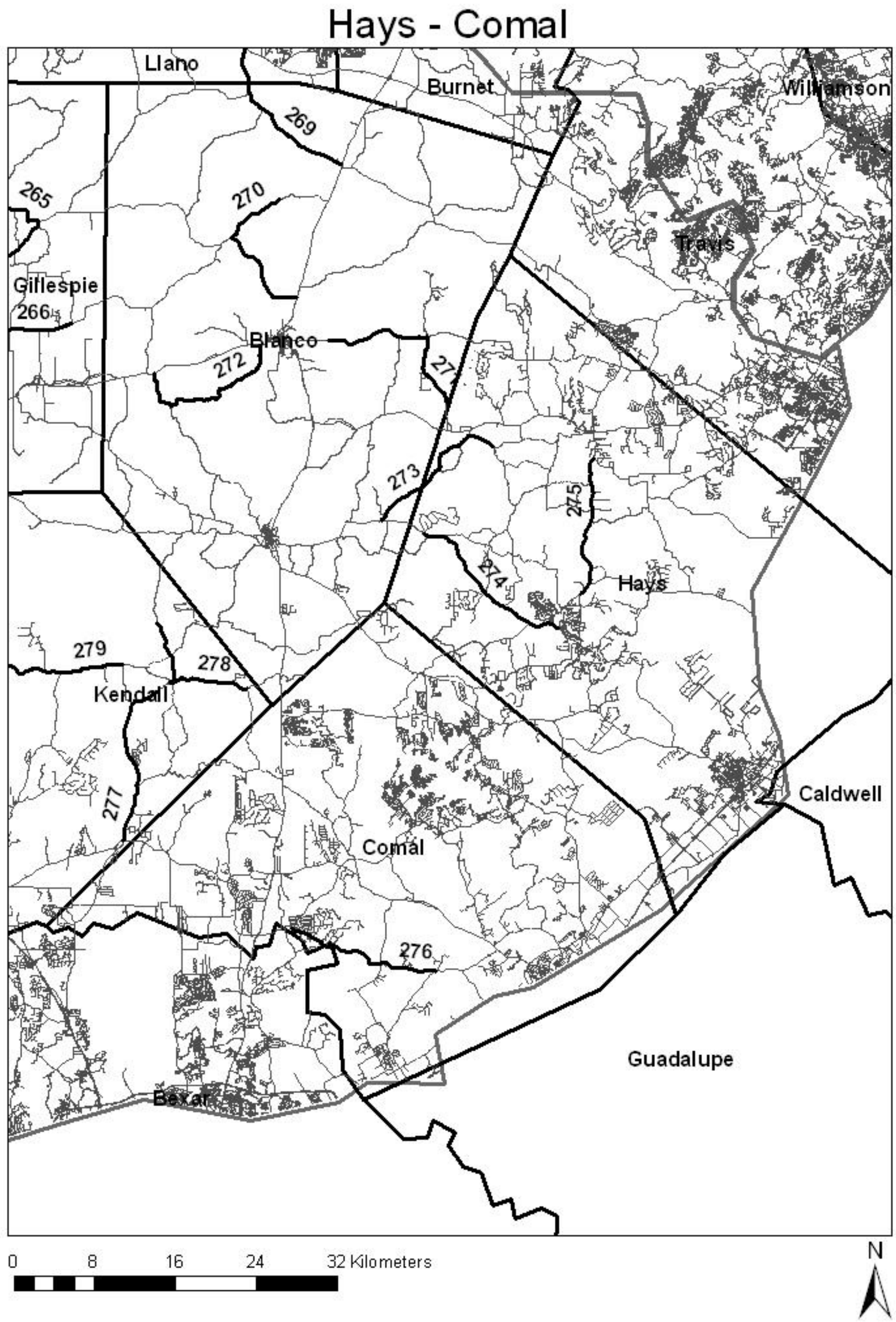



Crockett
216
217
Upton
215
Reagan
Irion
221
247
246
250
249
Schleicher
251
248
Pecos
Crockett
252
Sutton
Terrell
253
254
255
301
300
Val Verde
299
0
8
16
24
32 Kilometers
N

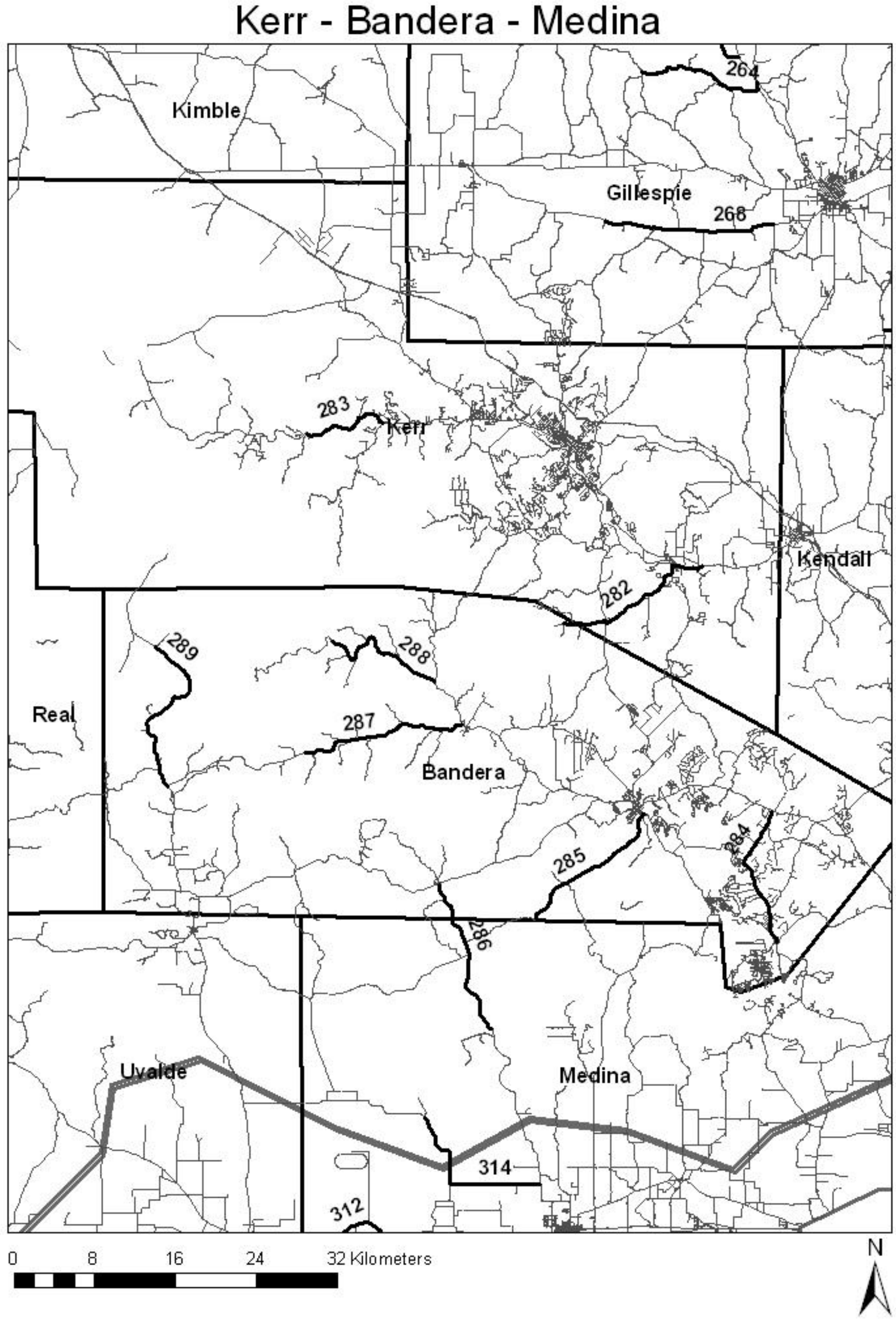
Schleicher - Menard - Sutton - Kimble

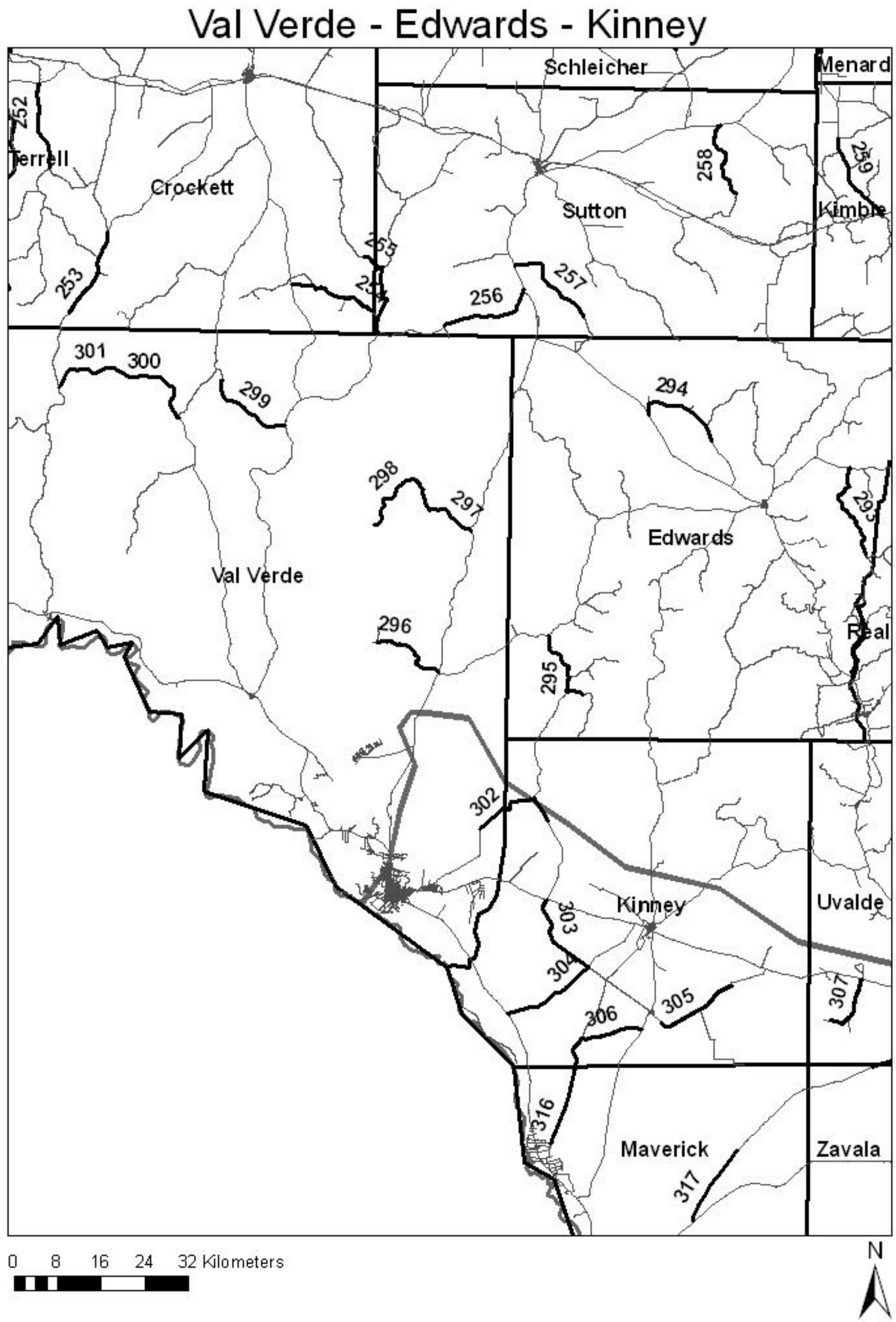


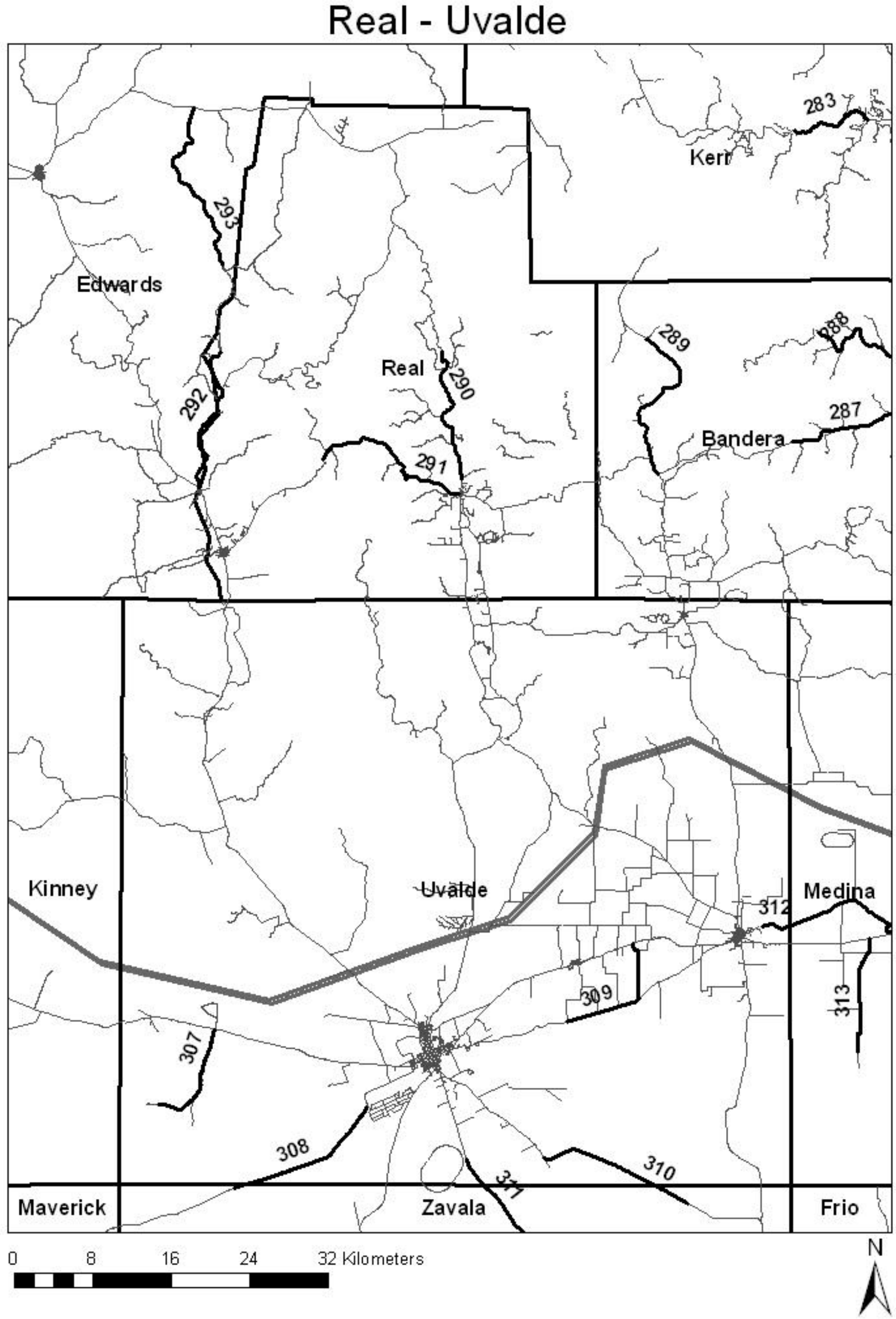

Mason - Llano - Gillespie - Blanco - Kendall
McCulloch
San Saba
Lampasas
Menard
Mason
Llano
Burnet
Kimble
Gillespie
Travis
Blanco
Hays
Kerr
Kendall
Comal
Bandera
Bexar
Medina
Uvalde
Guadalupe
0 8 16 24 32 Kilometers
N

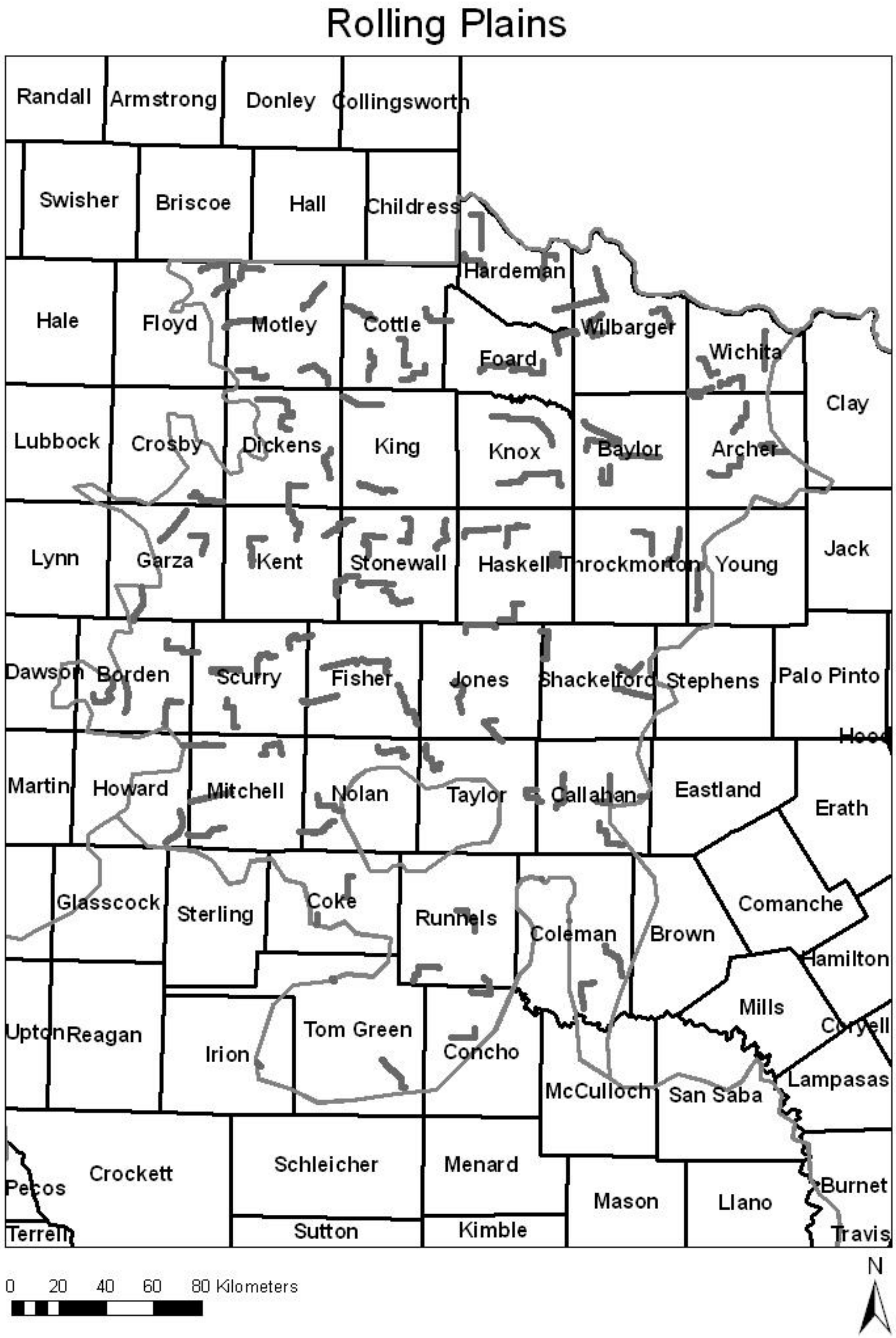


Hays - Comal
Llano
Burnet
Williamson
269
270
265
Travis
Gillespie
266
Blanco
272
273
275
274
Hays
279
278
Kendall
277
Caldwell
Comal
276
Guadalupe
Bexar
0 8 16 24 32 Kilometers
N

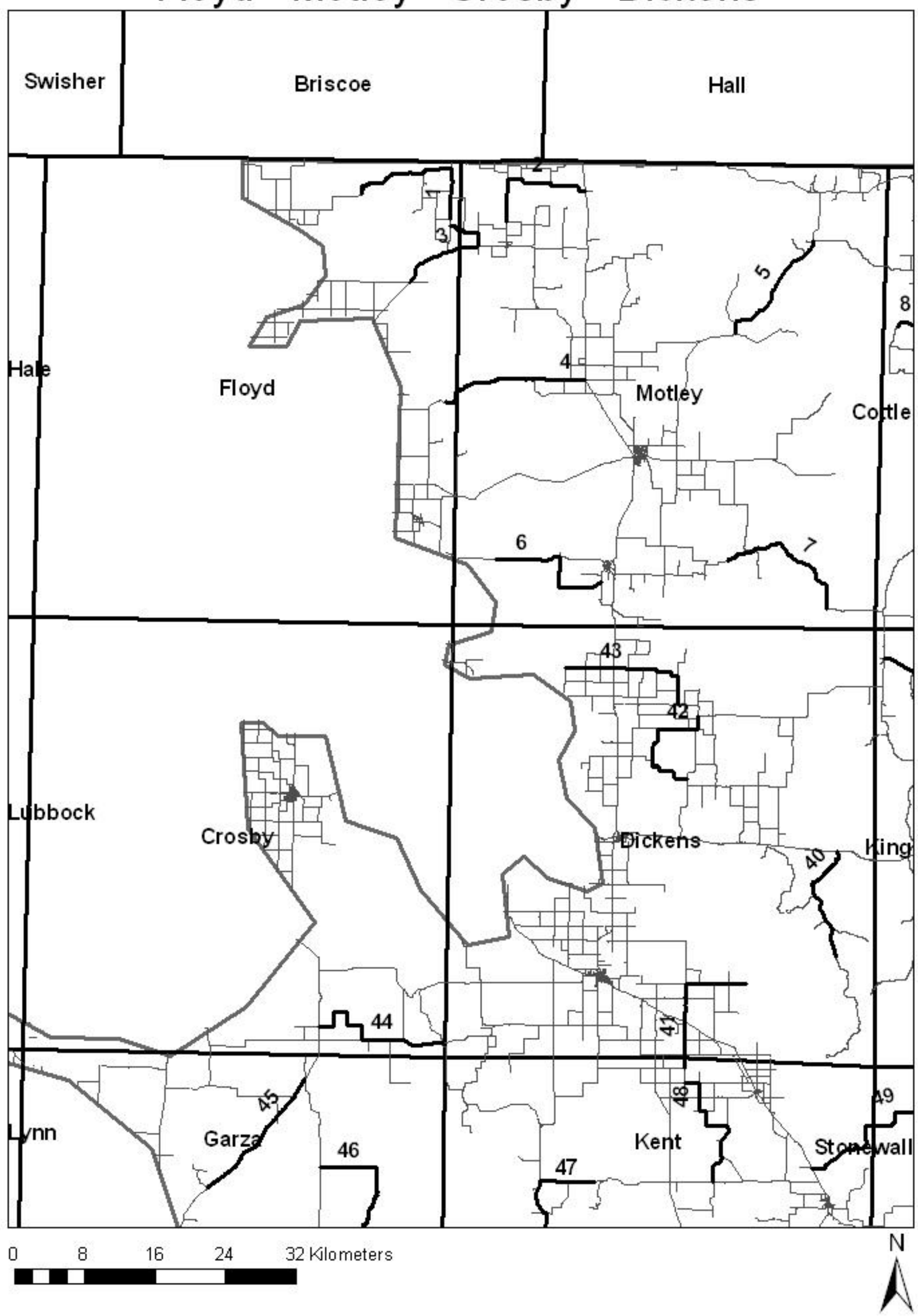

Kerr - Bandera - Medina
Kimble
Gillespie
264
268
283
Kerr
Kendall
282
289
288
Real
287
Bandera
284
285
286
Uvalde
Medina
314
312
0
8
16
24
32 Kilometers
N


Val Verde - Edwards - Kinney
Schleicher
Menard
Terrell
Crockett
Sutton
Kimble
Val Verde
Edwards
Real
Kinney
Uvalde
Maverick
Zavala
252
253
254
255
256
257
258
259
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
316
317
0 8 16 24 32 Kilometers
N

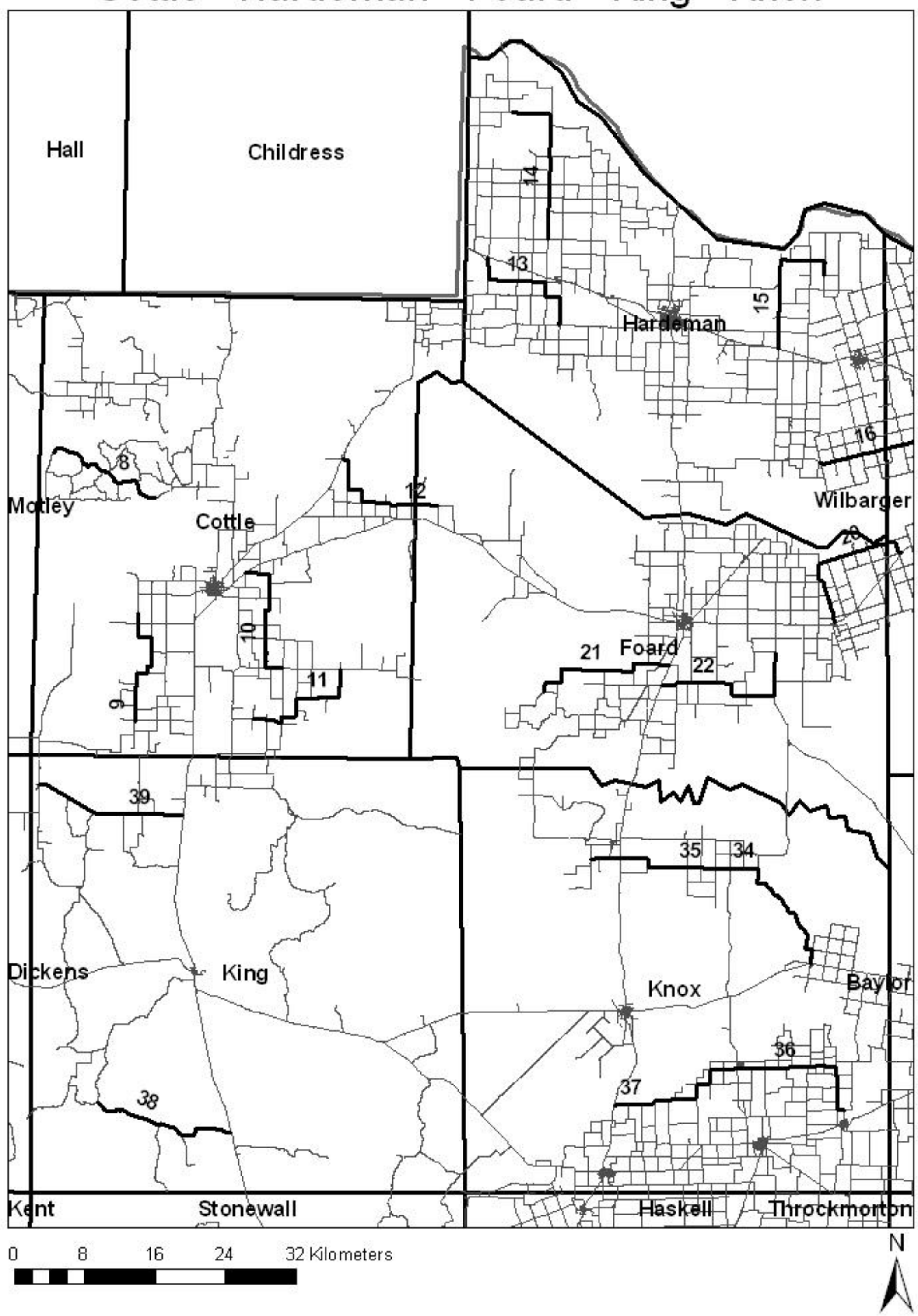

Real - Uvalde
Kerr
283
293
Edwards
289
288
Real
290
292
287
Bandera
291
Kinney
Uvalde
312
Medina
309
313
307
308
310
311
Maverick
Zavala
Frio
0
8
16
24
32 Kilometers
N

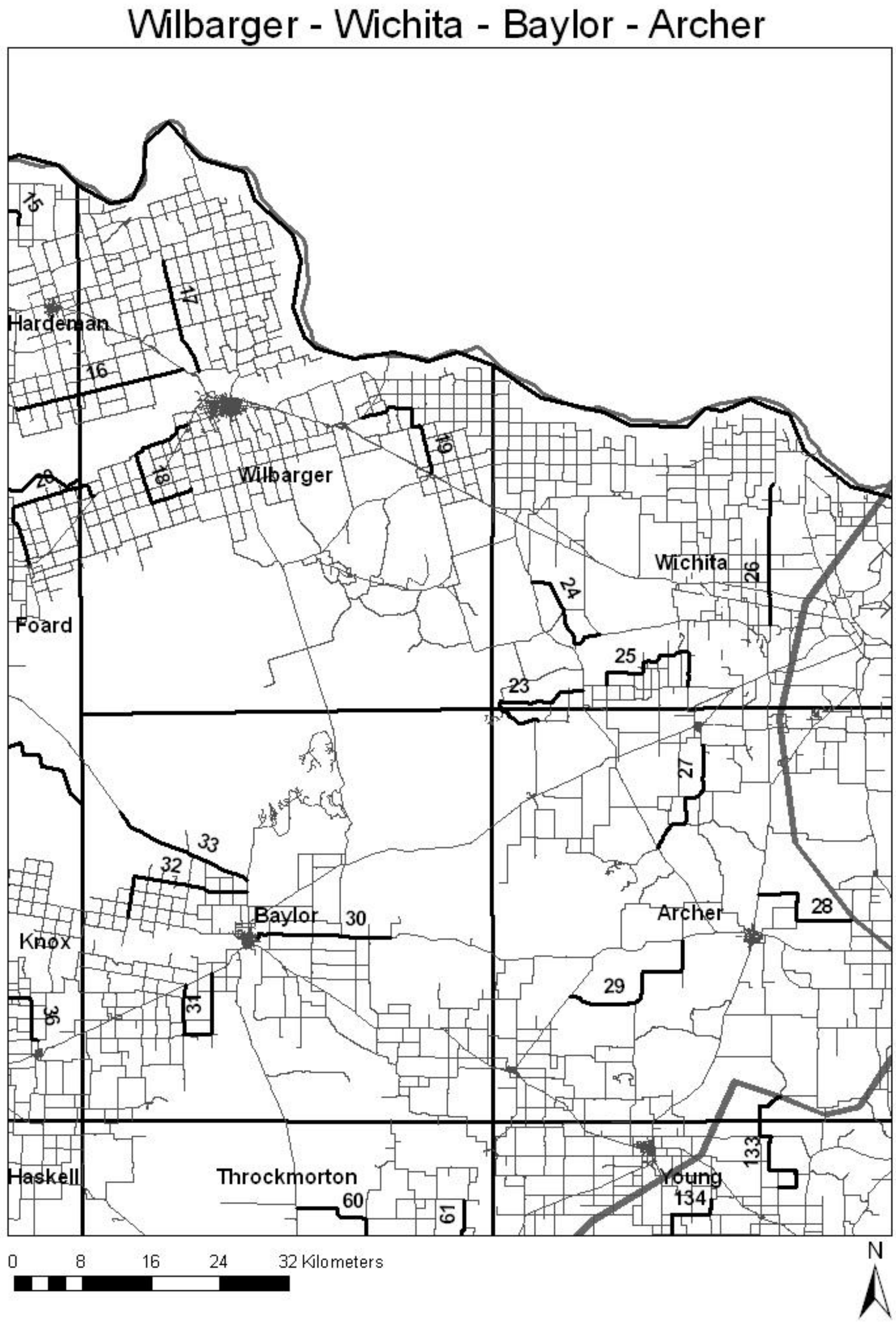

Rolling Plains
Randall
Armstrong
Donley
Collingsworth
Swisher
Briscoe
Hall
Childress
Hardeman
Hale
Floyd
Motley
Cottle
Foard
Wilbarger
Wichita
Clay
Lubbock
Crosby
Dickens
King
Knox
Baylor
Archer
Lynn
Garza
Kent
Stonewall
Haskell
Throckmorton
Young
Jack
Dawson
Borden
Scurry
Fisher
Jones
Shackelford
Stephens
Palo Pinto
Hood
Martin
Howard
Mitchell
Nolan
Taylor
Callahan
Eastland
Erath
Glasscock
Sterling
Coke
Runnels
Coleman
Brown
Comanche
Hamilton
Upton
Reagan
Irion
Tom Green
Concho
Mills
Coryell
McCulloch
San Saba
Lampasas
Pecos
Crockett
Schleicher
Menard
Mason
Llano
Burnet
Terrell
Sutton
Kimble
Travis
0 20 40 60 80 Kilometers
N

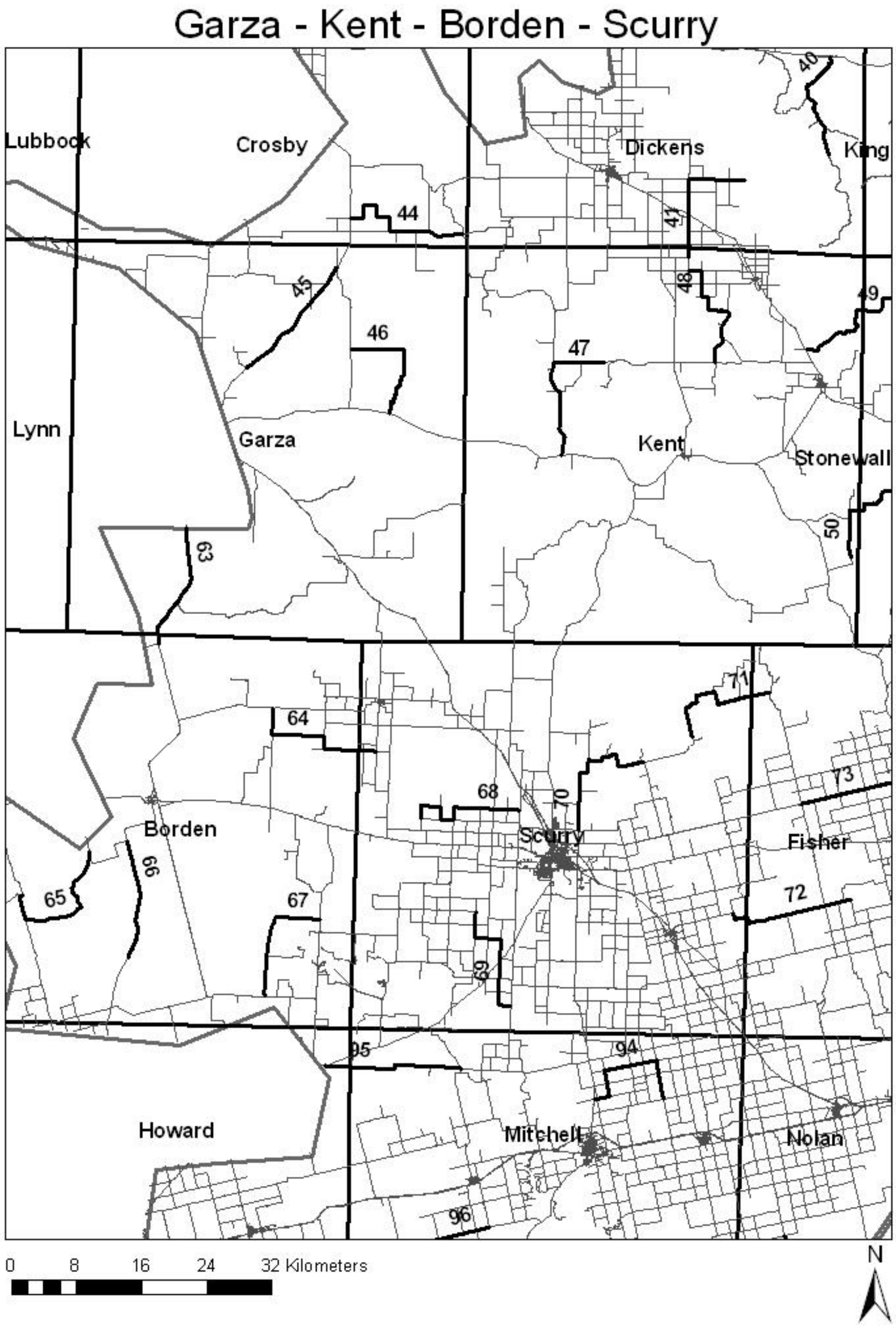
Floyd - Motley - Crosby - Dickens



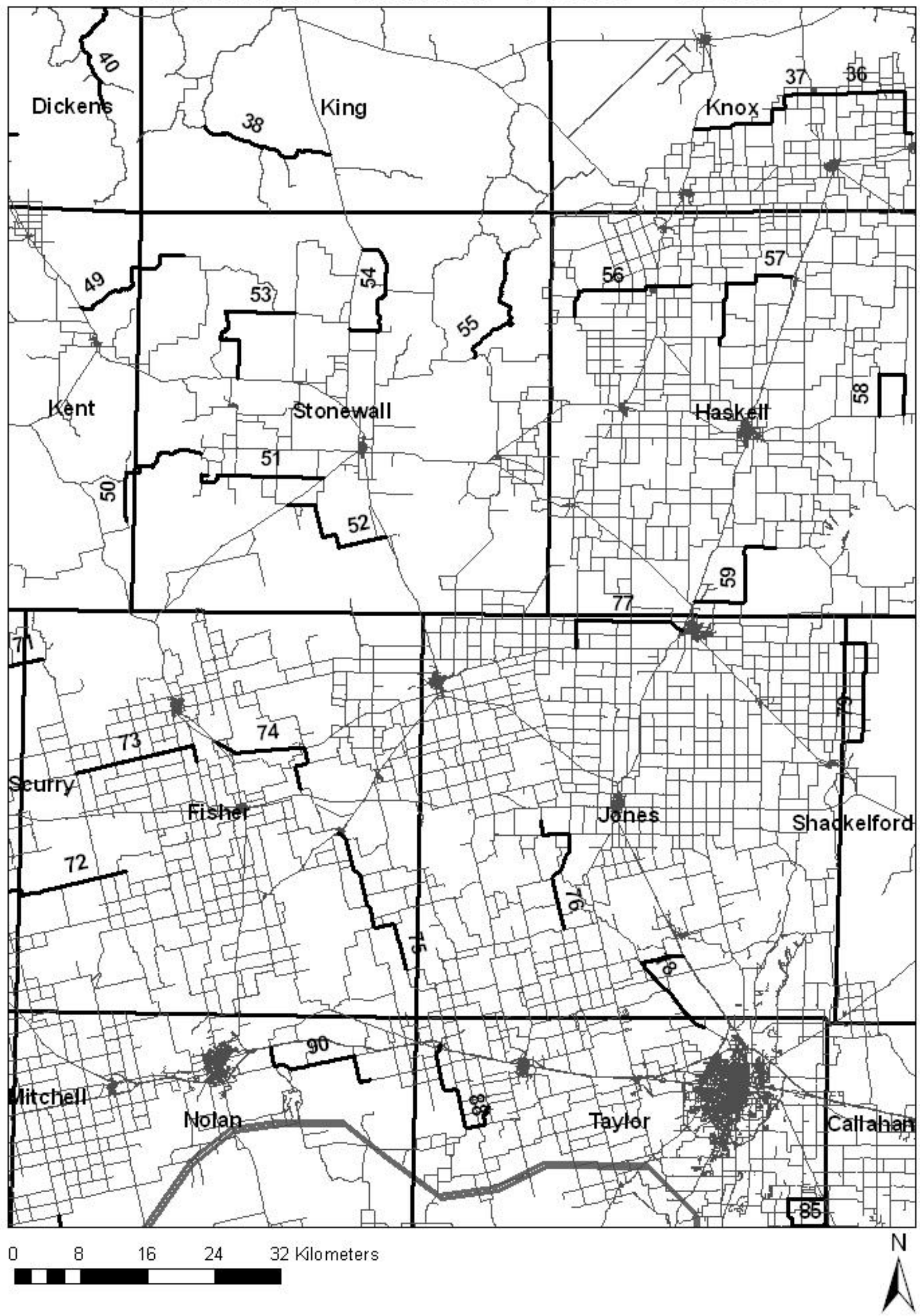
Cottle - Hardeman - Foard - King - Knox

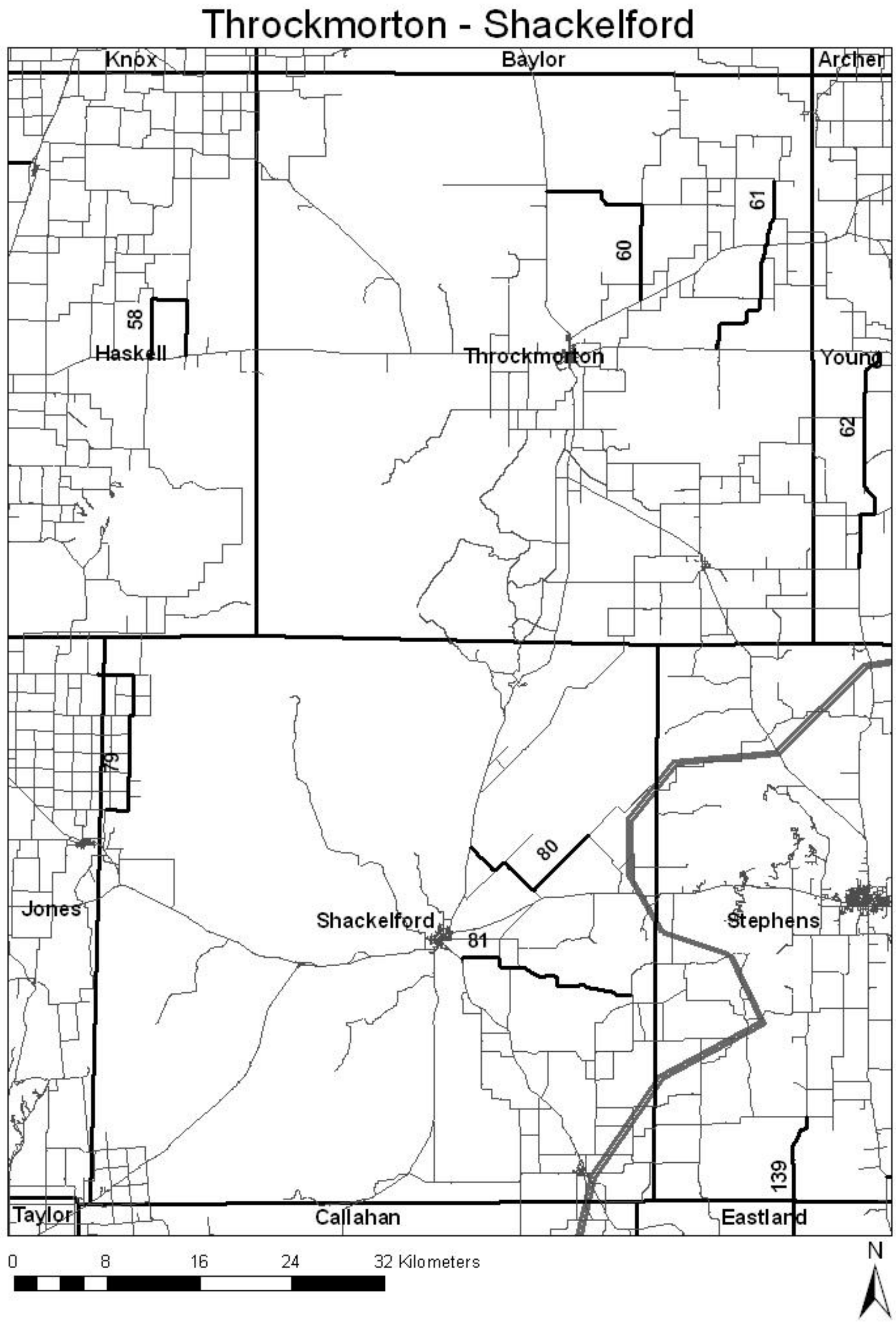


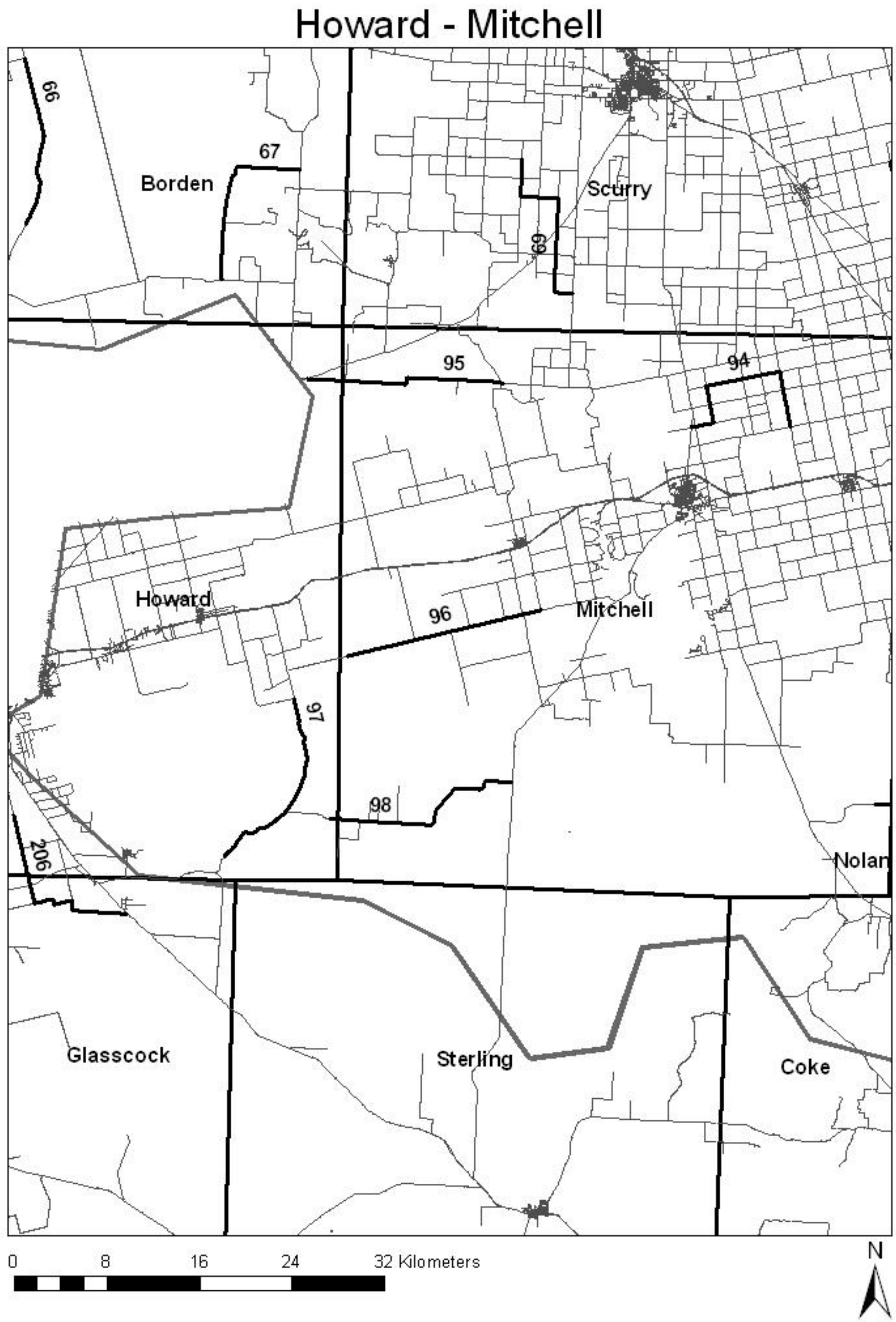

Wilbarger - Wichita - Baylor - Archer
15
17
Hardeman
16
19
20
18
Wilbarger
Wichita
26
24
Foard
25
23
27
33
32
28
Baylor
30
Archer
Knox
29
36
31
Haskell
Throckmorton
133
Young
134
60
61
0
8
16
24
32 Kilometers
N

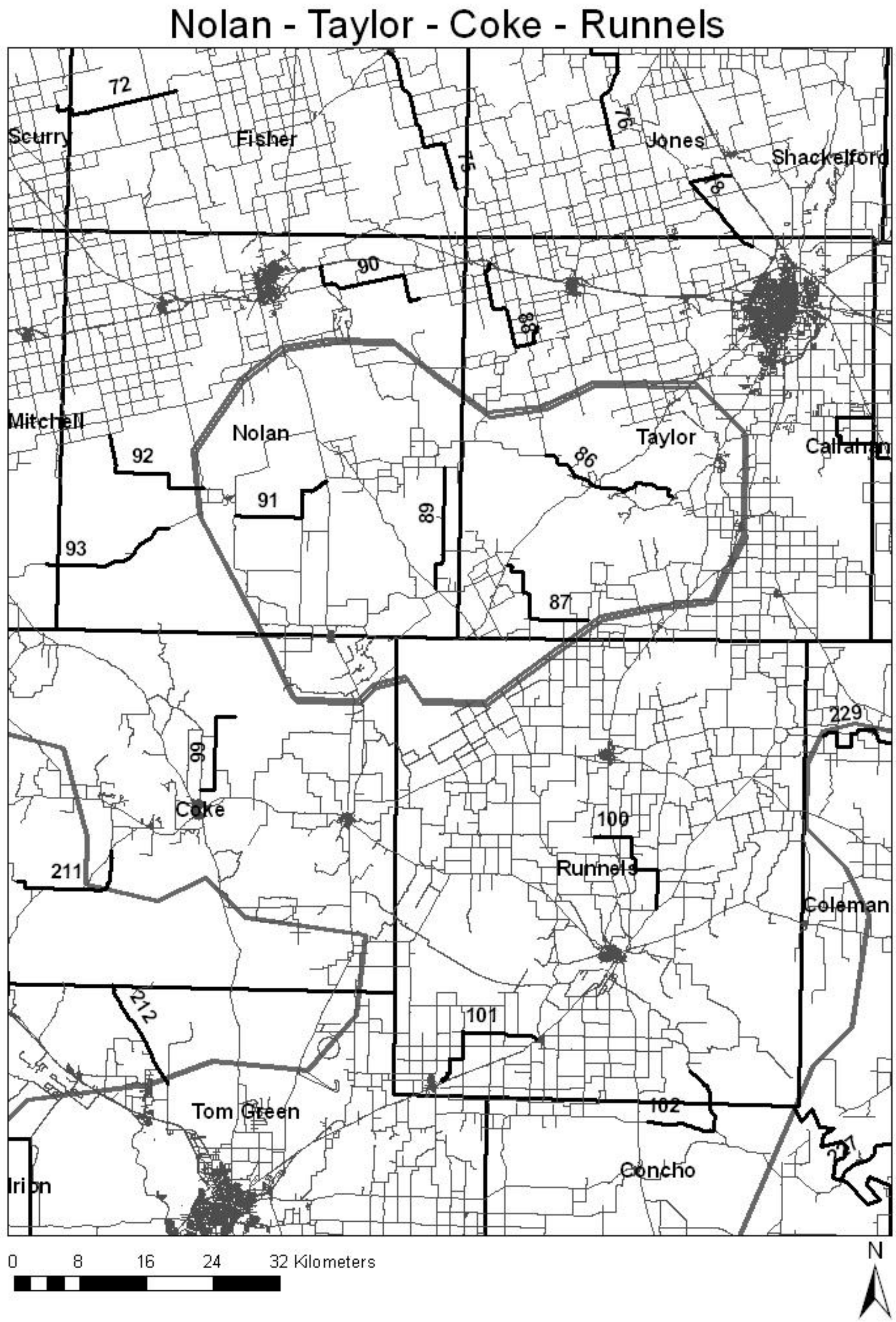

Garza - Kent - Borden - Scurry
Lubbock
Crosby
Dickens
King
Lynn
Garza
Kent
Stonewall
Borden
Scurry
Fisher
Howard
Mitchell
Nolan
40
41
44
45
46
47
48
49
50
63
64
65
66
67
68
69
70
71
72
73
94
95
96
0 8 16 24 32 Kilometers
N

Stonewall - Haskell - Fisher - Jones

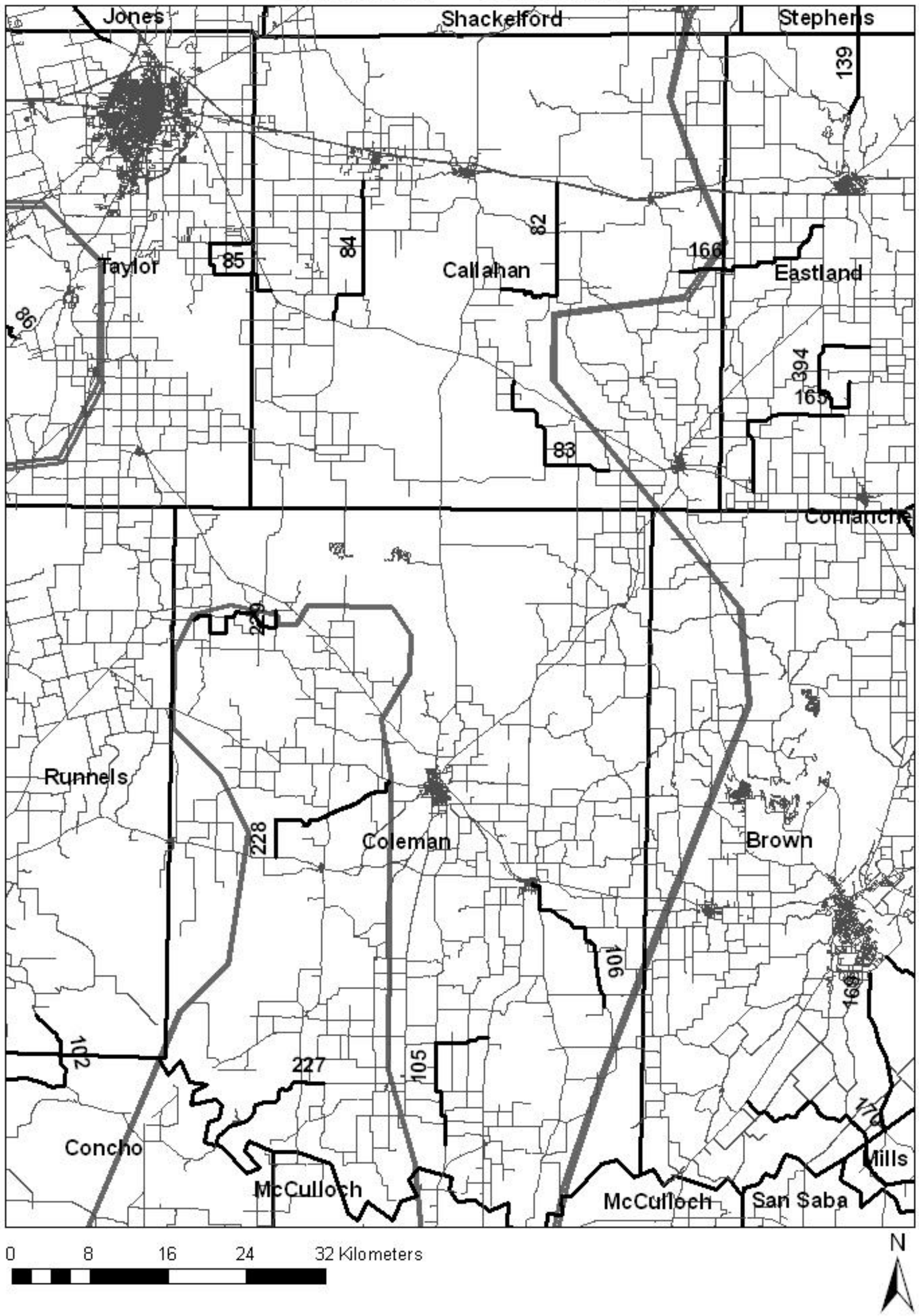


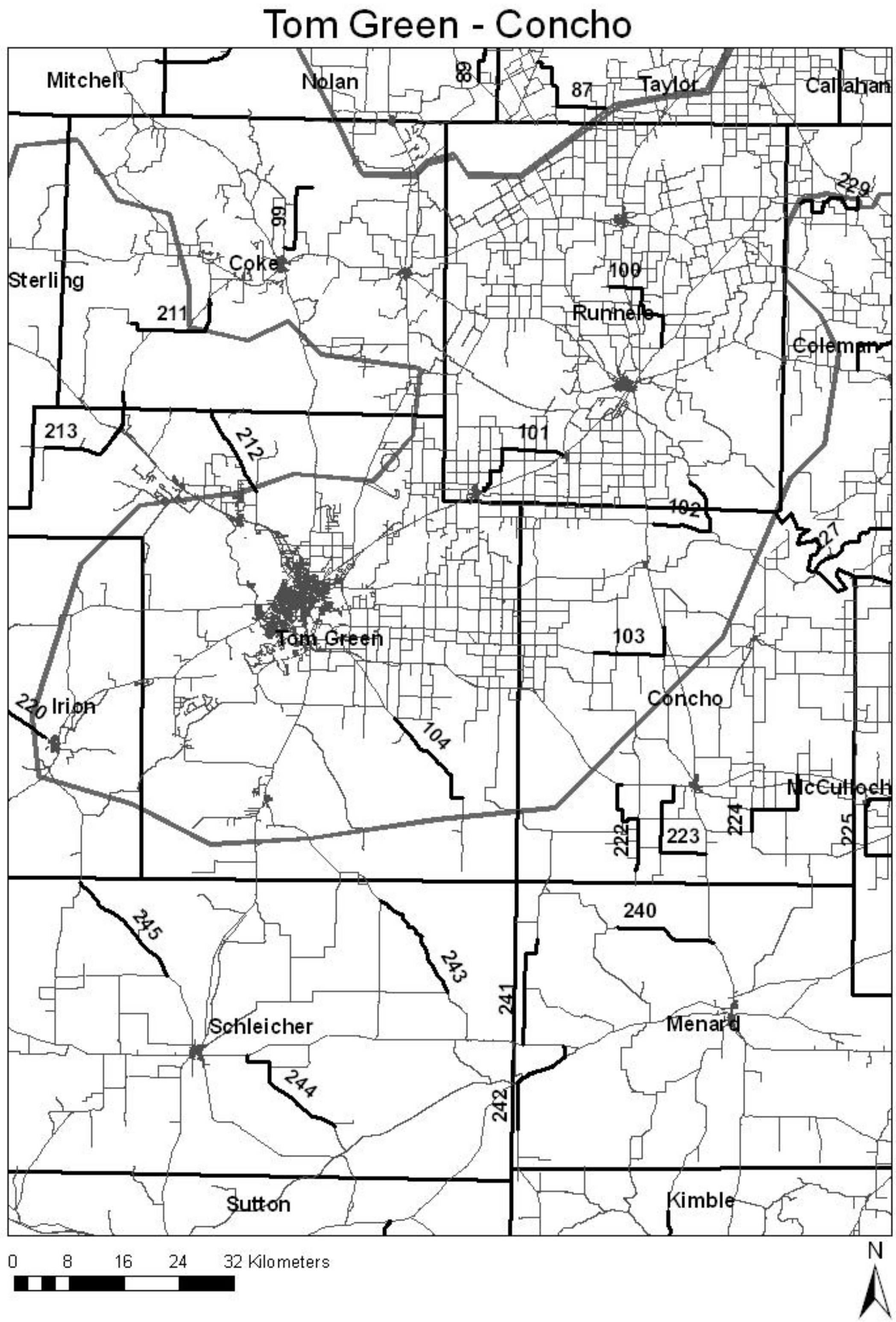

Throckmorton - Shackelford
Knox
Baylor
Archer
61
60
58
Haskell
Throckmorton
Young
62
79
80
Jones
Shackelford
81
Stephens
139
Taylor
Callahan
Eastland
0
8
16
24
32 Kilometers
N


Howard - Mitchell
66
67
Borden
Scurry
69
95
94
Howard
96
Mitchell
97
98
206
Nolan
Glasscock
Sterling
Coke
0
8
16
24
32 Kilometers
N


Nolan - Taylor - Coke - Runnels
72
Scurry
Fisher
76
Jones
Shackelford
75
78
90
88
Mitchell
Nolan
Taylor
Callahan
92
86
91
89
93
87
229
99
Coke
100
211
Runnels
Coleman
212
101
Tom Green
102
Irion
Concho
0 8 16 24 32 Kilometers
N

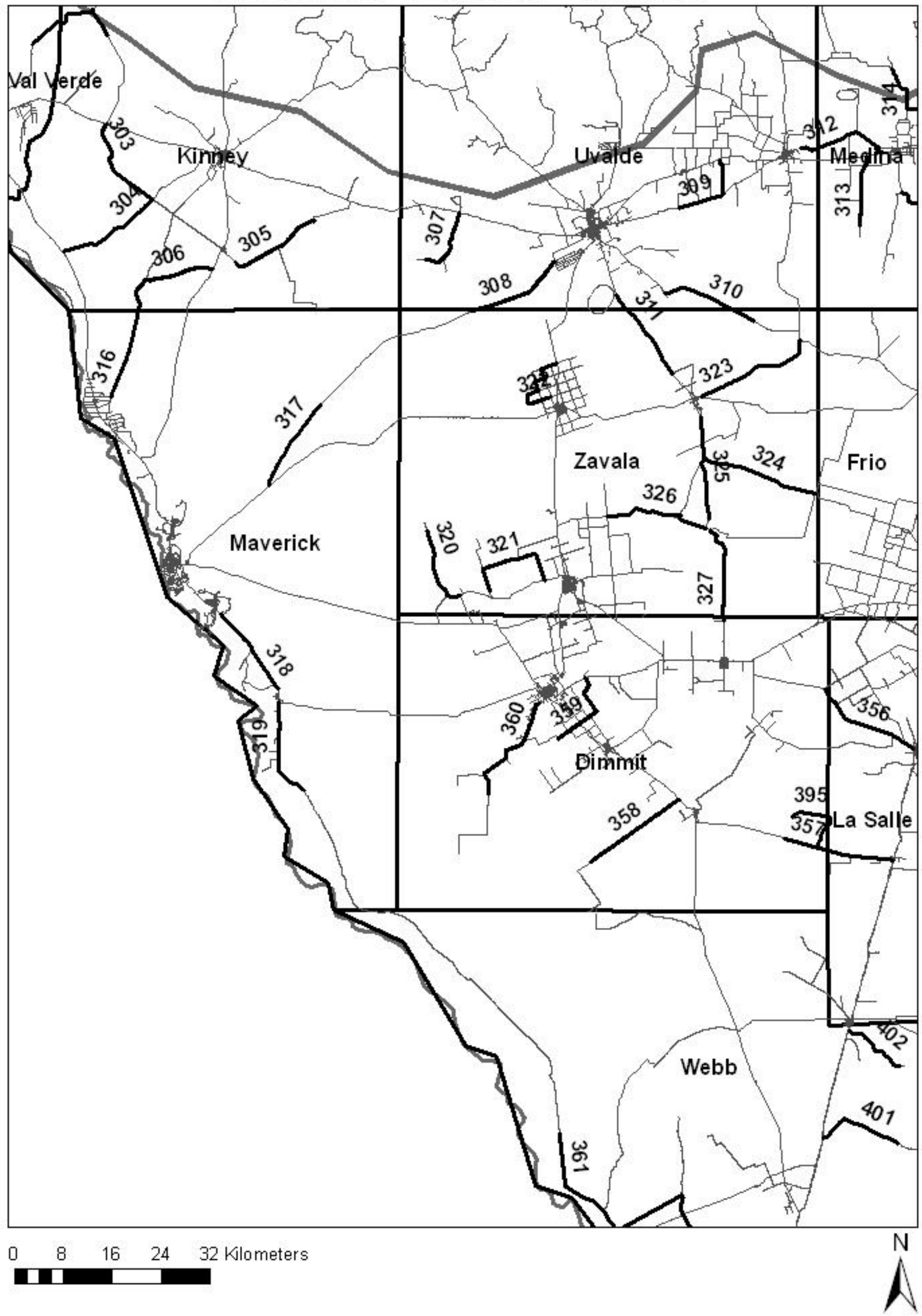
Callahan - Coleman

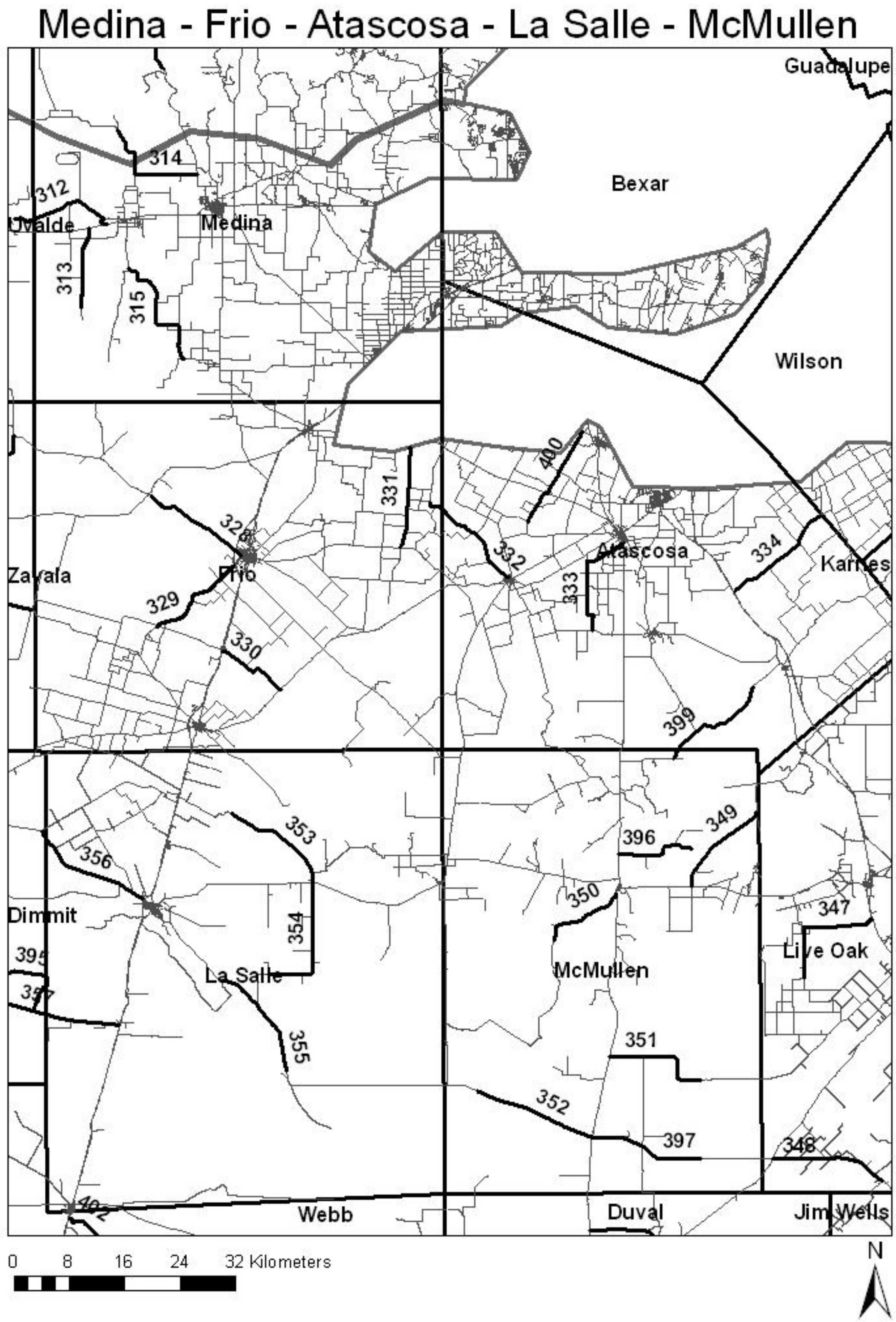



Tom Green - Concho
Mitchell
Nolan
Taylor
Callahan
87
89
99
229
Coke
Sterling
211
100
Runnels
Coleman
213
212
101
102
27
Tom Green
103
220
Irion
Concho
104
McCulloch
222
223
224
225
245
240
243
241
Schleicher
Menard
244
242
Sutton
Kimble
0 8 16 24 32 Kilometers
N

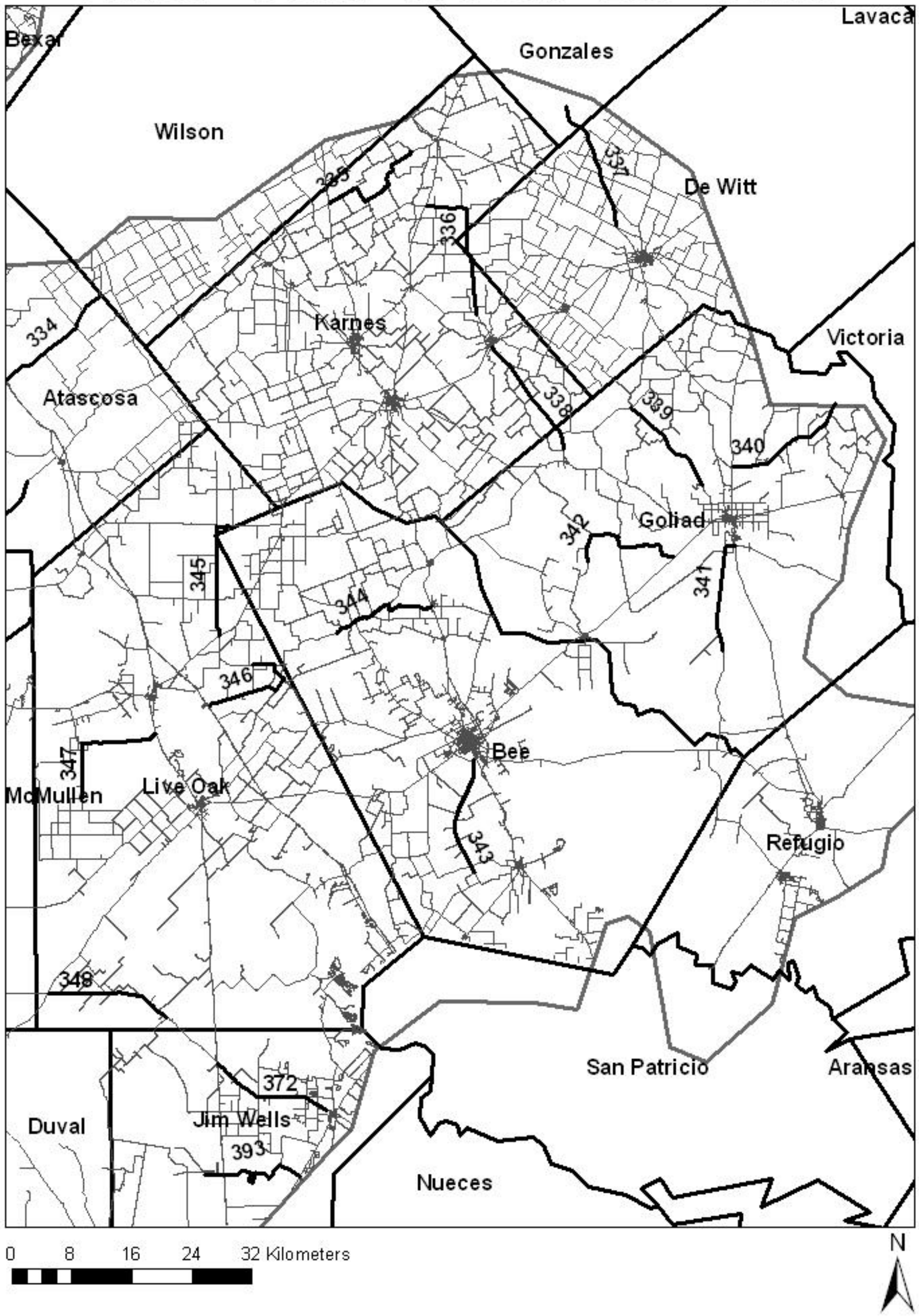

South Texas
Sutton
Kimble
Gillespie
Blanco
Travis
Williamson
Lee
Edwards
Kerr
Hays
Bastrop
Real
Kendall
Comal
Caldwell
Fayette
Val Verde
Bandera
Colorado
Guadalupe
Gonzales
Lavaca
Bexar
Kinney
Uvalde
Medina
Wilson
De Witt
Maverick
Zavala
Frio
Atascosa
Karnes
Victoria
Goliad
Calhoun
Dimmit
La Salle
McMullen
Live Oak
Bee
Refugio
Aransas
San Patricio
Webb
Duval
Jim Wells
Nueces
Kleberg
Zapata
Jim Hogg
Brooks
Kenedy
Starr
Hidalgo
Willacy
Cameron
0 20 40 60 80 Kilometers
N

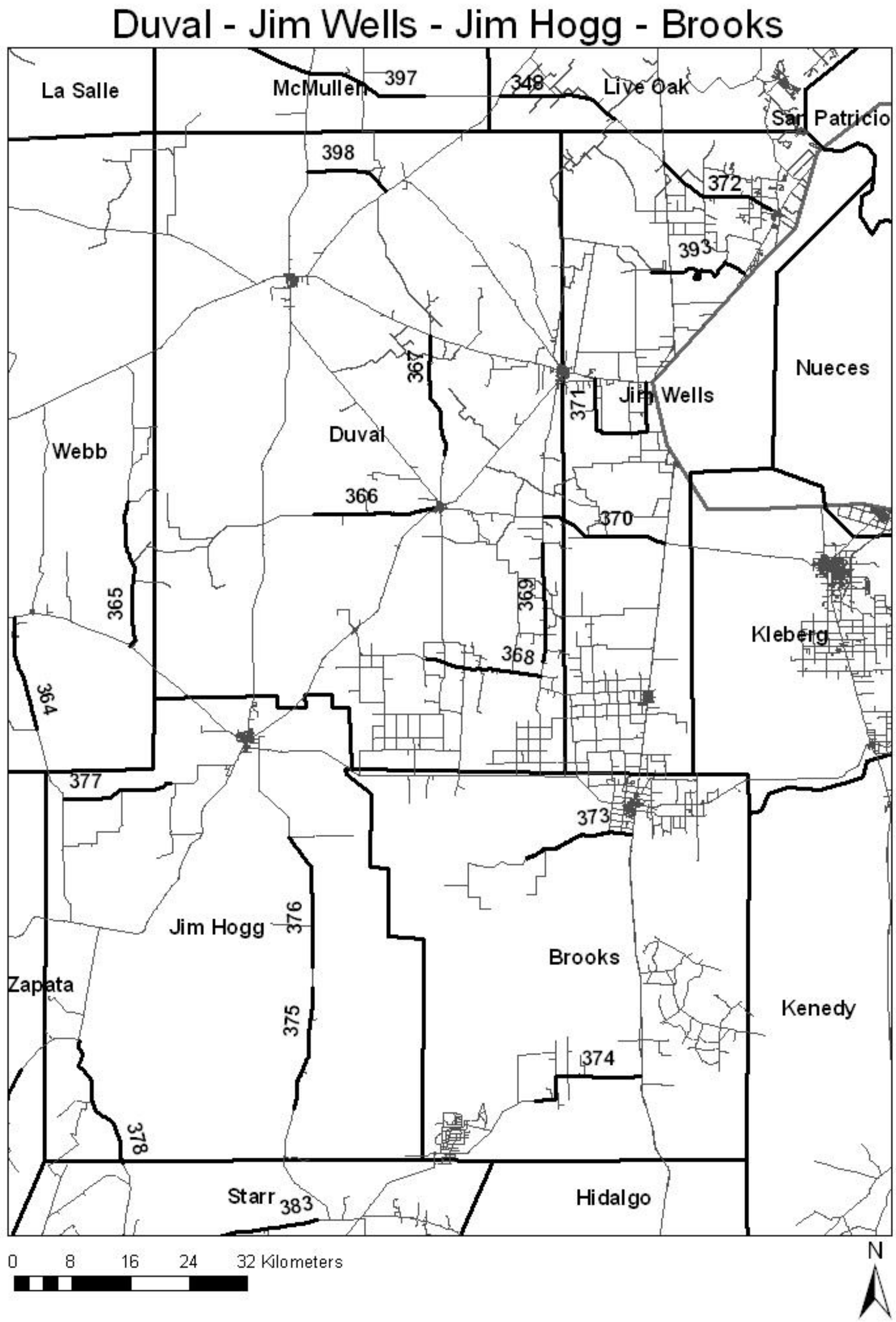
Maverick - Zavala - Dimmit

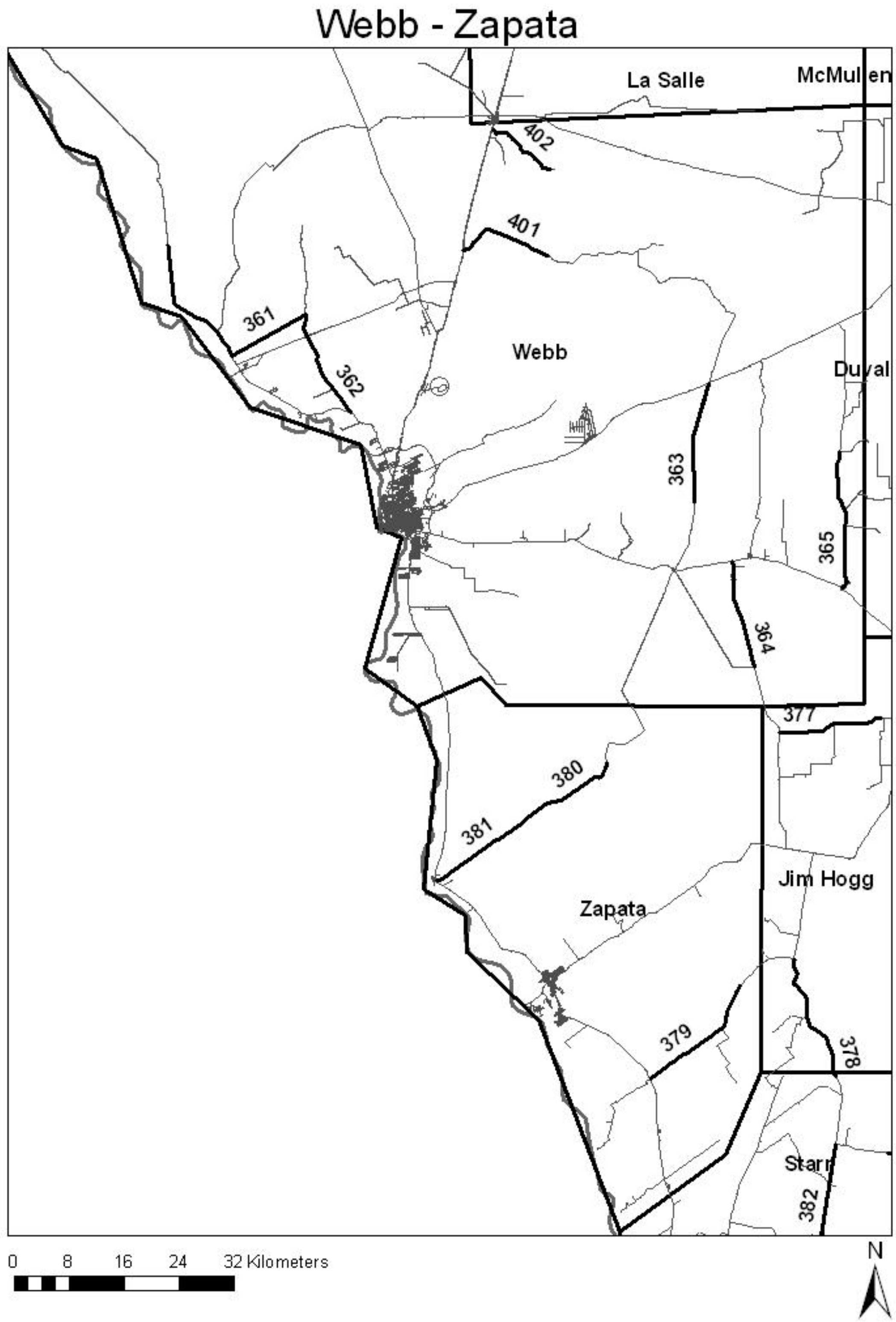


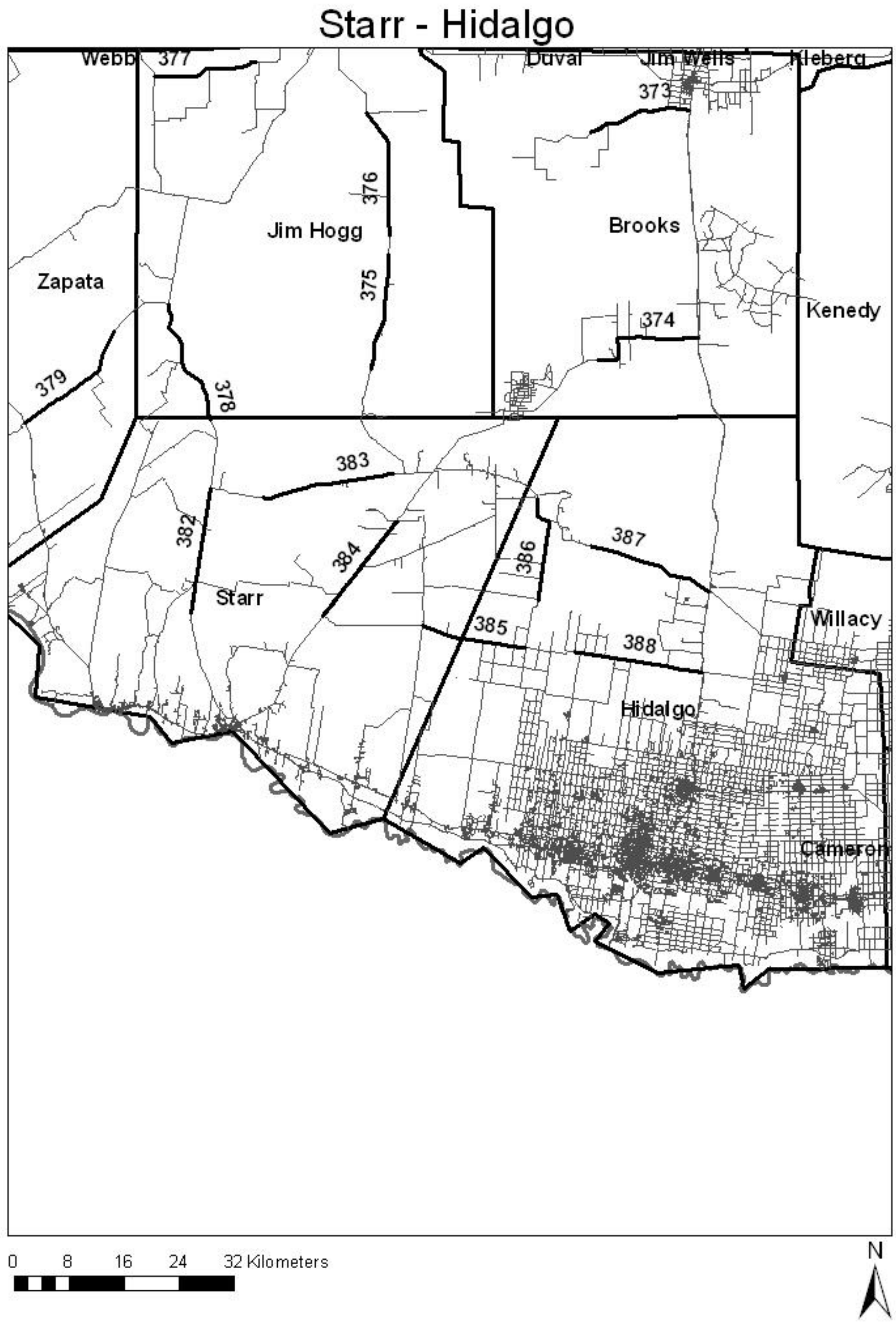

Medina - Frio - Atascosa - La Salle - McMullen
Guadalupe
Bexar
Wilson
Medina
Uvalde
Frio
Zavala
Atascosa
Karnes
Dimmit
La Salle
McMullen
Live Oak
Webb
Duval
Jim Wells
312
313
314
315
328
329
330
331
332
333
334
347
348
349
350
351
352
353
354
355
356
396
397
399
400
402
0 8 16 24 32 Kilometers
N

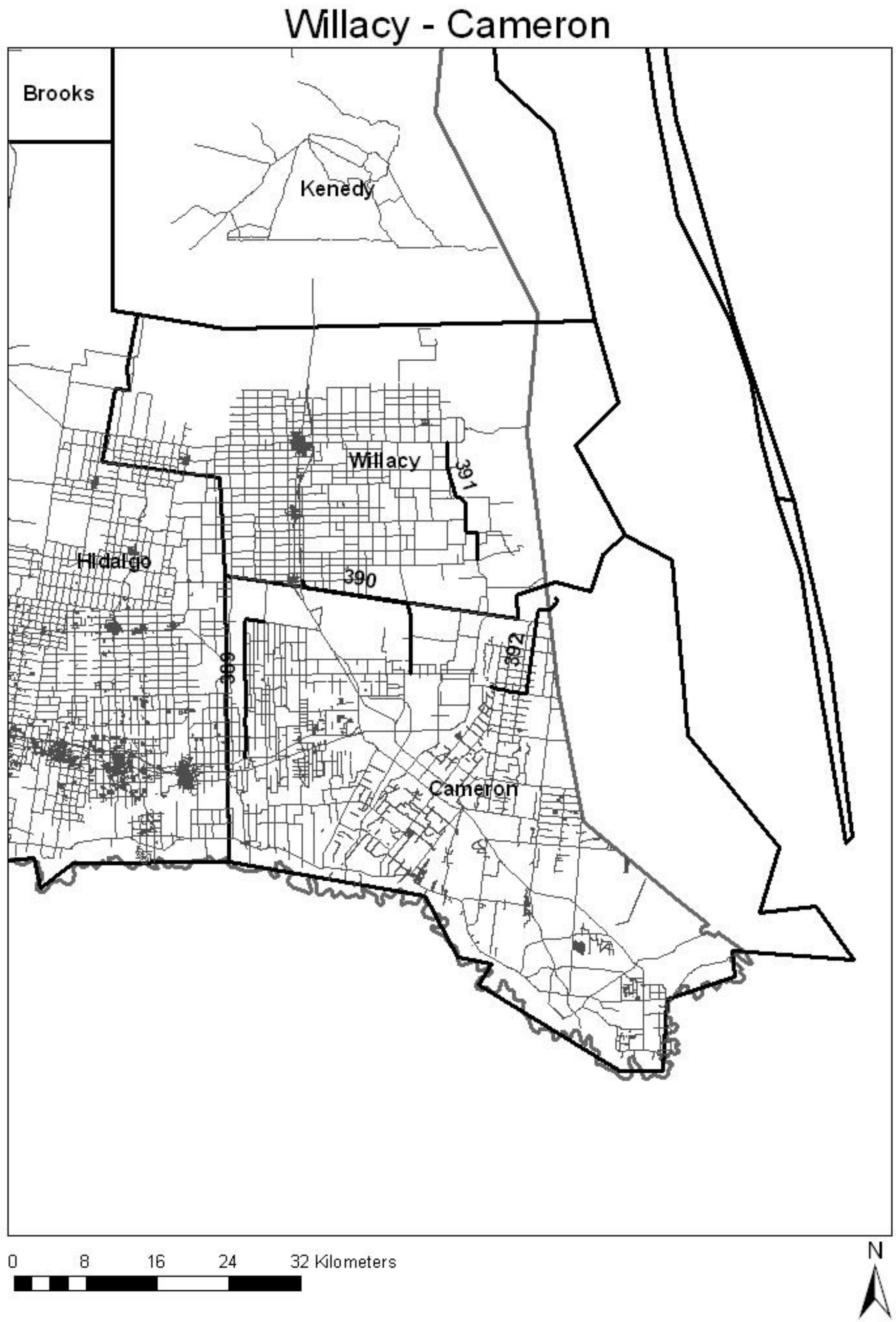
Karnes - Dewitt - Live Oak - Bee - Goliad




Duval - Jim Wells - Jim Hogg - Brooks
La Salle
McMullen
397
348
Live Oak
San Patricio
398
372
393
Nueces
367
371
Jim Wells
Duval
Webb
366
370
365
369
Kleberg
368
364
377
373
376
Jim Hogg
Brooks
Zapata
Kenedy
375
374
378
Starr
383
Hidalgo
0 8 16 24 32 Kilometers
N


Webb - Zapata
La Salle
McMullen
402
401
361
362
Webb
Duval
363
365
364
377
380
381
Jim Hogg
Zapata
379
378
Starr
382
0 8 16 24 32 Kilometers
N


Starr - Hidalgo
Webb
377
Duval
Jim Wells
Kleberg
373
376
Jim Hogg
Brooks
Zapata
375
374
Kenedy
379
378
383
387
382
384
386
Starr
Willacy
385
388
Hidalgo
Cameron
0 8 16 24 32 Kilometers
N


Willacy - Cameron
Brooks
Kenedy
Willacy
391
Hidalgo
390
389
392
Cameron
0 8 16 24 32 Kilometers
N

Transect Descriptions

While establishing our survey transects, we recorded driving directions and transect descriptions for each transect. When road names were marked, we included them in transect descriptions. Where road names were not marked, we used the most visible landmarks to describe transects. The majority of transects started and ended at road intersections or clearly visible landmarks. To aid observers in locating transects, we recorded transect endpoints in UTM coordinates. We provided a list of transect descriptions and endpoints organized by transect number.

Rolling Plains

1. Start at Fairmont Baptist Church on FM1065
   Follow FM1065 north to FM689
   Follow FM689 west to top of caprock escarpment
   Endpoint1: 310319 3792169
   Endpoint2: 300182 3794984

2. Start at FM599 and CR146 intersection
   Follow FM599 north to CR152
   Follow CR152 east to Hwy 70
   Endpoint1: 316750 3791907
   Endpoint2: 325744 3795331

3. Start at intersection of FM97 and CR110
   Follow FM97 to CR125
   Follow CR125 to CR142
   Follow CR142 to intersection
   Turn west at intersection and follow road to FM1065, stop
   Endpoint1: 305708 3784973
   Endpoint2: 310298 3791363

4. Start at FM2999 and Hwy 70
   Follow FM2999 west to end of pavement
   FM2999 becomes CR112
   Follow CR112 west to Overstreet Ranch sign
   Endpoint1: 309821 3771315
   Endpoint2: 325661 3773867

5. Start at gate to the Lucky Knob Camp of Matador Ranch
   Follow FM94 northeast to intersection with CR240, stop
   Endpoint1: 342830 3779245
   Endpoint2: 351670 3789693

6. Start at red gate along FM684 (315477, 3753379)
   Follow FM684 east to CR316
   Follow CR316 south to FM3203, stop
   Endpoint1: 315476 3753383
   Endpoint2: 327576 3750846

7. Start at red gate along curve in road on CR408 (353177, 3747801)
   Follow CR408 to gate of Russellville Camp (341854, 3753236)
   Endpoint1: 353179 3747800
   Endpoint2: 341851 3753232

8. Start at cattle guard with green gate (372941, 3774777) on main Matador WMA road
   Follow main road to old wood/wire gate
   Endpoint1: 372945 3774777
   Endpoint2: 361289 3779956

9. Start at Hwy 62 and CR221, follow CR221 south to FM1023
   Follow FM1023 south to dirt road CR230
   Continue on CR231 to FM2278, follow FM2278 to FM452, stop
   Endpoint1: 370899 3761592
   Endpoint2: 370555 3749310

10. Start at Hwy 70 and CR408
    Follow CR408 to CR411, turn south on to CR411
    Follow CR411 south, CR411 becomes CR425
    Follow CR425 to FM1038
    Follow FM1038 to FM1278, stop
    Endpoint1: 383188 3766182
    Endpoint2: 387467 3755344

11. Start at FM3102 and FM1038, Follow FM3102 to FM1278
    Turn south onto FM1278, Follow FM1278 to CR457, stop
    Endpoint1: 393904 3755218
    Endpoint2: 384088 3749580

12. Start at CR327 and FM104
    Follow CR327 to intersection, turn east on CR331
    Follow CR331 to FM2532, turn east on FM2532
    Follow FM2532 to CR347, turn north on CR347, then turn east on CR346
    Follow CR346 to intersection
    Endpoint1: 394203 3779204
    Endpoint2: 405076 3773928

13. Start at FM268 South and Hwy 287
    Turn left at Rogers Rd.
    Turn right at Wrinkle Rd., go left at “T”
    Turn right at FM road
    Stop at FM 104
    Endpoint1: 410805 3802141
    Endpoint2: 418896 3794447

14. Start at Pickrell Rd. and FM680
    Stop at King Rd.
    Endpoint1: 417556 3804231
    Endpoint2: 413435 3818668

15. Start at FM2006 and Hwy 287
    Stop at Love Rd.
    Endpoint1: 443806 3791775
    Endpoint2: 449073 3800152

16. Start at Coburn Rd. and FM1167
    Stop at Hwy 287
    Endpoint1: 448641 3778844
    Endpoint2: 468223 3783332

17. Start at CR97 and FM925
    Stop at CR106
    Endpoint1: 470096 3783100
    Endpoint2: 465879 3796020

18. Start at FM2073 and Hwy 70
    Turn left on FM2074
    Stop at FM2585
    Endpoint1: 468654 3776764
    Endpoint2: 469209 3769426

19. Start at Hwy183 and FM370
    Go right on FM1763
    Stop at Hwy 287
    Endpoint1: 489123 3777675
    Endpoint2: 497123 3771263

20. Start at FM262 and Hwy 70
    Go right at FM98
    Stop at Hwy 70
    Endpoint1: 450292 3760626
    Endpoint2: 457918 3768534

21. Start at FM2003 and Hwy 6
    Continue on dirt road
    Stop at first road on left
    Endpoint1: 431529 3755774
    Endpoint2: 417101 3752644

22. Start at FM1594 and Hwy 6
    Go left at FM267
    Stop at CR146
    Endpoint1: 430513 3753412
    Endpoint2: 443485 3757164

23. Start at Hwy 25 and FM1180
    Stop at FM2846
    Endpoint1: 514884 3745831
    Endpoint2: 509666 3742323

24. Start at Lazy J Road and Hwy 25
    Left at FM367
    Stop at FM2384
    Endpoint1: 508931 3758410
    Endpoint2: 516841 3752387

25. Start at FM1206 and Hwy 258
    Right at FM368
    Stop at Hwy 258
    Endpoint1: 517734 3746428
    Endpoint2: 527096 3746247

26. Start at FM369 and FM367
    Stop at Burkburnet city limit sign
    Endpoint1: 536687 3753475
    Endpoint2: 537114 3769946

27. Start at FM368 and FM1954
    Stop at Hwy 25
    Endpoint1: 528864 3739468
    Endpoint2: 523647 3727479

28. Start at Davis Rd. and Hwy 79
    Left on Kinder Rd.
    Stop at FM172
    Endpoint1: 535326 3722050
    Endpoint2: 546251 3719007

29. Start at FM2178 and FM210
    Right on Wolf Rd.
    Stop at FM Rd.
    Endpoint1: 526541 3716741
    Endpoint2: 513391 3710186

30. Start at Cowan Camp Rd. and FM422
    Stop at N. Baskin St.
    Endpoint1: 492427 3717005
    Endpoint2: 476972 3716979

31. Start at FM2395 and Hwy 277
    Right at FM1152
    Stop at Hwy 277
    Endpoint1: 471554 3712812
    Endpoint2: 468557 3711443

32. Start at FM2069 and FM1919
    Stop at Hwy 82/114
    Endpoint1: 475657 3722391
    Endpoint2: 461798 3719405

33. Start at FM1919 and FM2582
    Stop at Self Rd.
    Endpoint1: 475658 3723746
    Endpoint2: 460950 3731631

34. Start at CR3590 and FM267
    Stop at Hwy 82
    Endpoint1: 438269 3732563
    Endpoint2: 447489 3721702

35. Start at CR2400 at "T"
    Continue on FM1756
    Stop at FM267
    Endpoint1: 422445 3733664
    Endpoint2: 438244 3732564

36. Start at FM2534 and FM267
    Right at FM266
    Stop at CR4389
    Endpoint1: 439155 3709722
    Endpoint2: 451295 3704986

37. Start at FM2534 and Hwy 6
    Stop at FM267
    Endpoint1: 425175 3705593
    Endpoint2: 439167 3709723

38. Start at CR448 and Hwy 83
    Follow CR448 to CR415, stop
    Endpoint1: 381514 3702433
    Endpoint2: 366395 3705928

39. Start at Hwy 62 and FM193
    Follow FM193 to FM2569, stop
    Endpoint1: 375967 3738667
    Endpoint2: 359667 3742104

40. Start at CR371 and Hwy 82
    Follow CR371 south to "Y" in road
    Endpoint1: 354366 3720071
    Endpoint2: 354212 3708035

41. Start at CR138 and CR136, follow CR138 north into Dickens Co.
    CR138 becomes CR345
    Follow CR345 to Hwy 70, continue north on CR345 to CR386
    Follow CR386 east to gate/cattle guard, stop
    Endpoint1: 343982 3704959
    Endpoint2: 337039 3695355

42. Start at CR242 and FM265
    Follow CR242 west to road intersection
    Continue north on CR242 to intersection at old wood bridge (CR228)
    Continue west on CR228 to FM265
    North on FM265 to FM193, stop
    Endpoint1: 337365 3728419
    Endpoint2: 338566 3735600
    *Transect is very sandy, use caution

43. Start at CR243 and FM193
    Follow CR243 north to intersection, turn west
    Follow road to CR241, turn north on CR241
    Follow CR241 to CR210, turn west
    Follow CR210 across Hwy 70, CR210 becomes CR110
    Follow CR110 to CR121, stop
    Endpoint1: 336174 3736845
    Endpoint2: 323428 3741081

44. Start at FM651 and CR236
    Follow CR236 to CR217, follow CR217 to CR232
    Follow CR232 to CR221, follow CR221 to CR236
    Follow CR236 to CR225, follow CR225 to FM261
    Follow FM261 east to CR395 (just past White River bridge)
    Endpoint1: 295363 3700186
    Endpoint2: 309322 3698319

45. Start at FM2008 and FM651
    Follow FM651 to CR217, stop
    Endpoint1: 293745 3694159
    Endpoint2: 282736 3681839

46. Start at CR186 and FM2008, follow CR186 east to CR345
    Follow CR345 south to Hwy 380, stop
    Endpoint1: 295517 3684077
    Endpoint2: 300277 3676145

47. Start at FM1081 and Hwy 380, follow FM1081 north to CR222
    Follow CR222 back to FM1081, follow FM1081 north to FM2320
    Follow FM2320 to Hwy sign (FM2320 #356)
    Endpoint1: 321447 3671084
    Endpoint2: 326765 3682514

48. Start at CR112 and FM2320, follow CR112 to FM1228
    Follow FM1228 north to CR116, follow CR116 to Goodall Ave. (CR116)
    Follow Goodall Ave. to FM643, cross FM643 to CR118
    Follow CR118 north to CR179, follow CR179 west to CR138, stop
    Endpoint1: 340241 3682419
    Endpoint2: 337021 3693724

49. Start at CR160 and Hwy 70, follow CR160 into Stonewall Co.
    Stop at intersection with private road (Patterson Ranch)
    Endpoint1: 351475 3684031
    Endpoint2: 363898 3690325

50. Start at CR433 and CR423, follow CR423 west into Kent Co. to CR438
    Follow CR438 south to gate of Don Harris
    Endpoint1: 366053 3666496
    Endpoint2: 357033 3658399

51. Start at FM610 and CR410, follow CR410 west to CR434
    Follow CR434 to gate at 366787, 3664006, stop
    Endpoint1: 380707 3663632
    Endpoint2: 366791 3664005

52. Start at Hwy 83 and CR476, follow CR476 west to CR412
    Turn west on CR412, follow CR412 to FM610, stop
    Endpoint1: 388190 3656583
    Endpoint2: 376363 3660474

53. Start at FM1646 and CR328, follow CR328 to CR324
    Follow CR324 to Hwy 380, stop
    Endpoint1: 377234 3683410
    Endpoint2: 370429 3675635

54. Start at Hwy 83 and FM1263, follow FM1263 to CR214
    Follow CR214 to Hwy 83, stop
    Endpoint1: 385323 3691118
    Endpoint2: 383761 3681464

55. Start at FM1835 and CR235, follow CR235 to CR233, stop
    Endpoint1: 398809 3678088
    Endpoint2: 402882 3690675

56. Start at FM617 and CR165
    Stop at CR174
    Endpoint1: 424911 3686891
    Endpoint2: 410774 3683002

57. Start at Hwy 277 and FM617
    Left at FM2163
    Stop at CR118
    Endpoint1: 436989 3687874
    Endpoint2: 428298 3679526

58. Start at Hwy 380 and CR265
    Right at CR266
    Right at “T” (go south)
    Stop at Hwy 380
    Endpoint1: 447386 3671038
    Endpoint2: 450335 3671229

59. Start at Paint Creek Rd. and Hwy 277
    Go right at FM618
    Stop at Nanny Rd.
    Endpoint1: 425274 3648776
    Endpoint2: 435007 3655266

60. Start at CR420 and Hwy 283
    Right at FM2356
    Stop at Hwy 79
    Endpoint1: 481466 3685441
    Endpoint2: 489580 3676106

61. Start at CR440 and FM1711 (end of FM1711)
Stop at Hwy 380
Endpoint1: 501078 3686303
Endpoint2: 496061 3671923

62. Start at Hwy 380 and FM578
Turn right at "T"
Stop at FM209
Endpoint1: 510081 3671547
Endpoint2: 508364 3652950

63. Start at FM669 and rock gate (275213, 3662115)
Follow FM669 south to J. Dennis Rd., stop
Endpoint1: 275212 3662115
Endpoint2: 271876 3647801

64. Start at FM1269 and CR2202, follow CR2202 west into Borden Co.
CR2202 becomes Hughes Rd. in Borden Co.
Follow Hughes Rd. west then north to Four Mile Rd.
Follow Four Mile Rd. west to FM612
Follow FM612 north to FM2350, stop
Endpoint1: 298656 3634646
Endpoint2: 285932 3639889

65. Start at CR224 and FM1054, follow FM1054 south to Muleshoe Rd.
Follow Muleshoe Rd. to CR257, stop
Endpoint1: 255050 3617064
Endpoint2: 263294 3622243

66. Start at CR257 and FM669, follow FM669 south to pull off (268070, 3609283)
Stop
Endpoint1: 267956 3623556
Endpoint2: 268069 3609278

67. Start at FM1785 and FM1205, follow FM1205 to FM1610
Stop
Endpoint1: 284988 3604525
Endpoint2: 291672 3613952

68. Start at CR264 and FM1611, follow CR264 west to CR254
Follow CR254 west to road intersection (304140, 3626331)
Endpoint1: 316274 3627390
Endpoint2: 304139 3626327

69. Start at CR3138 and FM2835, follow CR3138 west to CR397
    Follow CR397 north across Hwy 350 (becomes CR395)
    Follow CR395 north to CR3116, follow CR3116 west to CR3105
    Follow CR3105 north to CR3104, stop
    Endpoint1: 315158 3603317
    Endpoint2: 310821 3614909

70. Start at CR1105 and CR1116, follow C1116 west to CR127
    Follow CR127 south to CR126, stop
    Endpoint1: 331608 3633349
    Endpoint2: 323453 3624913

71. Start at CR349 and CR357, follow CR349 west into Scurry Co.
    CR349 becomes CR1274 in Scurry Co.
    Follow CR1274 to CR1105, follow CR1105
    Stop at cattle guard (337470, 3636347)
    Endpoint1: 347012 3641887
    Endpoint2: 337470 3636342

72. Start at CR4114 and CR4151, follow CR4151 south into Fisher Co.
    Road becomes CR442 in Fisher Co.
    Follow CR442 east across FM611 to 356951, 3616382
    Endpoint1: 342509 3614718
    Endpoint2: 356954 3616381

73. Start at CR303 and CR309, follow CR309 north to CR320
    Follow CR320 west to FM611, stop
    Endpoint1: 365450 3629615
    Endpoint2: 350927 3628155

74. Start at CR212 and Hwy 70
    Turn right at FM1224
    Stop at CR216
    Endpoint1: 367727 3631882
    Endpoint2: 377925 3626203

75. Start at FM1085 and FM57
    Continue on FM1085
    Stop at CR166
    Endpoint1: 382462 3621061
    Endpoint2: 390633 3604573

76. Start at FM3116 and FM1812
    Go left at FM2746
    Go right at CR439
    Stop at blue gate on left
    Endpoint1: 409563 3609417
    Endpoint2: 406876 3622506

77. Start at Hwy 277 and FM2834
    Left at FM1661
    Stop at Hwy 92
    Endpoint1: 423740 3645295
    Endpoint2: 410987 3643205

78. Start at Hwy 277 and FM605
    Left at FM2404
    Stop at CR660
    Endpoint1: 423847 3606225
    Endpoint2: 426437 3597596

79. Start at CR164 and FM142
    Continue on CR164 until "T"
    Go left at "T" then follow to FM142
    Continue on FM142, stop at Jones co. line
    Endpoint1: 443536 3632079
    Endpoint2: 442783 3643781

80. Start at FM2482 and Hwy 283
    Left at CR112
    Stop at CR113
    Endpoint1: 474955 3628895
    Endpoint2: 485021 3629869

81. Start at FM601 and Hwy 6
    Continue on FM601, stop at CR103
    Endpoint1: 474133 3619280
    Endpoint2: 488723 3616140

82. Start at I-20 and FM2228
    Follow CR461
    Right at DLB sign
    Continue on CR
    Stop at CR462
    Endpoint1: 471913 3583196
    Endpoint2: 466156 3572271

83. Start at FM2287 and Hwy 36
    Stop at CR445
    Endpoint1: 467540 3563044
    Endpoint2: 477298 3553851

84. Start at Hwy 36 and FM604
    Stop at FM2700
    Endpoint1: 449257 3569197
    Endpoint2: 452219 3583398

85. Start at FM1750 and Hwy 36
    Left at CR118
    Stop at Hwy 36
    Endpoint1: 440747 3577042
    Endpoint2: 442887 3572167

86. Start at CR351 and FM89
    Continue past Hwy 277
    Go left at CR279
    Go left at CR280
    Stop at intersection with FM89
    Endpoint1: 401414 3572363
    Endpoint2: 416758 3567327

87. Start at FM277 and CR216
    Left on FM1086
    Stop at CR186
    Endpoint1: 396747 3559144
    Endpoint2: 406553 3552576

88. Start at I-20 and FM1085
    Left at FM126
    Stop at CR389
    Endpoint1: 394750 3595632
    Endpoint2: 400519 3588059

89. Start at intersection of Hwy 153 and CR196
    Follow CR196 north
    Stop at intersection of CR196 and CR197
    Endpoint1: 388154 3556320
    Endpoint2: 389245 3570991

90. Start at FM1856 and I-20
    Left at CR220
    Right at paved CR
    Stop at mailbox 501
    Endpoint1: 374372 3595253
    Endpoint2: 386261 3591297

91. Start at intersection of Hwy 70 and CR180
    Follow CR180 west
    At intersection of CR180 and CR181, follow CR181 west
    Stop at intersection of CR181 and FM1170
    Endpoint1: 374991 3569263
    Endpoint2: 363972 3565099

92. Start at CR133 and FM608
    Follow CR133 to FM1230
    Stop
    Endpoint1: 360212 3568392
    Endpoint2: 348847 3575004

93. Start at Walnut Creek Ranch sign on CR345
    Follow CR345 east into Nolan Co.
    CR345 becomes CR273 in Nolan Co.
    Follow CR273 east to Double M Ranch sign, stop
    Endpoint1: 341184 3559256
    Endpoint2: 355976 3563630

94. Start at CR412 and FM1899, follow CR412 north to CR456
    Follow CR456 west to CR153, follow CR153 south to CR145
    Follow CR145 west to Hwy 208, stop
    Endpoint1: 333933 3591813
    Endpoint2: 325399 3591765

95. Start at CR226 and FM1229, follow CR226 into Howard Co.
    Stop at Hwy 350 and CR48 (CR226 is CR48 in Howard Co.)
    Endpoint1: 309177 3595538
    Endpoint2: 292307 3595943

96. Start at green gate to oil pad on CR371
    Follow CR371 east, CR371 becomes CR262
    Follow CR262 to CR264, stop
    Endpoint1: 295784 3572056
    Endpoint2: 312440 3576010

97. Start at FM821 and Snyder Field Rd.
    Follow FM821 south to 2nd cattle guard
    Stop
    Endpoint1: 291136 3568422
    Endpoint2: 285167 3554813

98. Start at Mitchell co. line on FM2183
    Follow FM2183 east to Hwy 163, stop
    Endpoint1: 294233 3558043
    Endpoint2: 309915 3561193

99. Start at Graham Valley Rd. and Sanco Rd.
    Right at Graham Valley Rd.
    Stop at end of road
    Endpoint1: 359809 3532077
    Endpoint2: 364004 3540820

100. Start at FM2647 and FM382
     Left on CR344
     Left at "T" CR209
     Cross over Hwy 83
     Stop at CR338
     Endpoint1: 414830 3517730
     Endpoint2: 407203 3526403

101. Start at Hwy 67 and FM2872
     Left on CR357
     Right at CR391
     Left at "T"
     Stop at Hwy 67
     Endpoint1: 400351 3502016
     Endpoint2: 389034 3496814

102. Start at Fuzzy Creek Gate on left
     Left on CR4827
     Stop at silver gate on left (10 mi.)
     Endpoint1: 413647 3491953
     Endpoint2: 418881 3498209

103. Start at FM765 and FM2402
     Left at CR1115
     Stop at 10 mi.
     Endpoint1: 404982 3473158
     Endpoint2: 415169 3476942

104. Start at Hollik Rd. and FM1223
Stop at hard right turn (10 mi.)
Endpoint1: 376091 3463695
Endpoint2: 385865 3452057

105. Start at Hwy 283 and FM1026
Left on FM1026
Left on CR244
Stop at Casa Grande Game Ranch
Endpoint1: 464954 3495869
Endpoint2: 460520 3484897

106. Start at FM1176 and Willis Ave.
Stop at CR212
Endpoint1: 469481 3511650
Endpoint2: 476838 3499059

Cross Timbers

107. Start at CR171 and Valentine School Rd.
Go north on Valentine School Rd. to Bevering
Go west on Bevering to CR810, turn north on CR810, follow to Old T-Bone
Turn west on Old T-Bone Rd., continue until Thornberry, stop
Endpoint1: 556334 3773143
Endpoint2: 569473 3771477

108. Start at intersection of CR1740 and CR2393
Follow CR2393 south to West Gaines Rd.
Follow West Gaines Rd. east to Glascow
Take Glascow north to CR810, stop
Endpoint1: 557448 3765080
Endpoint2: 565162 3767965

109. Start at Sandrock Hill Rd. and Rocking R Rd.
Go east on Rocking R Rd.
Turn south on Parker, follow to Burrus Rd.
Go east on Burrus Rd. to CR171
Take CR171 south to CR2332, stop
Endpoint1: 575007 3768486
Endpoint2: 581905 3761018

110. Start at CR2332 and Riverland Rd.
Go south on Riverland to Prairie Flower Rd.
Take Prairie Flower Rd. west to Cueba Ln. (Cueba Ln. becomes CR3392)
Take CR3392 to Moser Rd., stop
Endpoint1: 584356 3760840
Endpoint2: 577878 3749274

111. Start at intersection of Hwy 287 and New London Rd.
Go south on New London Rd. until merge with Sanzenbacher Rd.
Go east on Sanzenbacher until CR148, stop
Endpoint1: 577223 3738823
Endpoint2: 574230 3726301

112. Start at Hwy 287 and Hopewell Rd., continue north then west into Clay Co.
At "T" turn left (north) and follow west to FM1288
Stop at intersection
Endpoint1: 597915 3718703
Endpoint2: 590890 3726748

113. Start at FM1280 and Heard Rd.
Follow FM1280 east to Rocksprings Rd.
Follow Rocksprings to State Hwy 175
Stop
Endpoint1: 604351 3728008
Endpoint2: 618045 3734521

114. Start at FM1759 and Morris Rd.
Continue on FM1759 until “Y” in road
Turn left on White Rd., continue until splits
Go left on Gray
Gray ends at FM2849, turn right and continue until FM103
Stop
Endpoint1: 614356 3741443
Endpoint2: 618135 3750891

115. Start at intersection S.E. part of transect (see map)
Continue on Dean
Turn left on Alamo
Cross over FM1758 and take Fisher (left turn)
Go to “T” and turn right on Lama Rd.
Road runs into FM3043
Continue until Jordan Rd., stop
Endpoint1: 622200 3711606
Endpoint2: 611734 3710099

116. Start at CR2745 and FM730
Continue north turn west on FM455
Go southwest on Rushcreek Rd., turn right on Foster
Continue and turn south on Valentine Bluff Rd.
Continue and turn right, go to New Harp loop
Go to FM1655, stop
Endpoint1: 640414 3698124
Endpoint2: 631785 3705690

117. Start at FM922 and FM2848
Continue straight on CR332
Left at “T” continue on CR374
Left at CR385
Left at CR382
Go right on FM51 north, go left on FM346 west
Go to CR333, stop
Endpoint1: 668140 3706761
Endpoint2: 655188 3705187

118. Start at FM922 and FM373, go right on FM337
Veer right on FM318 near county barn
Turn right on FM338, go thru stop sign, cross over FM road
When road comes to "T" go left on CR331
Go right at CR367, follow around left turn
Go to FM1630, stop
Endpoint1: 650258 3708483
Endpoint2: 660497 3717246

119. Start at intersection of CR462 and CR417 (Marysville Church)
Continue on CR434?
Go down CR434 until FM1200
Go right on FM1200 south to CR418, stop
Endpoint1: 654227 3737980
Endpoint2: 664580 3730287

120. Start at intersection of FM1201 and CR410
Veer right at CR437 wide road (north)
Go left on CR408
Continue along river, stop at CR408
Endpoint1: 663290 3742269
Endpoint2: 658088 3744328

121. Start on CR103, follow then turn left on CR104
Turn right on CR106, follow until CR127 and go left
Follow until CR110 and then turn right
Stop at white gate
Endpoint1: 678785 3741181
Endpoint2: 688606 3746070

122. Start at CR107 and CR176
Go to CR155, turn left
Continue to CR201 and go right
Turn right on West Line Rd.
Continue to County Line Church Rd., go left
Cross over Hwy 377 (becomes Hollingshead Rd.), go to "T" and turn left
Stop at Dawkins Rd.
Endpoint1: 688286 3725083
Endpoint2: 695395 3720430

123. Start at Jordan Creek Rd. at gray trailer house
Turn right at "T" on CR226
Turn right on CR217
Veer right, stay on CR217
Turn left (south) on CR203
Turn right back on CR217
CR217 becomes CR281
Turn right at CR265, go to FM3496, stop
Endpoint1: 692869 3714475
Endpoint2: 682697 3711200

124. Start at Riley Rd. and W. Pecan Rd
Continue north on Riley Rd, go west (turns into Dixie Rd.)
Continue and go west on Scarbrough Rd.
Follow Sandusky Rd. across Hwy 377
Follow Ranch Rd. to Brewster Rd.
Endpoint1: 696933 3729111
Endpoint2: 692922 3741630

125. Start at Hwy 51 North and CR2224
Go east at CR2320 until intersection with CR2510
Stop
Endpoint1: 634288 3680910
Endpoint2: 645018 3681820

126. Start at Wise Rd. and Parker Dairy Rd.
Continue (road becomes CR2675), then veer right
Take CR2675 left (southwest)
Go south on CR2475 until FS920
Stop
Endpoint1: 633500 3700736
Endpoint2: 629867 3686351

127. Start at CR1810 and County Line Rd.
Follow County Line Rd. into Wise Co. (becomes CR1736)
Follow to CR1744, continue on CR1744 to CR1745 (do not take Holiday Ranch Rd.)
Take CR1745 (Butch and Beverly Ranch Rd.) to CR1810
Turn right on CR1810, go to CR1750 (Edgery Rd.), stop
Endpoint1: 599904 3685784
Endpoint2: 605872 3686661

128. Start at intersection of Coca Cola Ranch Rd. and Sims Rd.
Take Coca Cola Ranch Rd. north until CR1810
Go thru Cundiff, TX and turn north on Crafton Rd.
Veer right (northeast) when road splits
Go to end of big creek bridge pavement, stop
Endpoint1: 588950 3680499
Endpoint2: 598024 3689724

129. Start at Campsey Rd. and Crooked Creek Rd.
Take Campsey Rd. west to Post Oak Rd.
Take Post Oak Rd. south until "Y" in road at Red Road, stop
Endpoint1: 583023 3689837
Endpoint2: 579012 3680452

130. Start at CR148 and Puddin Valley Rd.
Follow Puddin Valley Rd. to Prospect Rd.
Take Post Oak Rd. north across to Clay Co.
Stop at Lapland Rd.
Endpoint1: 574444 3695384
Endpoint2: 576404 3705128

131. Start at CR2190 and Martin Rd.
Go west on Martin Rd., cross over Hwy 281, go west (becomes Roney Rd.)
Follow to CR1191, go north on CR1191
Stop at Old Gertrudes Rd.
Endpoint1: 570780 3686539
Endpoint2: 558306 3687540

132. Start at CR1191 and Burwick Rd.
Go east on Burwick until road comes to "T" at Lester Rd.
Go north (left) on Lester Rd.
Take Lester to Hwy 281
Stop
Endpoint1: 557923 3678785
Endpoint2: 569839 3679554

133. Start at Andrews Rd. and Blair Creek Rd., go west on Andrews Rd.
Continue to Garvey Ranch Rd., go left
Continue to Russing Rd., go right (merges into Olney Rd.)
Continue until FM1769, turn right (south)
Take FM road to McGee Road, stop
Endpoint1: 537985 3698449
Endpoint2: 537687 3687794

134. Start at Wilson Rd. and Rodgers Rd., go south on Rodgers Rd.
Go right (west) on Scobee Rd., continue to Taack Rd., go left
Continue on Taack Rd. until Hardy Rd., go left, continue to Rux Rd.
Go right and continue past first 90-degree turn
Stop at 2nd 90-degree turn (white gate)
Endpoint1: 529818 3686443
Endpoint2: 528710 3676641

135. Start at Miller Bend Rd. and Hwy 380, stay on Miller Bend until "T" at FM209
Go west on FM209 until Fort Belknap water building on left
Stop
Endpoint1: 522442 3670812
Endpoint2: 518554 3660682

136. Start at FM1287 and CR165
Veer right at CR166 (becomes Duff Prairie in Young Co.)
Cross over Hwy 67, go west on CR167
Continue thru open rangeland
Stop at FM701
Endpoint1: 538726 3644616
Endpoint2: 523014 3647331

137. Start at FM701 and CR176, continue on CR176 until CR173, stop
Endpoint1: 520356 3638556
Endpoint2: 511792 3628499

138. Start at Hwy 183 and CR157 (becomes CR154)
Follow CR154 until "T"
Take CR146 until FM1852, stop
Endpoint1: 510692 3600426
Endpoint2: 515869 3609702

139. Start at FM1032 and CR187
Continue until Hwy 6
Stop
Endpoint1: 503842 3605635
Endpoint2: 501787 3590292

140. Start at Grassy Ridge Rd. and FM4
Turn right on Fortune Bend Rd.
Stop at metal gate with green dumpster
Endpoint1: 556668 3632775
Endpoint2: 568120 3641472

141. Start at Hwy 254 and Keechi Creek Ranch Rd.
Turn right on Crawford Ln.
Go left on FM52
Go north on Oran Rd., then right on Rambling Rd.
Go right on Brannon Rd.
Endpoint1: 574915 3644982
Endpoint2: 587442 3648520

142. Start at FM919 and Calhoun Rd.
Turn right on Rock Creek Rd.
Stop at Hwy 108
(Shorter transect)
Endpoint1: 559058 3607922
Endpoint2: 553125 3601901

143. Start at railroad tracks and FM129
Turn right on Chestnut Mtn. Rd.
Continue until FM4, turn right
Go until FM3137
Stop
Endpoint1: 582168 3614416
Endpoint2: 568502 3615222

144. Start at FM1543 and Cougar Dr., continue on Cougar Dr. (becomes gravel road)
Stop at stop sign where pavement begins
Endpoint1: 601330 3606226
Endpoint2: 588792 3603140

145. Start at I-20 and Fairview Rd., go right at “T”
Go left on Clary Rd.
Go right on Old Millsap Rd.
Go right on Hwy 180, cross over and go north
Stop at bridge
Endpoint1: 597756 3618889
Endpoint2: 606326 3627166

146. Start at FM51 and Old Agnes Rd.
Continue on Old Agnes Rd. to Erwin Rd.
Stop
Endpoint1: 615462 3633321
Endpoint2: 612773 3647517

147. Start at FM51 and Veal Station Rd.
Cross over FM1707 and continue on Flat Rock Rd.
Stop at Baughman Hill Rd.
Endpoint1: 620391 3642757
Endpoint2: 633583 3637854

148. Start at CR308 and FM4
Go right at CR423
Go left at CR310
Go left at CR1205
Stop at CR1107
Endpoint1: 662877 3576511
Endpoint2: 654723 3569265

149. Start at South Hwy 171 and CR1126
Go right on CR1228
Go left on FM4
Go right at next CR1124
Go right on FM2331
Go left on CR1226
Stop at CR1121
Endpoint1: 641782 3588864
Endpoint2: 639499 3576434

150. Start at Hwy 171 and CR1000
Go left on CR916
Go right on FM2435
Take quick left on CR
Turn right on CR1005
Stop at CR913A
Endpoint1: 631521 3598632
Endpoint2: 643038 3595947

151. Start on Old Granbury Rd.
Stop at Hwy 377
Endpoint1: 619561 3592616
Endpoint2: 628845 3598945

152. Start at CR172 and Hwy 377, turn right at FM2870
Quick left on Bakers Crossing Rd.
Stop at FM51
Endpoint1: 592248 3579688
Endpoint2: 603369 3571588

153. Start at Star Hollow Rd. and FM1189
Continue south on Bluff Dale Rd.
Stop at intersection of Hwy 377
Endpoint1: 589037 3596034
Endpoint2: 593001 3580300

154. Start at FM203 and Hwy 67
Go right on CR2012
Go left at stop sign, left at second stop sign
Follow CR2650
Stop at CR2655
Endpoint1: 609645 3562237
Endpoint2: 614391 3549525

155. Start at CR229 and CR540
Go right on CR209, make quick left
Left on CR536
Stop at Hwy 220
Endpoint1: 586850 3553769
Endpoint2: 596420 3550022

156. Start at CR246 and FM914, merge right at "Y"
Go right at CR248
Go right at Hwy 6
Go left on CR270
Stop at intersection of CR264
Endpoint1: 576377 3549802
Endpoint2: 584785 3543331

157. Start at CR371 and FM2156
Cross over FM219 and continue on CR373
Continue until CR242, go left
Continue straight on paved CR242
Stop at stop sign
Endpoint1: 558954 3553601
Endpoint2: 567062 3560602

158. Start at gray mailboxes-CR401?
Continue until intersection of FM8
Stop
Endpoint1: 550415 3577336
Endpoint2: 558357 3568714

159. Start at I-20
Go to “T” and go right
Stop at intersection that has a gate with a “W” on it
Endpoint1: 554817 3596573
Endpoint2: 550891 3583598

160. Start at CR4981 and Hwy 16
Stop at “Y”-CR457A
Endpoint1: 542009 3566637
Endpoint2: 537760 3554860

161. Start at FM1477 and CR185 (east of Sipe Springs)
Take FM1477 south, go left at Hwy 36
Go left at CR118
Left at CR116
Stop at CR110
Endpoint1: 520843 3550477
Endpoint2: 527172 3543974

162. Start at CR403 and Hwy 16
Go right at CR419
Go left at CR2318
Stop at CR435
Endpoint1: 538661 3531257
Endpoint2: 536978 3546882

163. Start at FM1476 and Hwy 16
Go left on CR216
Stop at Hwy 36
Endpoint1: 544783 3514969
Endpoint2: 544140 3527569

164. Start at FM3200 and Hwy 16
Continue south on CR253
Stop at Hwy 573
Endpoint1: 538401 3525002
Endpoint2: 533108 3512086

165. Start at Hwy 36 and FM569
Go right on FM2731
Stop at CR559
Endpoint1: 491995 3551597
Endpoint2: 501208 3559402

166. Start at FM569 and Hwy 206
Continue on FM1864
Stop at CR423
Endpoint1: 499112 3578731
Endpoint2: 484504 3574073

167. Start at Hwy 183 and FM1467
Go right on CR291
Left at stop sign (Bethel Church)
Left at "T"
Stop at first CR on left
Endpoint1: 518962 3505222
Endpoint2: 523506 3516317

168. Start at FM2126 and CR267
Stop at Mills Co. 531
Endpoint1: 505610 3504161
Endpoint2: 513025 3491269

169. Start at FM45 and FM2126
Stop at CR532
Endpoint1: 503992 3502557
Endpoint2: 505420 3486351

170. Start at FM45 and FM586
Stop at Hwy 377
Endpoint1: 503865 3482694
Endpoint2: 491388 3489415

171. Start at FM2003 and Hwy 6
Continue on dirt road
Stop at first road on left
Endpoint1: 519486 3482839
Endpoint2: 503917 3482657

172. Start at FM573 and Hwy 183
Go south on FM573
Stop at FM574
Endpoint1: 531860 3491600
Endpoint2: 519488 3482881

173. Start at FM573 and Hwy 183
Stop at FM218
Endpoint1: 532203 3491477
Endpoint2: 532350 5058292

174. Start at CR2005 and Hwy 84
Stop at CR247
Endpoint1: 542451 3480186
Endpoint2: 553693 3488261

175. Start at Hwy 183 and CR423
Stop at 10 mi. (couldn't finish/high water)
Endpoint1: 549904 3463323
Endpoint2: 545017 3464111

176. Start at FM1241 and FM932
Stop at CR431
Endpoint1: 583574 3505706
Endpoint2: 596756 3497192

177. Start at FM219 and Hwy 281
Stop at CR277
Endpoint1: 584427 3526915
Endpoint2: 597730 3523748

178. Start on FM1238 at CR2205
Left at FM927, follow FM927
Stop at CR2593
Endpoint1: 603614 3531867
Endpoint2: 612059 3541546

179. Start at FM219 and Hwy 22
Stop at CR4230
Endpoint1: 610840 3515467
Endpoint2: 624109 3511057

180. Start at FM219 and Hillside Dr. at yellow light
Left at FM182
Stop at CR4165
Endpoint1: 633530 3516630
Endpoint2: 622854 3517981

181. Start at FM219 and FM1991
Right on FM3221
Right on CR3240
Left at FM219
Stop at Quail Ranch gate
Endpoint1: 635803 3517751
Endpoint2: 645007 3526050

182. Start at Hwy 22 and FM56
Stop at PR1380 on left
Endpoint1: 648313 3526494
Endpoint2: 643876 3539665

183. Start at Hwy 22 and CR3455
Left at FM56
Right on FM2490
Right at CR3540
Left at CR3535
Right at "T", left at paved CR
Right at "T"
Stop at FM56
Endpoint1: 650349 3525318
Endpoint2: 649786 3519151

184. Start at CR and Hwy 174
Go left (north) on FM2488
Right on CR1405
Right on CR1414
Left on next CR1413
Cross over Hwy 171
Go to CR418, stop
Endpoint1: 653006 3562889
Endpoint2: 666588 3567755

185. Start at FM1534 and CR2418
Go right on CR2421
Go left at "T" of CR1330 and CR1313
Go left at FM309, stop at CR1365
Endpoint1: 667471 3536416
Endpoint2: 664432 3549888

186. Start at CR2341 and I-35
Right on CR2318
Left on FM1304
Right on CR2312
Left on CR2302
Stop at FM1304
Endpoint1: 681113 3529168
Endpoint2: 671925 3526207

187. Start at FM933 and FM308
Stop at Patton Branch Rd.
Endpoint1: 676039 3502921
Endpoint2: 667577 3514675

188. Start at Hwy 36 and CR341
Left at CR342
Stop at end of FM931
Endpoint1: 629281 3462611
Endpoint2: 644210 3465161

189. Start at CR101 and FM932
Left at FM930
Right at FM2412
Stop at Indian Hills Rd.
Endpoint1: 598595 3483737
Endpoint2: 608819 3484427

190. Start at FM1690 and Hwy 281
Go right on FM2527
Go right on FM580
Stop at FM2313
Endpoint1: 578693 3454904
Endpoint2: 589071 3443209

191. Start at FM581 and CR2745
Stop at Hwy 281
Endpoint1: 564159 3460894
Endpoint2: 578973 3462331

192. Start at FM580 and Third St.
Stop at Hwy 1320
Endpoint1: 576992 3436697
Endpoint2: 561734 3441144

193. Start at FM1478 (Howe St.) and Sixth St.
Stop at end of FM Road (CR107)
Endpoint1: 577288 3436484
Endpoint2: 564806 3427840

194. Start at FM580 and FM581
Stop at Hwy 183
Endpoint1: 548678 3444439
Endpoint2: 557722 3453741

195. Start at Hwy 16 and FM500
Go right at CR117
Stop at cattle guard (10 mi.)
Endpoint1: 526800 3454578
Endpoint2: 525379 3468797

196. Start at FM765 and CR260
Stop at Hwy 190
Endpoint1: 503655 3475360
Endpoint2: 504726 3459482

197. Start at FM2997 and Hwy 190
Stop at FM45
Endpoint1: 495459 3456950
Endpoint2: 505035 3464183

198. Start at FM2340 and Hwy 281
Go left on FM963
Stop at FM1174
Endpoint1: 572922 3418305
Endpoint2: 584910 3414265

199. Start at FM1174 and FM963
Cross over Hwy 183
Stop at stream crossing
Endpoint1: 584907 3414258
Endpoint2: 595942 3423661

200. Start at Hwy 183 and FM2567
Stop at 10 mi.
Endpoint1: 602963 3417979
Endpoint2: 604030 3430945

201. Start at CR200 and FM963
Cross over FM1174
Stop at Archeson Manor gate on left
Endpoint1: 574731 3404447
Endpoint2: 589365 3410346

202. Start at CR340A and Hwy 281
Stop at gray house on left before river crossing
Endpoint1: 572950 3400129
Endpoint2: 573821 3389159

203. Start at FM2341 and Hwy 29
Stop at Burnet Co. Park
Endpoint1: 568446 3403551
Endpoint2: 558441 3412951

204. Start at FM970 and Hwy 183
Go right on FM2338
Stop at FM3405
Endpoint1: 607508 3405208
Endpoint2: 618641 3398315

205. Start at FM1869 and Hwy 183
Cross over Hwy 29, stop at Shin Oak Observation Deck
Endpoint1: 607334 3395645
Endpoint2: 590984 3392393

Edwards Plateau

206. Start at Overton Rd. and Hwy 87, follow Overton Rd. to Drumright Rd.
Follow Drumright to Hamby Rd., follow Hamby Rd. (becomes Longshore Rd.)
Follow Longshore Rd. to gate with stars
Endpoint1: 276744 3549836
Endpoint2: 267009 3558382

207. Start at FM2401 and Paymaster Rd., follow Paymaster Rd. to CR170
Follow CR170 across FM33 (becomes CR270)
Continue on CR270 to end of pavement, stop
Endpoint1: 260442 3510530
Endpoint2: 272130 3516781

208. Start at FM3093 and FM1357, follow FM3093 north
Stop at FM2401
Endpoint1: 260408 3497150
Endpoint2: 255759 3509536

209. Start at CR that runs north to FM2139 and Private entrance with blue "Notice" sign
Continue west on CR?
Stop at silver oil tanks on right (10.5 mi)
Endpoint1: 289068 3502315
Endpoint2: 273769 3502598

210. Start at intersection of FM2139 and Hwy 163
Follow FM2139 to Flint Rd., stop
Endpoint1: 293180 3506974
Endpoint2: 306914 3514864

211. Start at FM2034 and Mountain Rd., continue on FM2034
Turn right on Walnut Rd.
Stop at silver gate on right
Endpoint1: 349077 3524731
Endpoint2: 337663 3521077

212. Start at intersection of March Rd. and Sutton Rd.
Follow March Rd. about 8.7 miles to AR Ranch gate
Stop
Endpoint1: 355898 3496654
Endpoint2: 349236 3508528

213. Start at gravel road on north side of FM2034
Cross over Hwy 82
Stop at Hall Ranch Rd.
Endpoint1: 336392 3511159
Endpoint2: 325011 3503076

214. Start at CR308 and CR111
Follow CR111 to Hwy 349
Stop
Endpoint1: 220748 3482282
Endpoint2: 205413 3489944

215. Start at Hwy 67 and CR220
Follow CR220 to road intersection
Stop
Endpoint1: 224421 3459434
Endpoint2: 228445 3447020

216. Start at Hwy 67 and CR230, Follow CR230 to FM1555
Stop
Endpoint1: 227737 3458782
Endpoint2: 230989 3471140

217. Start at Elliot Rd. and FM1555
Follow FM1555 to Hwy 67
Stop
Endpoint1: 242683 3458487
Endpoint2: 236468 3472546

218. Start at Hwy 137 and Aldwell Rd., follow Aldwell Rd. to Water Station Rd.
Take Water Station Rd. north to 245394 3490140, turn west
Follow road west to 239172 3488627, turn north
Follow road north to 238921 3489631, stop
Endpoint1: 252859 3487025
Endpoint2: 238928 3489967

219. Start at intersection of CR412 and FM2469
Follow CR412 north to CR411
Follow CR411 west to cattle guard, stop
Endpoint1: 315503 3465432
Endpoint2: 307812 3475336

220. Start at intersection of CR410 and FM2469
Follow FM2469 east to TxDOT shed, stop
Endpoint1: 310729 3465574
Endpoint2: 325238 3460933

221. Start at intersection of Hwy 67 and CR131
Follow CR131 to 305066 3444836 (gate in fence on north side of road)
Stop
Endpoint1: 319834 3451802
Endpoint2: 305063 3444835

222. Start at CR2041 and Hwy 87, go right at FM176
Continue on FM176 until gravel, follow until house at dead end
Stop at driveway
Endpoint1: 409069 3454018
Endpoint2: 411059 3441576

223. Start at CR2304 and Hwy 83
Go right at CR2019
Stop at Hwy 87
Endpoint1: 421229 3444034
Endpoint2: 416471 3453926

224. Go south on CR3136 with Pasche Ranch sign at Hwy 87
Go left at CR3147
Stop at intersection of CR3147 and CR3326
Endpoint1: 434577 3455605
Endpoint2: 427931 3447248

225. Start at CR138 and Hwy 87
Go left onto FM2028
Stop at CR122
Endpoint1: 448921 3451920
Endpoint2: 449300 3443742

226. Start at CR116 and CR112
Go north on CR112
Left at FM2028
Right on CR120
Stop at “T” (white gate)
Endpoint1: 457438 3438801
Endpoint2: 451326 3447903

227. Start at FM1929 and Concho co. line at bridge
Cross over FM503 and continue on CR
Stop at 1st intersection
Endpoint1: 437213 3485108
Endpoint2: 448271 3491276

228. Start at CR424 and Hwy 153
Stop at Hwy 67
Endpoint1: 454863 3522092
Endpoint2: 443338 3514337

229. Start at CR484 and FM702, go right on CR485
Go right at "T"
Go left at FM1770
Go left on CR488
Go right at CR490
Go left at FM1770
Stop at CR492
Endpoint1: 443283 3539511
Endpoint2: 434974 3538536

230. Start at FM2732 and Hwy 190
Stop at end of pavement
Endpoint1: 519950 3452729
Endpoint2: 507173 3445910

231. Start at Hwy 190 and FM580
Stop at CR426
Endpoint1: 532316 3451576
Endpoint2: 542669 3442324

232. Start at CR432 and FM501
Continue on FM501
Stop at CR447
Endpoint1: 544263 3438923
Endpoint2: 535619 3427904

233. Start at Hwy 16 and FM965
Stop Welgehausen Rd.
Endpoint1: 528319 3379019
Endpoint2: 515568 3368910

234. Start at FM2233 and Hwy 71
Left at FM2900
Right at FM1431
Stop at CR132A
Endpoint1: 549403 3381961
Endpoint2: 555445 3391430

235. Start at FM501 and CR353
Continue west on FM501
Continue south on CR
Stop at Hickory Grove sign (Newsom Cemetery)
Endpoint1: 506448 3425689
Endpoint2: 502048 3413060

236. Start at Hwy 87 and FM1222
Stop at FM386
Endpoint1: 473062 3418711
Endpoint2: 488684 3421403

237. Start on Black Jack Rd. at Lange Polk Rd.
Go south on Black Jack Rd.
Go right a FM386
Stop at Pontotoc Street
Endpoint1: 481918 3415740
Endpoint2: 478015 3402567

238. Start at Hwy 87 and FM1723
Right on FM2389
Right at end of FM2389-James River Rd.
Stop at sign-Bat cave 5.8mi
Endpoint1: 479163 3400436
Endpoint2: 474048 3388132

239. Start at Hwy 87 and Simonsville Rd.
Left at FM783
Stop at Geistweidt Rd.
Endpoint1: 495458 3385648
Endpoint2: 486787 3375579

240. Start at FM3463 and Hwy 83
Stop at cattle guard on gravel road
Endpoint1: 422337 3430956
Endpoint2: 408335 3433219

241. Start at FM2873 and Hwy 190
Continue on gravel road
Stop at rock entryway to Sultemeir Ranch
Endpoint1: 394686 3416293
Endpoint2: 396657 3431594

242. Start at FM864 and Hwy 190
Left on FM1674
Stop at Colston Draw
Endpoint1: 400486 3416028
Endpoint2: 393842 3403781

243. Start at intersection of FM2084 and CR339 (Rudd Rd.)
Follow CR339
Stop at intersection of CR339 and CR350
Endpoint1: 373857 3437089
Endpoint2: 383675 3423739

244. Start at intersection of Hwy 190 and CR220
Follow CR220 until rock gate of Kohls Ranch
Stop at rock gate
Endpoint1: 354511 3414618
Endpoint2: 367295 3404141

245. Start at intersection of FM1828 and FM915
Follow FM915 to CR427
Stop at intersection of FM915 and CR427
Endpoint1: 342920 3426335
Endpoint2: 330256 3439759

246. Start at intersection of Hwy 163 and CR209
Follow CR209 to 4th cattle guard at 307820 3432977
Stop
Endpoint1: 293002 3432742
Endpoint2: 307824 3432978

247. Start at intersection of Hwy 137 and CR205
Follow CR205 to 2 signs that say James L Lamb Jr. at 274263 3433205
Stop
Endpoint1: 264707 3440245
Endpoint2: 274266 3433202

248. Start at intersection of Hwy 137 and FM1964
Follow FM1964 to 5 road intersection
Follow CR302 to intersection of CR302 and CR303
Stop at stop sign
Endpoint1: 272406 3418472
Endpoint2: 260245 3410148

249. Start at intersection of Hwy 190 and CR207
Follow CR207 to intersection of CR207, CR208, and FM1676
Stop at intersection
Endpoint1: 263005 3421278
Endpoint2: 253840 3435299

250. Start at intersection of FM1676, CR207, and CR208
Follow CR208 to entrance of J&J Cattle Co. (Red Corral)
End at 243187 3427431
Endpoint1: 253803 3435335
Endpoint2: 243190 3427423

251. Start at intersection of Hwy 190 and CR305
Follow CR305 to intersection with CR306
Continue to follow CR305 to I-10
Stop at I-10 access road
Endpoint1: 242294 3419333
Endpoint2: 245382 3403951

252. Start at intersection of Hwy 290 and CR406
Follow CR406 south to intersection of CR407
Stop
Endpoint1: 250675 3398295
Endpoint2: 252517 338260

253. Start at intersection of CR405 and FM2083
Follow FM2083 to Dog Canyon Trail
Stop
Endpoint1: 263181 3370958
Endpoint2: 256220 3356211

254. Start at Crockett co. line on Sutton CR412
Continue into Crockett Co. (CR412 becomes CR102)
Follow CR102 to Hwy 163
Stop
Endpoint1: 311634 3356454
Endpoint2: 296866 3361271

255. Start at intersection of FM189 and CR410
Follow CR410 north to CR411
Turn west on CR411, follow until it becomes CR101 in Crockett Co.
Follow CR101 to second cattle guard
Stop
Endpoint1: 312626 3352214
Endpoint2: 309998 3366320

256. Start at intersection of CR408 and FM189 (Phillips 66 sign)
Follow FM189 east to Hwy 277
Stop at intersection of FM189 and Hwy 277
Endpoint1: 324797 3353640
Endpoint2: 339382 3360329

257. Start at intersection of Hwy 277 and CR406 (Cusenbary Rd.)
Follow CR206 until 350377 3355501
Stop (there are oil field gates on both sides of road)
Endpoint1: 337708 3364776
Endpoint2: 350380 3355499

258. Start at intersection of FM864 and CR204
Follow CR204 to intersection with CR306 (Jacoby Ranch)
Stop
Endpoint1: 375361 3390538
Endpoint2: 378264 3377927

259. Start at FM1674 and I-10
Stop at KC214 (CR)
Endpoint1: 404827 3374118
Endpoint2: 397037 3388155

260. Start at FM2291 and I-10
Stop at Bear Creek Beefmasters gate on right
Endpoint1: 419193 3377627
Endpoint2: 415772 3392131

261. Start at FM385 and FM1871
Go northeast on FM1871
Stop at 10 mi.
Endpoint1: 443586 3382866
Endpoint2: 459259 3387740

262. Start at FM385 and FM1871
Continue on FM385 east
Stop at James River
Endpoint1: 443560 3382895
Endpoint2: 457385 3372581

263. Start at FM648 and FM783, take FM648 east
Stop at Hwy 87
Endpoint1: 487481 3368064
Endpoint2: 502997 3362829

264. Start at Hwy 87 and Old Mason Rd.
Right on Pecan Creek Rd.
Stop at Crenwelge Rd.
Endpoint1: 504779 3360317
Endpoint2: 493367 3361359

265. Start at FM1631 and Brewer PR
Left at FM1323
Stop at Hwy 16
Endpoint1: 529046 3357211
Endpoint2: 525299 3364634

266. Start at FM2721 and North Grape Creek Rd.
Right at FM1631
Stop at Cave Creek Rd.
Endpoint1: 536168 3351106
Endpoint2: 525946 3353590

267. Start at Hwy 290 and FM1376
Right on Grapetown Rd.
Stop at “T”
Endpoint1: 518846 3343654
Endpoint2: 517330 3335774

268. Start on FM2093 at Leyendecker Rd.
Go west on FM2093
Stop at Canyon Creek PR
Endpoint1: 506552 3346287
Endpoint2: 489764 3346570

269. Start at Hwy 71 and FM962
Stop at Hwy 281
Endpoint1: 553383 3378319
Endpoint2: 562867 3366862

270. Start at Hwy 281 and FM1323
Right on Round Mtn.- Sandy Rd. (CR307)
Stop at creek (10 mi.)
Endpoint1: 558434 3353743
Endpoint2: 556773 3363399

271. Start on FM2766 at Stubbs PR
Right at FM3232
Stop at 10 mi.
Endpoint1: 561551 3349401
Endpoint2: 5732492 3343368

272. Start at Hwy 290 and Flat Creek Rd. (CR204)
Right at Rocky Rd.
Stop at Hwy 290
Endpoint1: 554775 3348935
Endpoint2: 544393 3346139

273. Start at Creek Rd. and unmarked CR
Left at FM165
Stop at FM2325
Endpoint1: 577934 3338851
Endpoint2: 566874 3331541

274. Start at Plainview Rd. on FM2325
Stop at W. El Camino Real PR
Endpoint1: 571102 3330227
Endpoint2: 584354 3320881

275. Start at Jacobs Well Rd. and FM12
Stop at FM150
Endpoint1: 586629 3324256
Endpoint2: 587933 3337755

276. Start at Smithson Valley Rd. and FM1863
Stop at Shoenthal Rd.
Endpoint1: 557983 3291132
Endpoint2: 572199 3286840

277. Start at Hwy 46 and FM3351
Stop at Rawls Creek
Endpoint1: 541281 3299793
Endpoint2: 544607 3314546

278. Start at FM473 and Sattler Rd.
Go west on FM473
Right on Crabapple Rd.
Stop at Rocking B Ranch Rd. (cattle guard)
Endpoint1: 553586 3314877
Endpoint2: 544646 3321369

279. Start at FM473 and Sansom Rd.
Stop at FM1376
Endpoint1: 541283 3317208
Endpoint2: 527217 3315321

280. Start at Marquardt Rd. and FM1376
Stop at Chaparral Hill Rd. (10 mi.)
Endpoint1: 527161 3313259
Endpoint2: 525333 3298021

281. Start at Sisterdale-Linedale Rd. and FM1376
Stop at rock ranch entry (10 mi.)
Endpoint1: 526378 3318505
Endpoint2: 526114 3333890

282. Start at Hwy 27 and FM1350
Left at FM480
Right at Hwy 173
Left at Camp Verde Rd.
Stop at Saw Mill
Endpoint1: 499409 3312368
Endpoint2: 485659 3306659

283. Start at FM1340 and Hwy 39
Continue 10 mi.
Endpoint1: 467719 3326586
Endpoint2: 460191 3325476

284. Start at FM1283 and Hwy 16
Stop at park road 37
Endpoint1: 506271 3288002
Endpoint2: 506775 3275042

285. Start at Hwy 173 and FM1077
Stop at State Natural Area Headquarters sign
Endpoint1: 493673 3287784
Endpoint2: 482984 3277337

286. Start at FM470 and FM462
Take FM462 south, stop at mailbox "Dalton 7500"
Endpoint1: 473258 3280786
Endpoint2: 478535 3266452

287. Start at Hwy 16 and FM337
Stop at Clark Creek Rd. sign
Endpoint1: 475579 3296658
Endpoint2: 459982 3293829

288. Start at Hwy 16 and FM2107
Stop at first stream crossing on gravel road
Endpoint1: 472806 3300914
Endpoint2: 462677 3304911

289. Start at FM337 and FM187
Take FM187 north
Stop at Station C Rd.
Endpoint1: 446332 3290549
Endpoint2: 445137 3304314

290. Start at FM336 and Hwy 83
Stop at top of mountain (10 mi.)
Endpoint1: 426349 3290033
Endpoint2: 424362 3303023

291. Start at Hwy 83 and FM337
Stop at 10 mi.
Endpoint1: 426120 3288514
Endpoint2: 412311 3292062

292. Start at Hwy 55 and FM335, take FM335 north
Stop at rock ranch entry (10 mi.)
Endpoint1: 399775 3289229
Endpoint2: 401832 3302973

293. Start at intersection of Hwy 41 and FM335
Follow FM335 south to Hackberry Ranch (big red gate at CR227)
Stop at Hackberry Ranch
Endpoint1: 399128 3327814
Endpoint2: 402021 3311787

294. Start at intersection of Hwy 55 and CR740
Follow CR740 north
Go east on dirt road that becomes FM2995
Follow dirt road through 5 bump gates until it becomes FM2995
Follow FM2995 to Shanklin Ranch
Endpoint1: 362228 3337367
Endpoint2: 373766 3332586

295. Start at intersection of Hwy 377 and FM2523, follow FM2523 to CR650
Turn on CR650 and go through bump gate
Follow to ungated intersection, stop
Endpoint1: 343894 3297075
Endpoint2: 350158 3286170

296. Start at Hwy 277 and Miers Rd.
Follow Miers Rd. 9 miles to “Y” in road (Blue Sage PP & Culp signs)
Stop
Endpoint1: 312567 3295696
Endpoint2: 323777 3290390

297. Start at Hwy 277 and Dolan Creek Rd.
Follow Dolan Creek Rd., stop at Whitehead Brothers Ranch sign
Endpoint1: 319618 3325485
Endpoint2: 329654 3316145

298. Start at Whitehead Brothers Ranch sign on Dolan Creek Rd.
Stop at Devil’s River State Natural Area gate
Endpoint1: 312086 3317406
Endpoint2: 319620 3325487

299. Start at Hwy 163 and Juno Rd.
Follow Juno Rd. to power lines that cross road at a wash
Endpoint1: 295776 3335506
Endpoint2: 284231 3343995

300. Start at W. Juno Rd. and FM1024
Follow FM1024 to gate of Gries Ranch
Endpoint1: 276304 3336877
Endpoint2: 267738 3344381

301. Start at gate to Gries Ranch on FM1024
Follow FM1024 to the end of Howard Draw
Endpoint1: 267742 3344378
Endpoint2: 254342 3342553

South Texas

302. Start at sign to Doak Ranch on FM2523 (331417 3261605)
Follow FM2523 to FM3008
Turn on FM3008, follow to gate with "David Winters" on it, stop
Endpoint1: 331418 3261604
Endpoint2: 343761 3263095

303. Start at intersection of Standart Lane, FM3008, and Hwy 90
Follow Standart Lane along railroad until FM693
Endpoint1: 343570 3248649
Endpoint2: 351170 3236333

304. Start at Hwy 277 and FM693
Stop at railroad tracks
Endpoint1: 336474 3227741
Endpoint2: 351162 3236312

305. Start at railroad overpass on FM1572 (377582 3232918)
Follow FM1572 west to railroad crossing (363834 3226829)
Stop
Endpoint1: 377582 3232921
Endpoint2: 364600 3226088

306. Start at FM1908 and Hwy 131
Follow FM1908 west to Maverick co. line
Endpoint1: 361032 3224995
Endpoint2: 348893 3218342

307. Start at Hwy 90 and FM1022
Follow FM1022 to cattle guard
Stop
Endpoint1: 401220 3234128
Endpoint2: 395579 3226490

308. Start at CR207 and FM481
Follow FM481 to Uvalde/Zavala co. line
Endpoint1: 416708 3226228
Endpoint2: 403252 3218045

309. Start at FM1023 and CR302
Follow FM1023 east to intersection of FM1023, FM1049, and CR301
Follow CR301 east to CR305
Follow CR305 north to intersection with CR306
Continue on paved road, stop at Hwy 90
Endpoint1: 437119 3234946
Endpoint2: 443728 3242854

310. Start at intersection of CR370 and FM140
Follow FM140 to red gate on both sides of road
Stop
Endpoint1: 434735 3221056
Endpoint2: 449331 3216443

311. Start at intersection of FM117 and County Road
Follow FM117 northeast to Uvalde co. line, continue on FM117
Stop at plant entrance
Endpoint1: 436021 3207887
Endpoint2: 426866 3220863

312. Start at bridge on CR319 east of Sabinal
Continue on CR319 into Medina Co., road becomes CR511
Follow CR511 to Hwy 90, stop
Endpoint1: 456924 3244639
Endpoint2: 470301 3243976

313. Start at CR520 and Hwy 90
Follow CR520 to CR512
Turn west on CR512, go to CR520
Turn south on CR520
Follow CR520 to Koch Bros. Rd., stop
Endpoint1: 467799 3243392
Endpoint2: 466653 3231876

314. Start at CR321 and FM1796
Follow FM1796 south to CR421
Follow CR421 to intersection with FM462, stop
Endpoint1: 471873 3257624
Endpoint2: 483344 3251080

315. Start at intersection of CR5232 and FM2200
Follow FM2200 south to intersection with CR731
Endpoint1: 473472 3237572
Endpoint2: 481445 3224459

316. Start at intersection of FM1591 and FM1908
Follow FM1908 north to Kinney co. line, stop
Endpoint1: 344351 3203985
Endpoint2: 348905 3218363

317. Start at Hwy 57 and FM481
Follow FM481 to gate of Groff Ranch
Endpoint1: 370278 3189651
Endpoint2: 378520 3202671

318. Start at second intersection of FM1021 and FM2030
Follow FM2030 southeast to second intersection with FM2366, stop
Endpoint1: 362306 3168476
Endpoint2: 371621 3156313

319. Start at intersection of FM1021 and FM2644
Follow FM1021 to cattle guard at 375819 3139721, stop
Endpoint1: 371663 3154100
Endpoint2: 375825 3139718

320. Start at FM393 and FM2691
Follow FM2691 to end of pavement, stop
Endpoint1: 395990 3182086
Endpoint2: 401399 3171640

321. Start at FM393 and FM1668
Follow FM1668 to end of pavement
Turn south onto county road
Follow CR to gate on left (406282 3172155)
Endpoint1: 415193 3173991
Endpoint2: 406279 3172148

322. Start at FM1436 and FM1986
Follow FM1986 west and then back around to FM1436
Turn north on FM1436
Follow to intersection with Hwy 83, stop
Endpoint1: 416215 3204028
Endpoint2: 417103 3209462

323. Start at Hwy 57 and FM187
Stop at FM140
Endpoint1: 440828 3204062
Endpoint2: 456899 3213373

324. Start at intersection of FM1025 and FM117
Follow FM117 to intersection with CR4757 (Leona River Rd.), stop
Endpoint1: 441229 3193970
Endpoint2: 459501 3188267

325. Start at FM117 and Old Loma Vista Rd., Follow FM117 south to FM1025
Follow FM1025 to W. Old Loma Vista Rd., follow to gate with sign “Bommer Hunting Property”
Endpoint1: 440709 3200694
Endpoint2: 442011 3184145

326. Start at FM395 and FM1025, follow FM1025 to FM1867
Follow FM1867 to W. Old Loma Vista Rd., stop
Endpoint1: 425427 3184513
Endpoint2: 441599 3182533

327. Start at FM1867 and Old Loma Vista Rd., follow FM1867 south to PR, stop
Endpoint1: 442265 3182224
Endpoint2: 444395 3167350

328. Start at FM140 and Hwy 57
Stop at intersection with FM1581 (Shell station on right)
Endpoint1: 476697 3204699
Endpoint2: 489663 3196078

329. Start at FM1581 and I-35, stop at CR4440
Endpoint1: 488738 3194769
Endpoint2: 477582 3185881

330. Start at FM1583 and I-35
Stop at Hwy 85 (short transect)
Endpoint1: 487033 3182318
Endpoint2: 495370 3176700

331. Start at FM472 and FM462
Stop at FM140
Endpoint1: 512712 3197276
Endpoint2: 514099 3211644

332. Start at FM1549 and FM85
Stop at CR2880
Endpoint1: 528388 3192937
Endpoint2: 516968 3203751

333. Start at Hwy 16 and FM1332
Stop at FM140
Endpoint1: 544850 3197844
Endpoint2: 540456 3185316

334. Start at FM541 and I-37
Stop at CR218
Endpoint1: 560912 3190922
Endpoint2: 573290 3201927

335. Start at CR264 and FM887
Stop at Hwy 123
Endpoint1: 614772 3221164
Endpoint2: 603834 3214340

336. Start at FM627 and FM81
Stop at Hwy 80
Endpoint1: 623385 3199599
Endpoint2: 616779 3214070

337. Start at FM108 and Hwy 119
Stop at CR219
Endpoint1: 642104 3211311
Endpoint2: 635471 3227384

338. Start at FM81 and FM885
Stop at Chicken Creek Rd.
Endpoint1: 625681 3195193
Endpoint2: 635129 3181560

339. Start on FM1726 at Canyon View Dr.
Stop at FM884
Endpoint1: 653562 3176760
Endpoint2: 644127 3187104

340. Start at FM622 and Hwy 77
Stop at FM1961
Endpoint1: 657629 3179233
Endpoint2: 671324 3187649

341. Start at Sarco sign on FM2441
Stop at intersection of FM2441 and Hwy 183
Endpoint1: 656336 3154774
Endpoint2: 657960 3168654

342. Start at FM1351 and Hwy 59
Stop at FM1351 marker (10 mi.)
Endpoint1: 649862 3167326
Endpoint2: 638261 3166530

343. Start at FM888 and FM351
Stop at CR510
Endpoint1: 623163 3140227
Endpoint2: 623268 3125150

344. Start at FM1465 and Hwy 181
Go left on FM623
Stop at C5028 gate
Endpoint1: 617490 3160578
Endpoint2: 604888 3157115

345. Start at FM2049 and Hwy 72
Go straight on FM3192
Go right at FM882
Stop at CR205
Endpoint1: 589196 3156713
Endpoint2: 590504 3171315

346. Start at FM1358 and I-37
Stop at CR205
Endpoint1: 587909 3147320
Endpoint2: 593796 3152843

347. Start at FM1042 and Hwy 281
Go left on FM1873
Stop at CR112
Endpoint1: 580744 3143644
Endpoint2: 570965 3135011

348. Start at Hwy 59 and FM624
Stop at FM3469
Endpoint1: 566417 3108977
Endpoint2: 582182 3105867

349. Start at FM99 and Hwy 72
Stop at paved driveway past white house (10 mi.-next to large gravel pile)
Endpoint1: 554784 3148367
Endpoint2: 564049 3158964

350. Start at CR and Hwy 16
Stop at 10 mi.
Endpoint1: 543839 3147334
Endpoint2: 534843 3140587

351. Start at FM1962 and Hwy 16
Stop at first driveway on right side of gravel road
Endpoint1: 542908 3123751
Endpoint2: 556072 3120438

352. Start at FM624 and Hwy 16
Stop at DAC Ranch Gate
Endpoint1: 540300 3112171
Endpoint2: 523751 3118816

353. Start at Hwy 97 and FM469
Stop at oil tanks on left
Endpoint1: 499981 3148849
Endpoint2: 488281 3158838

354. Start at FM469 south and Hwy 97
Stop at ranch entry with cow skulls
Endpoint1: 499971 3148724
Endpoint2: 493490 3135712

355. Start at FM624 and CR? with brick building
Stop at FM624 sign (10 mi.)
Endpoint1: 487047 3134790
Endpoint2: 496199 3121755

356. Start at FM468 and I-35
Stop at Dimmit co. line
Endpoint1: 475481 3146510
Endpoint2: 461006 3156210

357. Start at FM133 and I-35
Stop at Encantado Ranch entry
Endpoint1: 472098 3128274
Endpoint2: 454347 3131831

358. Start at Hwy 83 and FM2688
Follow FM2688 to silver gate, stop
Endpoint1: 437173 3138202
Endpoint2: 422699 3127952

359. Start at Wilson Rd. and Hwy 85
Follow Wilson Rd. to FM1575
Follow FM1575 across Hwy 83 to its end
Stop
Endpoint1: 421894 3158051
Endpoint2: 417437 3148126

360. Start at FM2367 and FM186
Follow FM186 past FM3252 intersection
Continue on FM186 to green gate on west, white gate on east
Endpoint1: 414417 3153968
Endpoint2: 406037 3138929

361. Start at St. Tomas Creek on FM1472
Stop at end of pavement
Endpoint1: 444199 3059289
Endpoint2: 417626 3083634

362. Start at FM3338 and FM1472
Stop at 2nd bridge
Endpoint1: 444199 3059289
Endpoint2: 437650 3073457

363. Start at Hwy 59 and FM2895
Stop at gas plant (white tanks)
Endpoint1: 496378 3063461
Endpoint2: 494176 3046096

364. Start at FM649 and FM359
Stop at Vaquillas Rd.
Endpoint1: 499828 3037524
Endpoint2: 502988 3022076

365. Start at Hwy 359 and FM2050
Stop at San Pablo Rd.
Endpoint1: 515732 3033668
Endpoint2: 515393 3053417

366. Start at Hwy 359 and FM2295
Stop at 10 mi.
Endpoint1: 557299 3052544
Endpoint2: 540847 3051597

367. Start at FM3196 and Hwy 44
Stop at 10 mi.
Endpoint1: 556868 3076158
Endpoint2: 558863 3059726

368. Start at FM716 and FM1329
Stop at CR266
Endpoint1: 572107 3029494
Endpoint2: 556384 3031856

369. Start at CR228 and FM1329
Stop at CR208
Endpoint1: 572327 3031395
Endpoint2: 572237 3047679

370. Start at Hwy 281 and FM2295
Stop at FM1329
Endpoint1: 588937 3047772
Endpoint2: 572494 3051248

371. Start at FM625 and Hwy 359
Left on FM1554
Stop at Hwy 359
Endpoint1: 579410 3070287
Endpoint2: 586469 3069700

372. Start at FM624 and Hwy 281
Stop at CR209 just before Orange Grove city limit sign
Endpoint1: 588969 3099799
Endpoint2: 603545 3093462

373. Start at Hwy 281 and FM3066
Continue on CR110
Stop at “West” gate on right
Endpoint1: 584532 3007766
Endpoint2: 570082 3004437

374. Start at FM755 and Hwy 281
Stop at Galo Cattle Co. sign
Endpoint1: 585756 2974566
Endpoint2: 571187 2971309

375. Start at FM1017 and El Reposa gate
Stop at WW Jones Borregos Ranch gate
Endpoint1: 540763 2986761
Endpoint2: 538170 2970102

376. Start at Baluarte CR
Stop at Las Cuelas gate
Endpoint1: 537492 3007400
Endpoint2: 540787 2989498

377. Start at FM3073 and FM649
Stop at El Maguey Ln.
Endpoint1: 506619 3012658
Endpoint2: 521424 3014695

378. Start at Jim Hogg co. line
Stop at FM2687
Endpoint1: 514795 2962640
Endpoint2: 508798 2979543

379. Start at FM2687 and Hwy 83
Stop at silver gate on right
Endpoint1: 487854 2962191
Endpoint2: 500793 2975590

380. Start at end of transect 381
Stop at Rancho El Refugio entry
Endpoint1: 471073 3001011
Endpoint2: 481404 3008189

381. Start at FM3169 and Hwy 83
Stop at gravel piles (10 mi.)
Endpoint1: 456769 2991147
Endpoint2: 471078 3001014

382. Start at FM649 and FM2686
Left on FM3167
Stop at gate on left with two rusty posts sticking up high
Endpoint1: 514832 2952732
Endpoint2: 511962 2934399

383. Start at Cell tower on FM2686
Stop at silver gate to ranch “El Tanque Alegre Ranch Rd.”
Endpoint1: 522461 2951318
Endpoint2: 541440 2954887

384. Start at Alanaz Rd. and FM755
Stop at FM490
Endpoint1: 541924 2947850
Endpoint2: 531252 2934154

385. Start at FM2844 and FM490
Stop at intersection in McCook
Endpoint1: 545657 2932668
Endpoint2: 560693 2929410

386. Start on FM1017 at Hidalgo co. line
Right on FM681, stop at Arrowhead Ranch entry
Endpoint1: 562415 2951186
Endpoint2: 562493 2936365

387. Start at Hwy 281 and FM1017
Stop at white gates on each side of FM1017-shell oil
Endpoint1: 587321 2937692
Endpoint2: 570108 2944282

388. Start at Kamien Rd. and FM490
Stop at Hwy 281
Endpoint1: 567828 2928854
Endpoint2: 586290 2925917

389. Start at FM2556 and Hwy 83
Stop at intersection of FM506
Endpoint1: 615078 2894540
Endpoint2: 617211 2909625

390. Start at FM2629 and Hwy 77
Go right at FM507
Stop at intersection of FM507 and FM508
Endpoint1: 621476 2914212
Endpoint2: 633664 2903875

391. Start at FM1018 and FM1420
Stop at Hwy 186
Endpoint1: 641052 2916569
Endpoint2: 637601 2929657

392. Start at Dollar General Store on FM106
Left at FM2925
Stop at green Carl Webb Inc. building
Endpoint1: 642414 2902396
Endpoint2: 649788 2912240

393. Start at CR220 and Hwy 359
Follow CR220 west to “Y”
Go left, continue on CR220
Cross over Hwy 281 and continue on CR120
Stop at stop sign at “T”
Endpoint1: 599919 3084633
Endpoint2: 587178 3084867

394. Start at Hwy 183 and CR170
Go west on CR170
Turn left at CR209
Continue south through next intersection
Turn left at CR215
Go left at CR214
Turn left (north) at “T” intersection
Stop at right-hard turn (silver gate on left)
Endpoint1: 503881 3566398
Endpoint2: 501820 3562798

395. Start at Chapparal WMA headquarters
Go north on main WMA road
Stop at 8 mi.
Endpoint1: 459737 3130562
Endpoint2: 455543 3135338

396. Start at Hwy 16 and FM3445
Follow FM3445 east
Turn right into J. Daughtery WMA
Follow main WMA road to boat dock (end of road)
Endpoint1: 544196 3152974
Endpoint2: 554803 3153733

397. Start at Hwy 16 and FM624
Follow FM624 east
Stop at iron gate of corral on right
Endpoint1: 540369 3112113
Endpoint2: 556099 3108998

398. Start at FM2359 and Hwy 16
Continue on FM2359
Stop at Hwy 59
Endpoint1: 540035 3098690
Endpoint2: 550830 3095838

399. Start at FM791 and Poenisch Rd.
Continue on FM791 east
Stop at Metate River
Endpoint1: 551977 3166861
Endpoint2: 563667 3177286

400. Start at FM2146 and CR308
Continue north on FM2146, stop at FM476 (west of Poteet)
Endpoint1: 531017 3200942
Endpoint2: 538994 3214090

401. Start at Callaghan Rd. and I-35
Continue 9.5 mi. (stop at road closure)
Endpoint1: 460617 3082852
Endpoint2: 472941 3081942

402. Start at Martinena Rd. and I-35
Stop at 2nd bridge (road closure)
Endpoint1: 464836 3100284
Endpoint2: 473223 3094660

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