GIS-BASED MULTIPLE SCALE STUDY OF RIO GRANDE WILD TURKEY HABITAT IN THE EDWARDS PLATEAU OF TEXAS

A Dissertation

by

HUMBERTO LAURO PEROTTO BALDIVIEZO

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2005

Major Subject: Rangeland Ecology and Management

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Approved by:

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ABSTRACT

GIS-based Multiple-scale Study of Rio Grande Wild Turkey Habitat in the Edwards Plateau of Texas. (August 2005)

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Rio Grande wild turkey (RGWT) abundance in portions of the Edwards Plateau has declined steadily since the late 1970s as compared to other areas of the Edwards Plateau where populations have exhibited no trend. The reasons for this decline remain unclear. Possible factors include changes in habitat, and increased human population. The overall objective of this study was to identify landscape changes and habitat characteristics that affect RGWT populations using spatial analysis and modeling at multiple spatial scales. Specific objectives for this study included the quantification of flood-induced landscape changes between 1972 and 1995 along the Medina River bottomlands and their impact on RGWT habitat, the quantification of landscape characteristics of stable and declining study sites in the Edwards Plateau, and the development and evaluation of a GIS-based habitat-suitability model for female RGWTs during the breeding season that will allow the assessment of the spatial distribution of adequate habitat in the Edwards Plateau.

The analysis of the landscape characteristics along the North Prong Medina River due to flooding in 1978 had a negative impact on RGWT habitat. Changes in the spatial distribution of woody cover in the bottomlands and the removal of woody cover along riparian zones most likely limited habitat use and dispersal of RGWT along the North Prong Medina River. The analysis of landscape characteristics in sites with stable and declining of RGWTs populations showed that disturbance and a high proportion of woody cover were important factors influencing RGWT populations in areas where turkey numbers had declined. Landscape attributes were used as habitat variables to develop a habitat-suitability model for female RGWTs during the breeding season. The model performed well in characterizing high-suitability habitat for adult female RGWT during the breeding season in the study areas. The use of two scales relevant to RGWT provided important information about the high-suitability areas for female RGWT in stable and declining sites in the Edwards Plateau.

To Vivian and Vivian, my life and my hope…
To Pier Carlo, for being a great dad and friend…

Para Vivian y Vivian, mi vida y mi esperanza…
Para Pier Carlo, un gran papá y un gran amigo....

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CHAPTER I

INTRODUCTION

The Rio Grande wild turkey (RGWT, *Meleagris gallopavo intermedia*) is a gregarious, nomadic bird (Glazener 1967, Beasom and Wilson 1992). Its native range includes Kansas, Oklahoma, Texas, northeastern New Mexico, and northern Mexico. The Edwards Plateau of Texas consists of several forest and range types traditionally considered excellent habitat for RGWTs (Beasom and Wilson 1992). However, data from the Texas Parks and Wildlife Department shows that RGWT abundance in portions of Bandera, Kerr, and Real counties has declined steadily since the late 1970s (Fig.1.1), as compared to other areas of the Edwards Plateau where populations have exhibited no trend (Schaap 2005). The reasons for this decline remain unclear. Possible factors include changes in habitat (Hubbard et al. 1999), increased human population (Beasom and Wilson 1992), decreased availability of foraging resources (Thogmartin 2001), predation, disease, and natural disturbance (Peterson et al. 2002). These factors could affect population dynamics, and thus are of fundamental concern to natural resource managers (Trani and Giles 1999).

Several studies were conducted on RGWTs in Texas from the 1950s through the late 1970s. These efforts focused on nutrition, reproduction, and productivity (Thomas et al. 1966; Crockett 1973; Litton 1977; Beasom and Pattee 1978; Baker 1979). Over the

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This dissertation follows the style and format of Landscape Ecology.

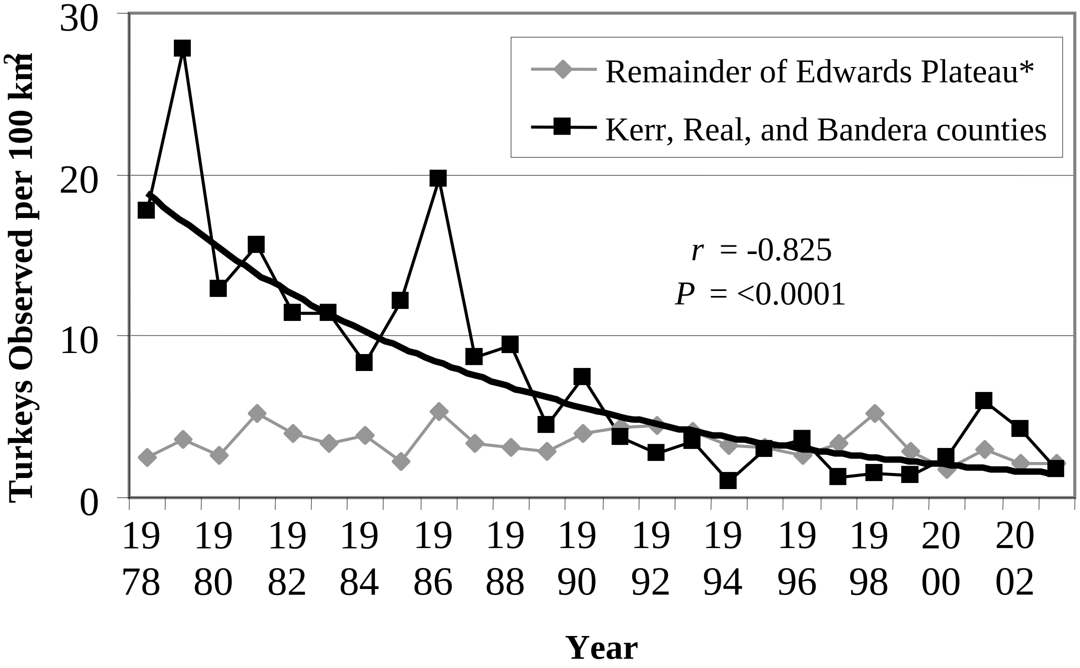

Figure. 1.1. Number of Rio Grande wild turkeys observed per 100 km^2 by Texas Parks and Wildlife Department biologists during summer production surveys for Bandera, Kerr, and Real Counties, Texas, and the remainder of the Edwards Plateau (EP), 1975–2002 (Schaap 2005). * Excludes counties in the EP with a mean value of less than 1 turkey observed per 100 km^2 including Taylor, Val Verde, Coke, Pecos, Kinney, Medina, Comal, Travis, Coleman, Burnet, Runnels, and Brewster counties. (Figure reprinted with permission of Schaap J.N. 2005. Ranges, movements, and spatial distribution of radio-tagged Rio Grande wild turkeys in the Edwards Plateau of Texas. M.S. Thesis, Texas A&M University)

last 25 years, few studies have been conducted on RGWTs in Texas or elsewhere (Peterson 1998), and no studies have addressed issues regarding the declining turkey abundance in the Edwards Plateau (M. Peterson, Texas A&M University, personal communication). There is a need to generate reliable knowledge regarding landscape habitat characteristics and habitat use of RGWT in the Edwards Plateau. This is essential to the management and preservation of RGWT, especially in areas of the Edwards Plateau where its population numbers have been declining.

The overall objective of this study was to identify landscape changes and habitat characteristics that affect RGWT populations using spatial analysis and modeling at multiple-spatial scales. Specific objectives for this study included:

1. Quantification of flood-induced landscape changes between 1972 and 1995 along the Medina River bottomlands and their impact on RGWT habitat (Chapter II).
2. Quantification of landscape characteristics of stable and declining study sites and their implications in RGWT habitat in the Edwards Plateau (Chapter III).
3. Development and evaluation of a GIS-based habitat-suitability model for RGWTs that will allow the assessment of the spatial distribution of adequate habitat in the Edwards Plateau (Chapter IV).

CHAPTER II

FLOODING-INDUCED LANDSCAPE CHANGES ALONG THE NORTH PRONG MEDINA RIVER AND IMPACTS ON RIO GRANDE WILD TURKEY HABITAT

Introduction

Spatial and temporal habitat changes are critical to the distribution and abundance of wildlife (Fahrig 1997, 2001). Changes in the type, size, and spatial arrangement of patches influence populations of avian species (Ambuel and Temple 1983; Estades 2001; Holmes and Sherry 2001; Saveraid et al. 2001; Stephens et al. 2003). Connectivity between habitat patches, and the presence and quality of dispersal routes, also influences avian numbers (Van Dorp and Opdam 1987). Changes in habitat structure also have been recognized as critical factors affecting the population dynamics of wild turkeys (*Meleagris gallopavo*) (Lindzey and Wanless 1973; Weinstein et al. 1995).

Several studies have addressed the relationship between landscape-spatial structure, especially woody cover, and the abundance of eastern wild turkeys (*M. g. silvestris*). Research in Arkansas has shown that woody patch size is positively related to nesting success (Thogmartin 1999). Habitat factors such as topographic position, amount of edge, and patch type (hardwood and mixed-pine hardwood-forest patches) also affect wild turkey nesting success (Thogmartin and Schaeffer 2000; Thogmartin 2001). Studies in Mississippi have shown that habitat-use patterns are consistent for males and females across spatial scales (Miller et al. 1999). Patch type (pine and hardwood-sawtimber patches) is key to wild turkey habitat use, and the presence of tall, mature-tree stands are critical for roosting habitat (Chamberlain et al. 2000). Lack of suitable roosting areas could limit turkey distribution. Furthermore, suitable roosts often are associated with drainage systems, which also are used by wild turkeys for nesting and dispersal (Palmer and Hurst 1995; Miller et al. 2000).

Winter roosting habitat is particularly important to Rio Grande wild turkeys (RGWTs, *M.g. intermedia*) because it provides the "home base" for flocks during the winter (Haucke 1975). Roost-site preservation is essential for maintaining RGWT populations (Litton and Harwell 1995). Roosting sites are composed primarily of patches of large tall trees with low-growing brush both under the roost trees and along the approach to the roost. Such woody patches often are located near creeks, rivers, and intermittent or dry drainages. Several studies in Texas have recognized the importance of drainage systems and their relationship to suitable-roosting habitat for RGWTs (e.g. Thomas et al. 1966; Gore 1973; Litton 1977). Removal and/or disturbance of roosting sites could lead to a reduction in wild turkey numbers (Cook 1973b). Similar results regarding RGWT numbers and their relationship to streams and drainage networks were found in Kansas (Capel 1973; Hennen and Lutz 2001), Iowa (Wigal 1973), and Oregon (Keegan and Crawford 2000). Thus, management practices used for brush control or removal should take into account roosting sites as well as the maintenance of adequate stands of woody species to provide food and cover for wild turkeys along drainage systems (Walker 1949, 1950; Litton 1977).

The RGWT is a gregarious, nomadic bird (Glazener 1967; Beasom and Wilson 1992). Its native range includes Kansas, Oklahoma, Texas, Northeastern New Mexico, and northern Mexico. It is thought that before European settlement there were approximately 3 million turkeys within their native range (Beasom and Wilson 1992). By the end of the nineteenth century, RGWT populations declined to approximately 100,000 birds due to habitat changes and unregulated hunting. In 1880, the first efforts to restore populations of wild turkeys across its native range were established through the enactment of legislation aimed at the restoration of RGWT to their native range (Beasom and Wilson 1992). Restocking appears to have been one of the best strategies used in restoring wild turkey abundance. Most RGWT have been restocked from populations originating from remnant flocks in the Edwards Plateau and South Texas (Peterson et al. 2002).

The Edwards Plateau consists of several woodland and savannah types traditionally considered excellent habitat for RGWTs (Beasom and Wilson 1992). However, data from the Texas Parks and Wildlife Department demonstrates that RGWT abundance in portions of Bandera, Kerr, and Real counties, with previously high numbers, has declined steadily since the late 1970s as compared to other areas of the Edwards Plateau where populations have exhibited no trend (Schaap 2005). The reasons for this decline remain unclear. Possible factors include changes in habitat (Hubbard et al. 1999), increased human population (Beasom and Wilson 1992), decreased availability of foraging resources (Thogmartin 2001), predation, disease, and natural disturbance (Peterson et al. 2002). These factors could affect population dynamics, and thus are of fundamental concern to natural resource managers (Trani and Giles 1999).

During the summer of 1978, remnants of tropical storm Amelia precipitated severe flooding along the Sabinal, Guadalupe, and Medina rivers, causing heavy loss of life and property. In less than 24 hours, more than 500 mm of rainfall fed the headwaters of the rivers and caused flashfloods. Massive, up to 1.80 m in diameter at breast height, bald cypress (*Taxodium distichum)* along riparian zones were pulled from the ground or snapped off (Bomar 1995). The flooded area corresponds with areas where wild turkey abundance has declined since the late 1970s. Thus, it is possible that landscape changes caused by this flood have contributed to the decline in RGWT abundance by altering the spatial configuration of woody cover suitable for roosting, breeding, and dispersal along the streams and bottomlands associated with the North Prong Medina River.

The objective of this study was to quantify landscape changes that resulted from the flooding of 1978 along the North Prong Medina River and its tributaries to determine their potential impact on RGWT habitat. The hypotheses were that (1) the amount of woody cover decreased significantly near the streams due to the flood of 1978, and that (2) suitable habitat was fragmented and connectivity reduced, which resulted in decreased overall habitat suitability of the area for RGWTs.

Study area

The study area consisted of the middle reaches of the North Prong Medina River near the boundary of Bandera and Kerr counties, Texas (Fig. 2.1). The upper reaches of the watershed are dominated by the Eckrant rock outcrop association which includes limestone derived shallow stony (undulating) or rocky (steep) clay soils (NRCS 2000). The bottomlands (<585 masl and <12% slope) are composed of 11 soil series, including deep loams, clay loams, or loams. Woody vegetation primarily consists of pecan (*Carya illinoensis*), Texas oak (*Quercus buckleyi*), shin oak (*Q. havardii*), post oak (*Q. stellata*), live oak (*Q. virginiana*), ashe juniper (*Juniperus ashei*), and bald cypress. Grasses include switchgrass (*Panicum virgatum*), bluestem (*Andropogon spp.*), gramas (*Bouteloua spp.*), Indiangrass (*Sorghastrum nutans*), curly mesquite (*Hilaria belangeri*), and buffalograss (*Buchloe dactyloides*) (Van Auken 1988; Randel 2003). The riparian zone forests (<200 m from streams) tend to be richer in woody species composition, and support trees having larger mean basal areas than other portions of the Edwards Plateau (Van Auken 1988; Armstrong et al. 1991).

Methods

Aerial photography from 1972 and 1984 and digital ortho-quadrangles from 1995 (1-m resolution) was classified into 3 categories (woody, non-woody, water) using an unsupervised classification in ERDAS 8.6. Overall classification accuracies were

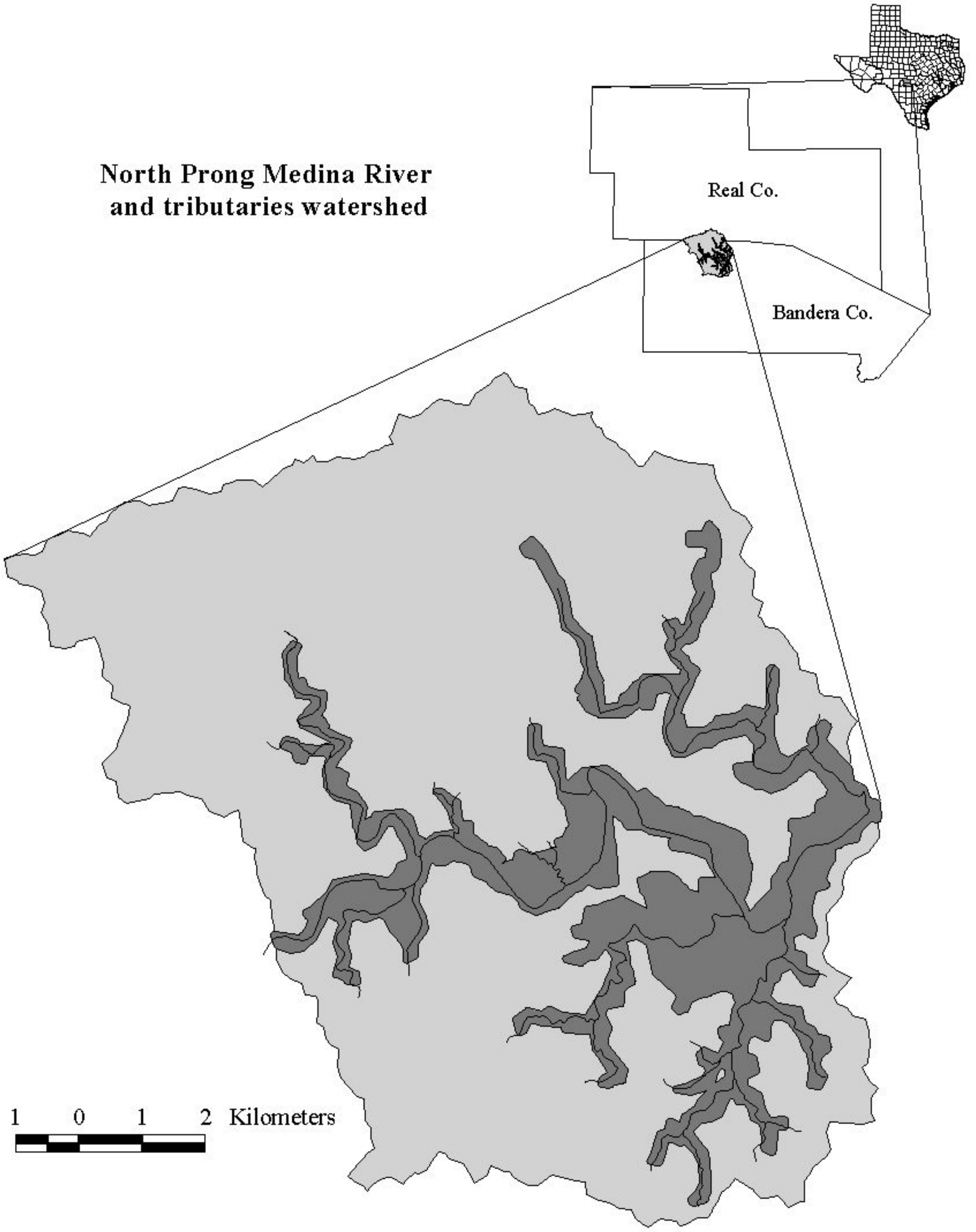

Figure 2.1. Study area location. The dark grey areas correspond to the bottomland of the North Prong Medina River in Bandera and Real Counties.

92% (1972), 93% (1984), and 93% (1995) (Congalton 1991). The analyses were performed at 2 spatial scales: The bottomlands of the North Prong Medina River and its tributaries, where the impact of flooding potentially extended; and in more detail, the riparian zones where roosting habitat typically was concentrated and the affects of flooding greatest.

Bottomland analysis

Bottomlands were defined based on a digital elevation model for the North Prong Medina River, as areas below 585 m altitude and with $\leq$12% slope. A 60-m buffer was added to include all bottomland water bodies, and a 200-m buffer was bottomland edge habitat. The bottomland section of the watershed had an area of 2,381 ha (21% of the watershed). A total of 70 km of stream was identified and classified into 24 first-order streams (35.1 km), 9 second-order streams (19 km), 2 third-order streams (13.1 km), and 1 fourth-order stream (2.8 km).

Using the bottomland-classified images (1975, 1984, and 1995), a moving-window analysis (diameter 400 m, step 50 m) was performed for each time period (Rho 2003). For each moving window, landscape metrics were calculated using Fragstats (McGarigal and Marks 1995). A set of variables was selected for quantifying changes in woody cover: percent woody cover, mean patch size (MPS), patch density (PD), edge density (ED), mean shape index (MSI), area-weighted mean shape index (AWMSI), mean nearest neighbor distance (MNN), and mean proximity index (MPI) (Gustafson et al. 1994; McIntyre 1995). Frequency distributions for each variable were calculated and compared them among years using the Kolmogorov-Smirnov Z goodness of fit test with a 0.05 level of significance. A total of 10,558 moving windows was used to build the frequency distributions.

Riparian zones analysis

Using ArcView 3.2a (ESRI), streams were manually digitized based on aerial photography, and classified into stream orders. Within each stream order, samples with a length of 400 m were selected randomly. A total of 47 samples was analyzed: 18 first-order, 15 second-order, 11 third-order, and 3 fourth-order streams. For each sample 50-m buffers up to a length of 200 m were created, and the classified images were clipped based on the buffers. For each clipped image, landscape metrics that describe the spatial pattern of woody cover: percent woody cover, MPS, patch size standard deviation (PSSD), largest patch index (LPI), PD, ED, MNN, and MPI (Gustafson et al. 1994; McGarigal and Marks 1995; Lausch and Herzog 2002) were determined using FRAGSTATS. Based on these metrics, the differences in woody cover among 1972, 1984, and 1995 for each stream order were compared using an analysis of variance, and their means were compared using Tukey's W procedure with a significance level of 0.05.

Results

Bottomland

The proportion of woody cover in the bottomland associated with the North Prong Medina River did not differ by year (Fig. 2.2). However, spatial distribution (MPS and PD) of woody cover was substantially different among years. Woody cover along the bottomland was distributed in small, high-density patches in 1972; while in 1984, woody patches were fewer but larger in size. In 1972, 48% of the bottomland had woody patches with a MPS of 0.01 ha, but in 1984, 37% of the bottomland had higher MPS values ranging between 0.03 and 0.05 ha. Woody-patch density decreased in range and number between 1972 (24 patches/ha, range 136.5) and 1984 (6 patches/ha, range 35.5). In 1995, frequency distributions of MPS and PD were intermediate to those of 1972 and 1984. These data are consistent with the hypothesis the flood of 1978 eliminated many small patches in the bottomland areas, leading to important increases of woody cover MPS and reduction of PD.

Woody-cover complexity in the bottomland off the North Prong Medina River changed significantly among 1972, 1984, and 1995. The proportion of ED in woody cover patches decreased between 1972 (mode ED = 1,800 m/ha, range ED = 3,857) and 1984 (mode ED = 700 m/ha, range ED = 2,044). Complexity metrics (MSI and AWMSI) showed opposite trends than expected between 1972 and 1984 (Fig. 2.2). Frequency distribution for MSI showed an increase in woody-cover complexity between both time

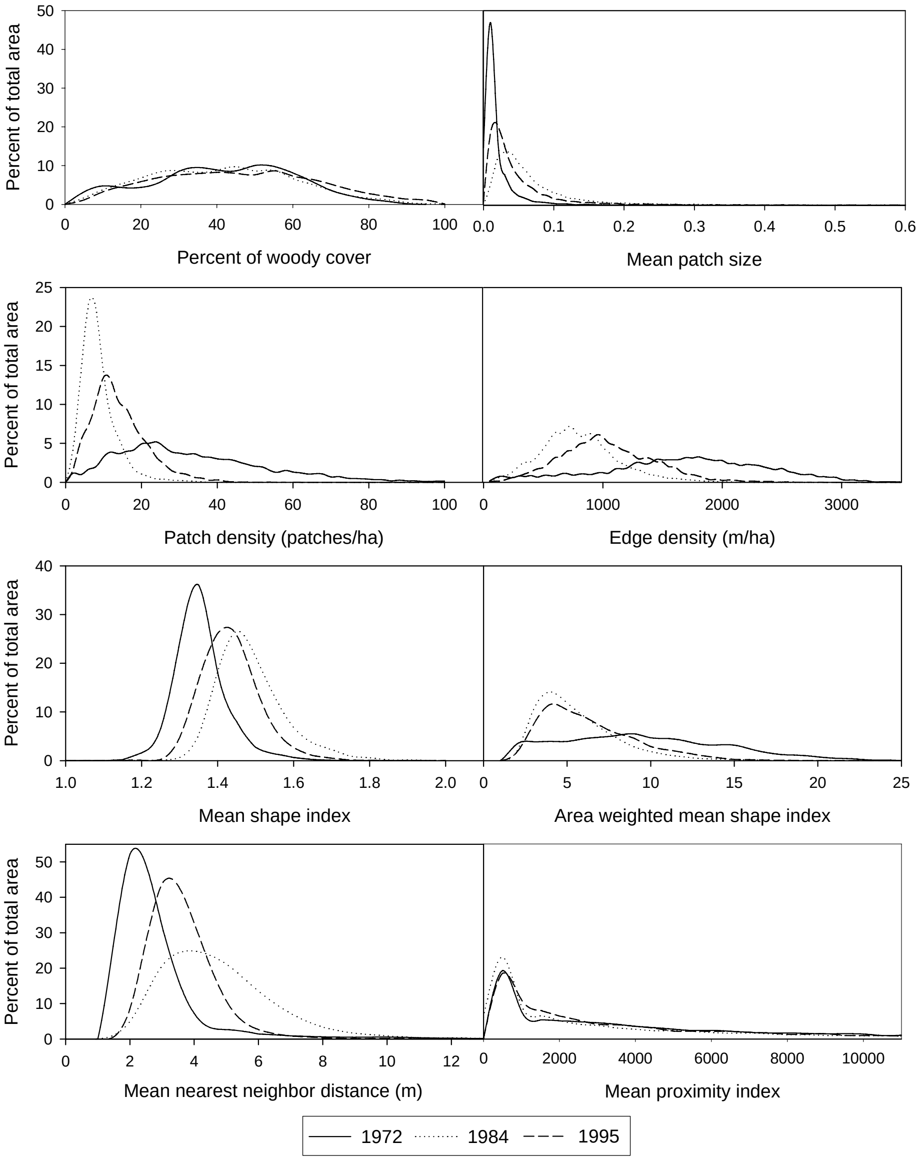

Figure 2.2. Frequency distributions of woody-cover metrics for the bottomlands in 1972, 1984, and 1995 based on moving-window analysis. Based on Kolmogorov-Smirnov Z tests, there were significant differences between the frequency distributions of any 2 years for all metrics, except percent of woody cover.

periods. However, a major decrease in the amount of small woody patches may explain the trend observed for MSI. Values for AWMSI decreased from 1972 (mode = 9, range

= 26.87) to 1984 (mode = 4, range = 17.07), instead of increasing. Smoothing of edges in larger patches, due to the flooding of 1978, may have contributed to the trends observed for AWMSI between 1972 and 1984. In 1995, complexity metrics (ED, MSI, and AWMSI) frequency-distribution curves were intermediate between those from 1972 and 1995. The removal of large numbers of small patches and the smoothing of edges in larger ones may have increased the distance between neighboring patches between 1972 and 1984.

The distance and proximity between neighboring patches increased between 1972 and 1995 (Fig. 2.2). Mode and range for MNN frequency distribution increased between 1972 (2 m and 180.8, respectively) and 1984 (4 m and 233.0, respectively). Although the MPI mode was 500 for all time periods, the proportion of bottomland with this value was lower in 1972 (19.3% of the bottomland area) than in 1984 (23.6% of the bottomland). In 1995, values for MNN and MPI frequency distribution were intermediate between those from 1972 and 1984. The flooding of 1978 likely removed small patches and smoothed edges of larger patches, increasing the distance between standing-woody patches and decreasing the proportion of areas with large MPI values.

Riparian zones

The proportion of woody cover changed differentially along stream orders between 1972, 1984, and 1995. No significant changes were observed in the proportion of woody cover in first- and second-order streams (lower-order streams), and areas beyond 50 m of third-order streams (Fig. 2.3). Areas within 50 m of third-order streams had significant decreases in the amount of woody cover between 1972 (49.4% woody cover), 1984 (25.4% woody cover), and 1995 (29.1% woody cover). Similar trends were observed for fourth-order streams (Fig. 2.3). Changes in the proportion of woody cover observed in riparian zones suggest that the flooding had greater impact in third- and fourth-order streams (higher-order streams).

Spatial distribution of woody cover in riparian zones, along the North Prong Medina River, was considerably different by year. In 1972, riparian zones had small woody patches in high densities for all streams, and woody-patch size decreased as stream order increased (Fig. 2.3). In 1984, woody-patch size and woody-patch size variability increased, while the number of patches decreased, as compared to 1972. However, LPI did not change for these 2 time periods along lower stream orders (first- and second-order streams), while it decreased significantly along higher-order streams (third- and fourth-order streams). In 1995, metrics that describe spatial distribution of woody cover (MPS, PSSD, PD, and LPI) had intermediate values to those from 1972 and 1984 (Fig. 2.3). Increased MPS, decreased PD and similar LPI values between 1972 and 1984, along first- and second-order streams, are most likely due to a coalescence of contiguous patches. Increased MPS, and decreased PD and LPI values, in third- and fourth-order streams, during the same time period, indicate a decrease in the number of small woody patches and the size of larger patches. Changes in the spatial distribution of

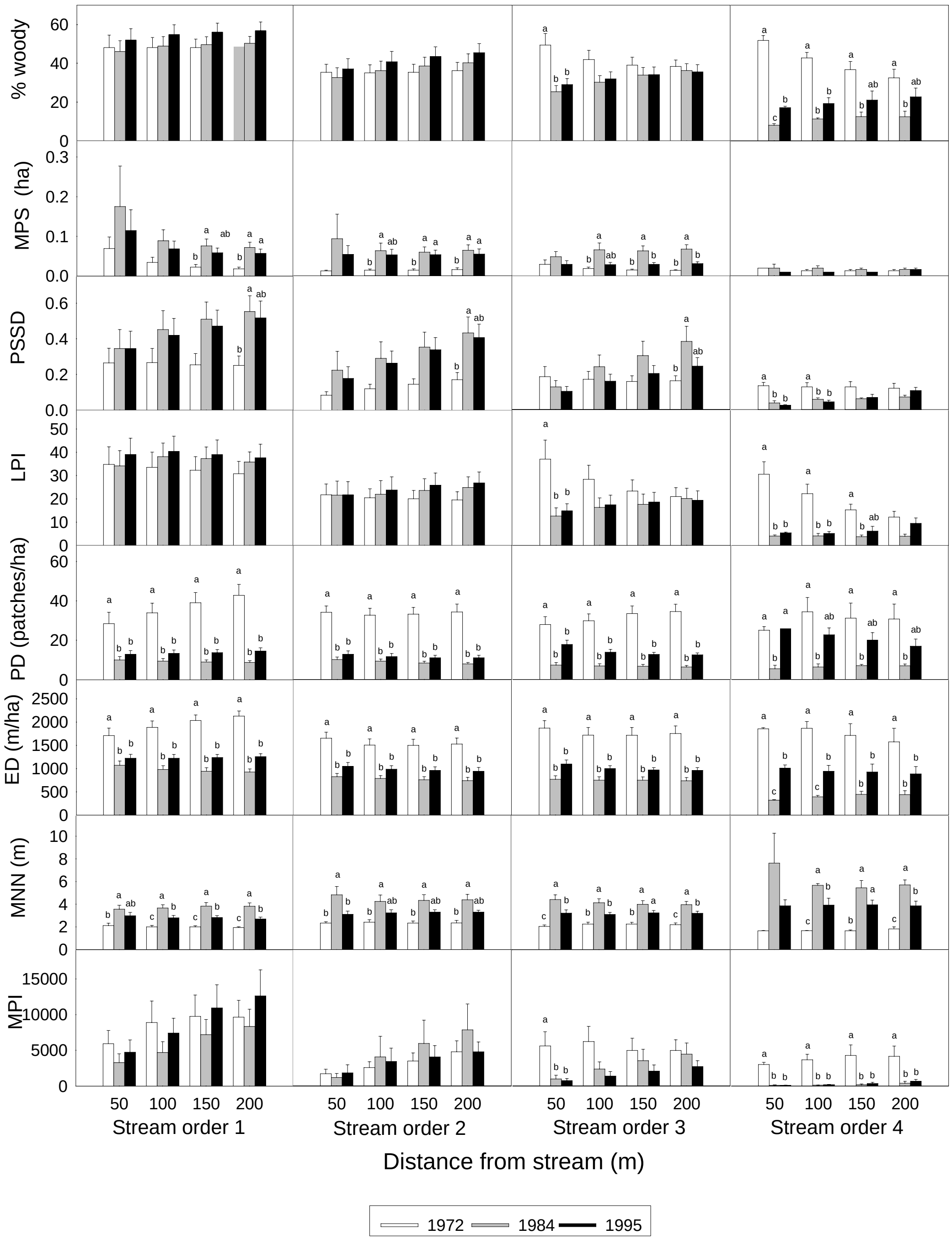

Figure 2.3. Riparian zones, woody-cover metrics by distance from stream and stream order, in 1972, 1984, and 1995. Percent woody (percent of woody cover), MPS (mean patch size), LPI (largest patch index), PD (patch density), ED (edge density), MNN (mean nearest neighbor), and MPI (mean proximity index).

woody cover along riparian zones of the North Prong Medina River indicate the woody-cover patches coalesced into contiguous patches in first- and second-order streams, while third- and fourth-order streams may have been impacted by the flooding of 1978, causing a reduction in the number and size of woody patches. Metrics describing spatial distribution of woody cover (MPS, PSSD, PD, and LPI) in 1995 were intermediate between those from 1972 and 1984.

Woody-patch edge and proximity between neighboring patches changed along riparian zones of the North Prong Medina River between 1972 and 1984. Values of ED before the flooding (mean = 1750 m/ha in 1972) were greater than after the flooding (mean = 727 m/ha in 1984) for all stream orders (Fig. 2.3). The decrease in ED was greater in higher-order streams than lower-order streams. Distance between neighboring patches increased for all stream orders between 1972 and 1984. For these time periods, MNN values increased by 2.2 m in first-, second-, and third-order streams, while in fourth-order streams, MNN values increased by 4.4 m (Fig. 2.3). There were no substantial changes in MPI values between 1972 and 1984. There were no significant changes in MPI values between 1972 and 1984 for first-, second-, and areas beyond 50 m of third-order streams. For the same time period, MPI values decreased by 82.5% in areas within 50 m of third-order streams and by 96.1% all across fourth-order streams (Fig. 2.3). Higher-order streams were impacted the most by the flooding of 1978 and reduced woody-cover areas, decreasing the number, size and edge of woody patches, and increasing the distance between them. These changes likely had negative impacts on

RGWT roosting, breeding and dispersal habitat. In 1995, values for ED, MNN, and MPI were different from those of 1984 and seem to be returning to 1972 values.

Discussion

It is proposed the flooding of 1978 had a negative impact on RGWT habitat associated with the bottomland and riparian zones along the North Prong Medina River. Although the amount of woody cover did not change significantly for most of the area, its spatial structure changed after the flood. The changes in the proportion of woody patches between 1972 and 1984 suggest the flooding eliminated many small woody patches (area < 1000^2 m). The presence of small woody patches decreased by 72.8% between 1972 and 1984. The flood event also decreased the amount of edge and thus in the complexity of woody patches. While shape index values (SI) were similar for small patches, SI values for large patches decreased between 1972 and 1984 (Fig. 2.4). The number of small patches and the complexity of large patches were reduced by the flooding of 1978. This reduction in patch density and complexity may have had an impact on RGWT roosting and dispersal habitat.

Although woody cover increased slightly and ED decreased from 1972 to 1984, MSI increased along the bottomland of the North Prong Medina River (Fig. 2.2), a result which might appear counterintuitive. Values of MPS also increased in this period (Fig. 2.2); an inspection of the patch size-specific SI and PD distribution revealed a substantial reduction in small patch density, which had consistently low SI (Fig. 2.4).

This decrease in small woody patches with smaller SI values resulted in the increase in MSI value for the bottomland areas of the North Prong Medina River (Fig. 2.2). In contrast to MSI, AWMSI values decreased in the bottomland between 1972 and 1984 (Fig. 2.2) despite the large reduction in small patches with low SI. These were due to the decrease in SI values for large patches between 1972 and 1984 (Fig. 2.4). Since larger patches were weighted several magnitudes greater than smaller patches in determining AWMSI, decreased values of SI for large patches resulted in lowered AWMSI values for the bottomland areas. In 1995, there appeared to be a recovery process as the frequency distribution of patch area, SI, MSI and AWMSI, were intermediate between 1972 and 1984 values. Thus, the use of MSI and AWMSI alone might offer limited understanding for the changes in complexity of woody cover. Combined use of these metrics with frequency distributions of SI and PD, by patch size, helped explain changes in the density and complexity of woody patches in bottomland areas of the North Prong Medina River between 1972 and 1995 and their possible impacts for RGWT. The reduction in the number of small patches and the decrease in the amount, or smoothing, of edge in larger patches increased the distance between neighboring patches between 1972 and 1984.

The flooding of 1978 reduced the connectivity of woody patches in the bottomland of the North Prong Medina River. The distance between neighboring-woody patches was greater in 1984 than it was in 1972 (Fig. 2.2). It is likely that this was caused by the removal of small patches and the “smoothing” of the edges of large woody patches within the bottomland. By 1984, a large portion of the bottomlands had lower

MPI values relative to 1972 (Fig. 2.2). According to Gustafson and Parker (1994) and Gustafson et al. (1994), the proximity index is a useful indicator of habitat accessibility

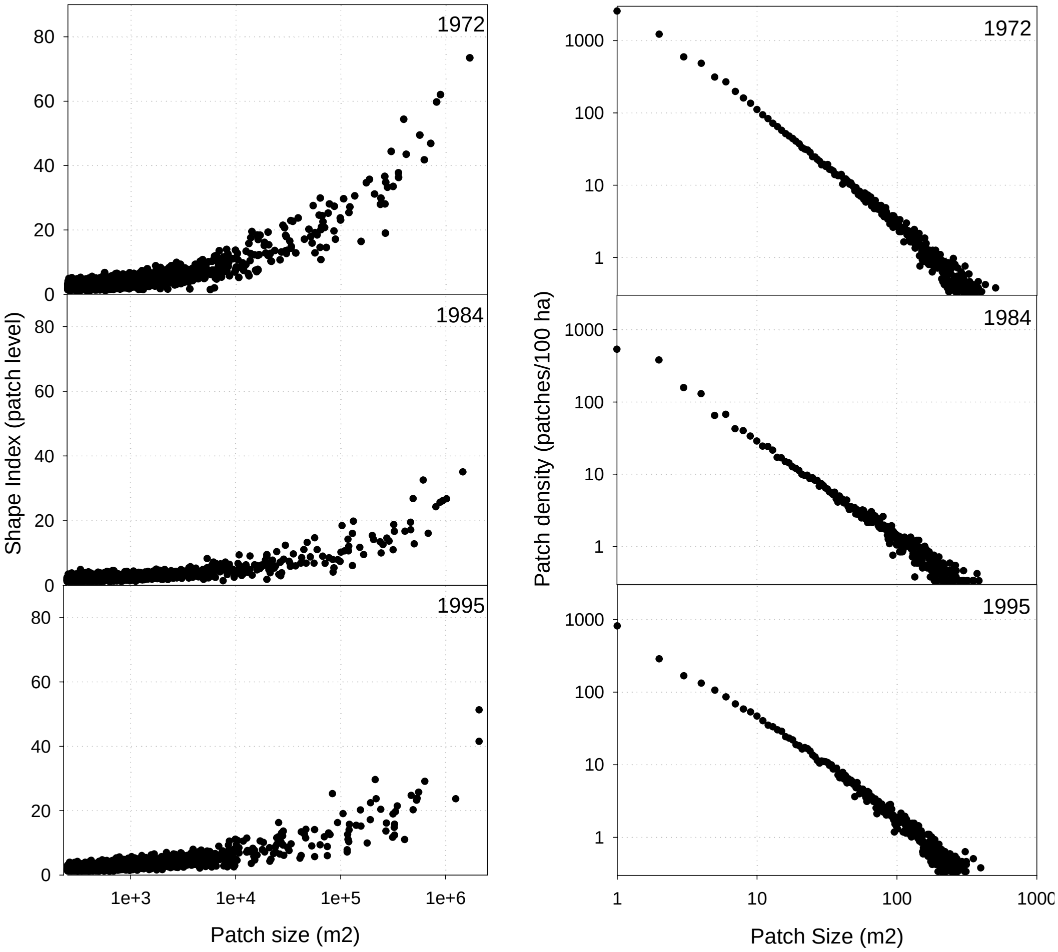

Figure 2.4. Frequency distributions of patch shape index and patch density by patch size in the bottomland areas of the North Prong Medina River for 1972, 1984, and 1995.

across a fragmented landscape. Gustafson et al. (1994) suggested that if the variation of total area is low, losses in proximity values occur as a result of increasing isolation of patches. This argument is consistent with the results observed in the bottomland area of the North Prong Medina River. The amount of woody cover in the bottomland did not change significantly after the flooding of 1978, but the shape, size, and spatial configuration of woody patches did, which resulted in increased distance between woody patches and reduced connectivity among woody areas. The removal of large trees and the decrease in the number of small patches, the proportion of edge habitat, and connectivity of woody cover have the potential to negatively impact RGWT habitat for roosting, breeding, feeding, and dispersal (Gore 1973; Thomas et al. 1973; Litton 1977; Quinton et al. 1980; Hennen and Lutz 2001). Therefore the reductions observed in the number of small patches and connectivity across the bottomland as a result of the flood may have negatively impacted RGWT habitat. Cobb et al. (1993) and Cobb and Doerr (1997) found that flood events in North Carolina had a negative impact on demography and reproduction of wild turkeys.

Based on woody-cover classification for RGWT habitat (Walker 1949, 1950; Quinton et al. 1980), about 55% of the bottomland areas had poor or suboptimal habitat for RGWT (Fig. 2.5) both before and after the flooding of 1978. It is likely that quality habitat was concentrated along riparian zones of the North Prong Medina River. The flooding had a significant impact on the landscape of riparian zones, especially along higher-order streams. The amount of woody cover and the proportion of large patches in the riparian zones were greatly reduced between 1972 and 1984 (Fig. 2.3), converting these areas to poor or sub-optimal habitat for RGWT. The number of patches and amount of edge in the riparian zones also decreased. The distance between woody patches increased, and the MPI decreased. Consequently, connectivity of woody cover along riparian zones also decreased.

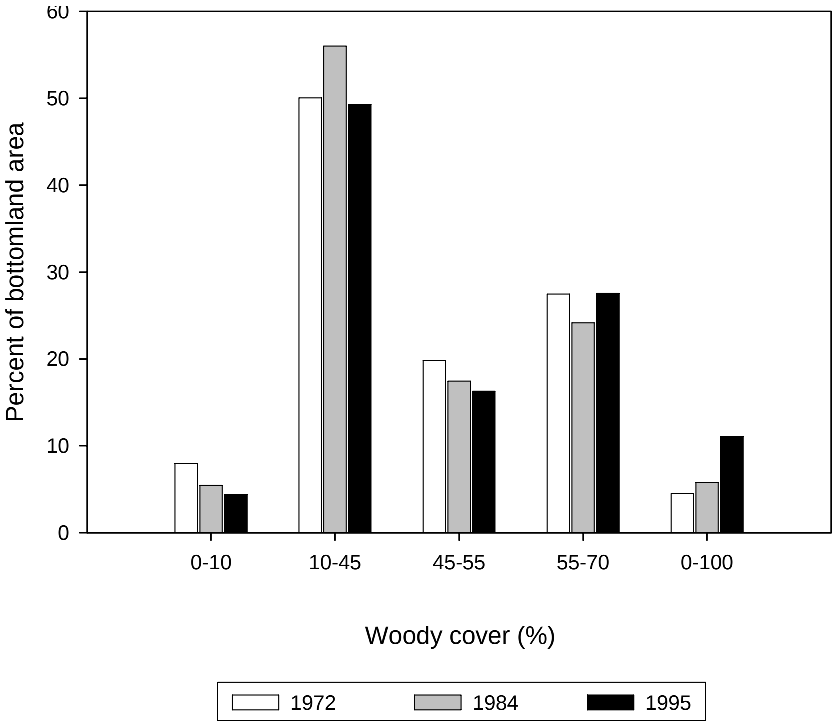

Figure 2.5. Proportion of bottomlands with different woody categories, and associated habitat suitability for Rio Grande wild turkey in 1972, 1984, and 1995.

Riparian zones in this portion of the Edwards Plateau tend to be richer in woody species composition and mast producing species than uplands (Van Auken 1988). Riparian zones are important to RGWT because they provide habitat for roosting, feeding, breeding, and dispersal (Palmer and Hurst 1995). Roosting habitats are located primarily along the drainages and are essential to wild turkeys (Haucke 1975; Litton

1977). These areas are important sources of food for RGWT (Gore 1973). Lehman et al. (2002) reported that Rio Grande and eastern wild turkeys have similar requirements for nesting cover. Studies have associated riparian habitats to wild turkey nesting (Palmer and Hurst 1995; Miller et al. 2000; Thogmartin 2001), and female RGWT have been reported to use woody habitats along riparian areas for brood rearing (Hennen and Lutz 2001). Wild turkey dispersal depends on good connectivity along riparian zones (Litton 1977; Gustafson et al. 1994).). The removal of roosting trees and/or disturbance of roosting areas have a negative impact on RGWT numbers (Thomas et al. 1966; Cook 1973b; Gore 1973).

As Bomar (1995) indicated, the flooding of 1978 removed large trees from riparian areas along the North Prong Medina River. This corroborates the results presented here that show large amounts of woody cover were lost along riparian zones of higher-order streams (up to 89% loss in fourth-order streams) resulting in substantial reduction of suitable habitat for RGWT in these areas. Therefore the fragmentation of woody cover, due to the flooding of 1978, may have limited roosting habitat, areas for feeding, breeding, and travel ways for RGWT along higher-order streams of the North Prong Medina River. The lost of travel ways for RGWT along higher-order streams also likely limited the connectivity among suitable habitat areas along lower-order streams. These changes are likely to have contributed to the decline of RGWT in the study area.

There appears to have been a recovery process that has taken place in the bottomland and the riparian zones after the flooding of 1978. In 1995, 17 years since the flooding, most of the woody-cover metrics at both scales had intermediate values to those of 1972 and 1984. Smaller and more woody patches were observed in 1995 than in 1984. However, they were still fewer than those observed in 1972. The nearest neighbor distance between woody patches also decreased from 1984 to 1995, suggesting increased connectivity among woody patches, but had not yet recovered to the 1972 level.

A large proportion of the bottomland in the North Prong Medina River consisted of poor or sub-optimal habitat quality for RGWT. The amount of woody cover did not change significantly following the flooding of 1978 but the connectivity of adequate habitat for wild turkeys was reduced. Better habitat conditions for RGWT are concentrated along riparian zones. The flooding of 1978 reduced the amount of woody cover in riparian zones of higher-order streams. Such a disturbance in the higher-order streams resulted in the fragmentation of woody patches, reduction of connectivity between patches, and overall decreases in the amount of suitable habitat, limiting areas for roosting, feeding, breeding, and dispersal of RGWT. The flooding of 1978 likely contributed to the decline of RGWT in the study area. There appears to have been a recovery process of the bottomland landscape 17 years after the flooding. There has been a partial recovery of woody cover along the riparian zones and bottomland of the North Prong Medina River that may benefit RGWT habitat. However further studies are necessary to examine whether or not the recovery of woody cover in areas affected by the flooding of 1978 will provide suitable habitat for the use and dispersal of RGWT.

As the removal of large amounts of woody cover by the flooding of 1978 most likely limited habitat use and dispersal of RGWT, management practices should be directed to provide adequate habitat conditions for roosting, feeding, breeding, and dispersal of RGWT. Areas along streams should be assessed for availability of roosting sites. Management of riparian areas with mast producing species should be encouraged to provide adequate supplies of food. Adequate stands of woody species should be left along drainage systems to provide breeding habitat, feeding routes and travel ways for RGWT.

CHAPTER III

COMPARISON OF LANDSCAPE CHARACTERISTICS AT SITES WITH STABLE AND DECLINING RIO GRANDE WILD TURKEY POPULATIONS IN THE EDWARDS PLATEAU OF TEXAS

Introduction

Rio Grande wild turkeys (RGWTs, *Meleagris gallopavo intermedia*) are gregarious nomadic birds of southern North America (Glazener 1967; Beasom and Wilson 1992; Kennamer and Kennamer 1995). Their native range includes Kansas, Oklahoma, Texas, and northeastern New Mexico, in the United States, and Chihuahua, Cohahuila, Nuevo Leon, and Tamaulipas, in Mexico. In Texas, the Edwards Plateau consists of ecological sites traditionally considered excellent RGWT habitat (Taylor 1949; Peterson et al. 2002). However, data from the Texas Parks and Wildlife Department show that RGWT abundance in portions of Bandera, Kerr, and Real counties has steadily declined compared to other areas of the Edwards Plateau, where proportions have increased or remained stable (Peterson et al. 2002). Possible factors that may have negatively impacted RGWT populations include unsuitable woody cover (Walker 1949, 1950; Gore 1973; Quinton et al. 1980; Beasom and Wilson 1992), disturbance (Gore 1973; Lindzey and Wanless 1973), decreased availability of foraging resources (Thogmartin 2001), predation, and diseases (Peterson et al. 2002).

Open areas, well interspersed with woody cover, are important to RGWT habitat (Schorger 1966; Beasom and Wilson 1992). Habitat for RGWTs should contain a maximum of 65–70% woody cover. Optimal habitat should consist of 50% open areas with well-interspersed woody cover for roosting, feeding and dispersal. Roosting habitat provides the “home base” during winter months (Haucke 1975). Roost sites are essential for maintaining RGWT populations (Litton and Harwell 1995) and are primarily composed of large trees near creeks, rivers, and intermittent or dry drainages. Removal or disturbance of roosting sites could lead to a reduction of wild turkey numbers (Cook 1973b). Roosting sites are important for suitable RGWT roosting habitat (Thomas et al. 1966; Gore 1973; Litton 1977).

Diets of RGWTs consist mainly of insects and herbaceous vegetation (Quinton et al. 1980). Woody plants, especially mast producing species (*Quercus stellata* and *Q. virginiana*), also are an important component of RGWT diets (Beasom and Wilson 1992). Randel (2003) found that insects, particularly orthoptera, were important to poult diets. Quinton et al. (1980) found that insects, grasses, and forbs frequently ingested by turkeys were abundant in open areas. However, lack of woody patches in these areas would limit RGWT use, thus reducing escape routes and dispersal habitat. Dispersal routes are important because RGWTs have marked seasonal shifts (Thomas et al. 1966; Keegan and Crawford 2000). Seasonal movements from winter ranges to reproductive ranges by female RGWTs represent the largest portions of their movement. Therefore, the open areas interspersed with woody cover are important for roosting, feeding, and dispersal habitat for RGWTs.

Human and natural disturbances also affect RGWT populations (Gore 1973; Lindzey and Wanless 1973; Beasom and Wilson 1992). Land used for recreational purposes, camping areas, highways, industrial parks, and urban and rural development negatively affects RGWT populations (Lindzey and Wanless 1973). Overgrazing and improved pastures also affect RGWT food sources and limit feeding and dispersal habitat especially in bottomland areas (Gore 1973).

The objective of the study was to quantify and compare landscape characteristics of sites with stable and declining populations of RGWTs in the Edwards Plateau of Texas to better understand why RGWT numbers have decreased in the southeastern portion of this region. The hypotheses were that (1) the proportion and spatial distribution of woody cover was different between sites with stable and declining populations, and (2) disturbance was significantly higher in sites where populations had declined than in sites where populations had remained stable.

Methods

Study areas

The study areas are located in the southeastern portion of the Edwards Plateau in Kerr, Real, Bandera, and Medina counties, Texas. The dominant soils correspond to the Tarrant-Eckrant-Purves and Eckrant-rock outcrop-Bracket soil associations. The Tarrant-Eckrant-Purves soil association corresponds to limestone derived shallow, clayey, stony, and cobbly soils, and the Eckrant-rock outcrop-Bracket corresponds to cobbly clayey to loamy, shallow soils (Dittmar et al. 1977; Hensell et al. 1977; Dittemore and Coburn 1986). The topography varies from gently undulating uplands to strongly sloping areas in a benched landscape. Major vegetation types correspond to live oak-mesquite-juniper parks or woods. Woody vegetation primarily consists of live oak (*Q. virginiana*), Ashe juniper (*Juniperus ashei*), and shin oak (*Q. havardii*) forming mottes or woodlands (Randel 2003). Grasses include swtichgrass (*Panicum verigatum*), bluestem (*Andropogon spp*.), red grass (*Bothriochloa spp.*), little bluestem (*Schizachyrium scoparius*), grama grass (*Bouteloua spp*.), Indian grass (*Sorghastrum nutans*), wildrye (*Elymus spp*.), curly mesquite (*Hilaria belangeri*), and buffalo grass (*Buchloe dactyloides*).

Regions supporting stable and declining RGWT populations were delineated based on winter roost counts and landowner interviews as part of a larger study that proposes to address the spatial extent and degree of the decline in RGWT abundance in the Southern Edwards Plateau of Texas (Peterson, unpublished data). Two sites were selected within each of the regions with stable (sites S1 and S2) and declining (sites D3 and D4) RGWT abundance. The spatial extent of each study sites was based on the minimum convex polygons for all turkey locations observed on the site. The respective areas of the study sites were 45,993 ha for site S1 (30°01’N, 99°18’W), 15,931 ha for site S2 (29°49’N, 99°45’W), 11,989 ha for site D3 (29°52’N, 99°25’W), and 15,141 ha for site D4 (29°39’N, 99°06’W). Each study site was sampled by generating random sample points and buffering them to create 3,500-ha sample areas. This area was calculated based on the largest seasonal range observed in the study area (Schaap 2005). To consider a sample area for analysis, ≥90% of the area was required to be within the limits of minimum convex polygon for all turkey locations. Four sample areas were obtained for site S1, two samples for sites S2 and D3, and three samples for site D4 (Fig. 3.1).

Data collection and analysis

Data on ecological sites and their spatial distribution were obtained from the Soil Survey Geographic database (SSURGO). Soil series were combined into ecological sites (USDA 2004) and sampled for each study site using the created sampling areas. Digital elevation models (DEM) were obtained from Texas Natural Resources Information System (TNRIS). The DEMs were used to derive surface area indices (SAI) (Jenness 2004). Surface area index values >1,000 were classified as high relief terrain (HRT). Percentage of rough terrain was calculated for each sample area.

Landsat TM imagery from April 2000 was obtained from the Global Land Cover Facility (University of Maryland, United States). The image was classified, using an unsupervised classification (Leica Geosystems 2003), into three classes: woody, non-woody, and water cover. Overall accuracy for the classification was 87% (Congalton 1991). The classified grids were clipped based on the sample areas. Patch Analyst (GRID) (Elkie et al. 1999) was used to obtain metrics that describe spatial structure:

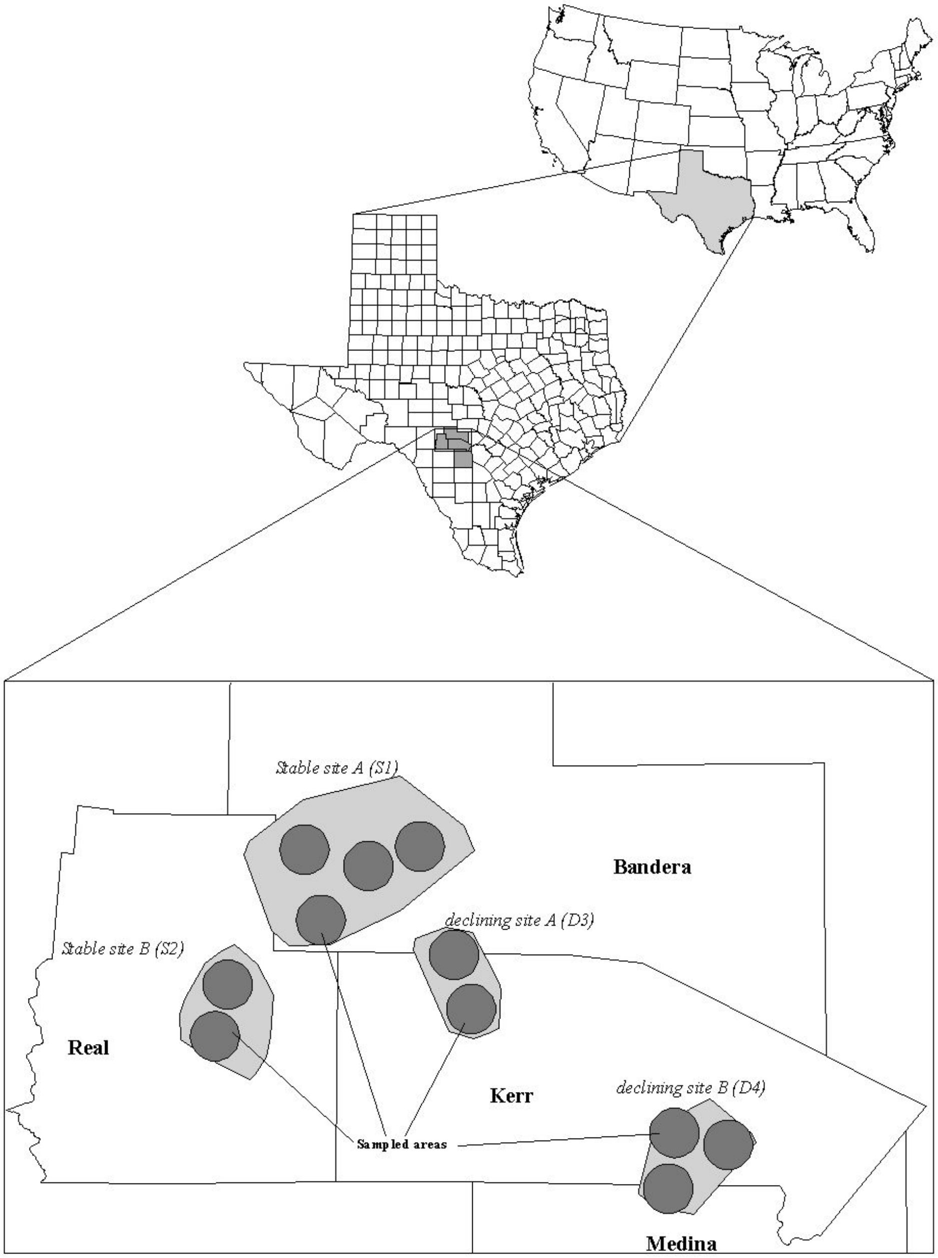

Figure 3.1. Location of Rio Grande wild turkey study sites characterized by stable (S1, S2) and declining (D3, D4) turkey abundance.

percent woody cover, mean patch size (MPS), patch density (PD), and largest patch index (LPI). The amount of usable space available to RGWT in each study area (Guthery 1997) was determined. Usable space in these areas was defined as bottomland areas excluding HRT with >70% woody cover (Walker 1949, 1950) and its adjacent upland.

Available digital orthophoto quadrangles (DOQ) from 1995 (1 m resolution) were obtained from TNRIS. These DOQs were used to manually digitize roads, disturbed areas, and streams for each sample area. Croplands, improved pastures, and urban development were classified as disturbed areas. Streams were classified according to stream order. For each sample area, a 50-m buffer was created from streams. The amount and spatial distribution of woody cover was calculated for these buffer zones using two methods: the first included all of the terrain within 50 m of streams; the second excluded areas with HRT. The proportion of woody cover for each stream order, including HRT areas within 50 m of streams, was also determined. A 50-m-buffer zone was created around roads and disturbed areas in each sample area. The length and proportion of streams that were within the 50-m buffers of roads and disturbed areas were determined.

Ecological sites, stream density, percentage of HRT woody cover metrics, proportion of usable space, road density, road density in disturbed areas, proportion of streams impacted by roads and proportion of streams impacted by disturbed areas were compared between sites using the Kruskall-Wallis *t*-test with a significance level of 0.05.

Results

Ecological site composition was substantially different among the 4 study sites, yet there were no clear-cut differences between the stable sites and the declining sites. Sites S2 and D3 were similar in their ecological site composition (>50% steep rocky and 25–35% low stony hill), while low stony hill was the dominant ecological site in site S1 (71%). Site D4 was more diverse (9 ecological sites) and had greater evenness (Fig. 3.2).

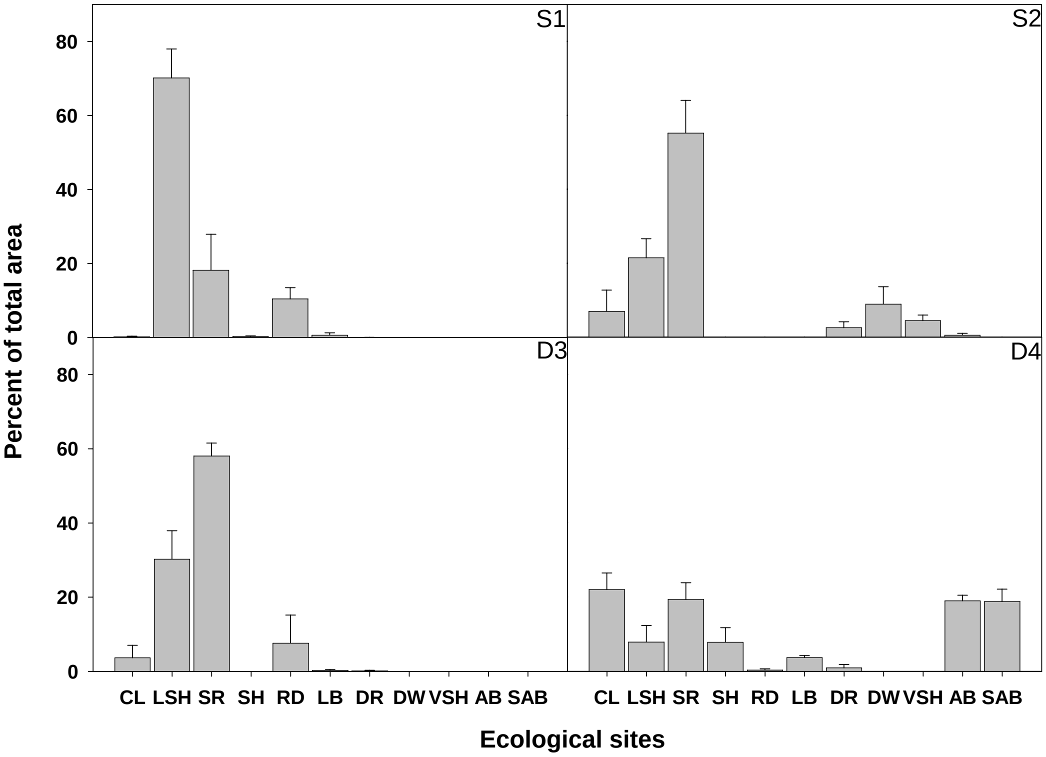

Figure 3.2. Frequency distributions of ecological sites (USDA 2004) in stable (S1, S2) and declining (D3, D4) sites. Ecological sites: CL = clay loam, LSH = low stony hill, SR = steep rocky, SH = shallow, RD = redland, LB = loamy bottomland, DR = deep redland, DW = draw, VSH = very shallow, AB = adobe, and SAB = steep adobe.

Proportions of HRT did not differ consistently between stable and declining sites (Fig. 3.3). The highest proportions of HRT were observed in sites S2 and D3 (31 and 20%, respectively), and there were significantly different from sites S1 and D4 (0.23 and 6%, respectively). These HRT may have contributed to the similarity of ecological sites S2 and D3 (Fig. 3.3). Stream densities for all stream orders were higher in site D3 than in the other 3 study sites (Fig. 3.4), but the differences were not consistent between stable and declining sites. Higher stream densities were consistently found in lower stream orders and decreased as stream order increased.

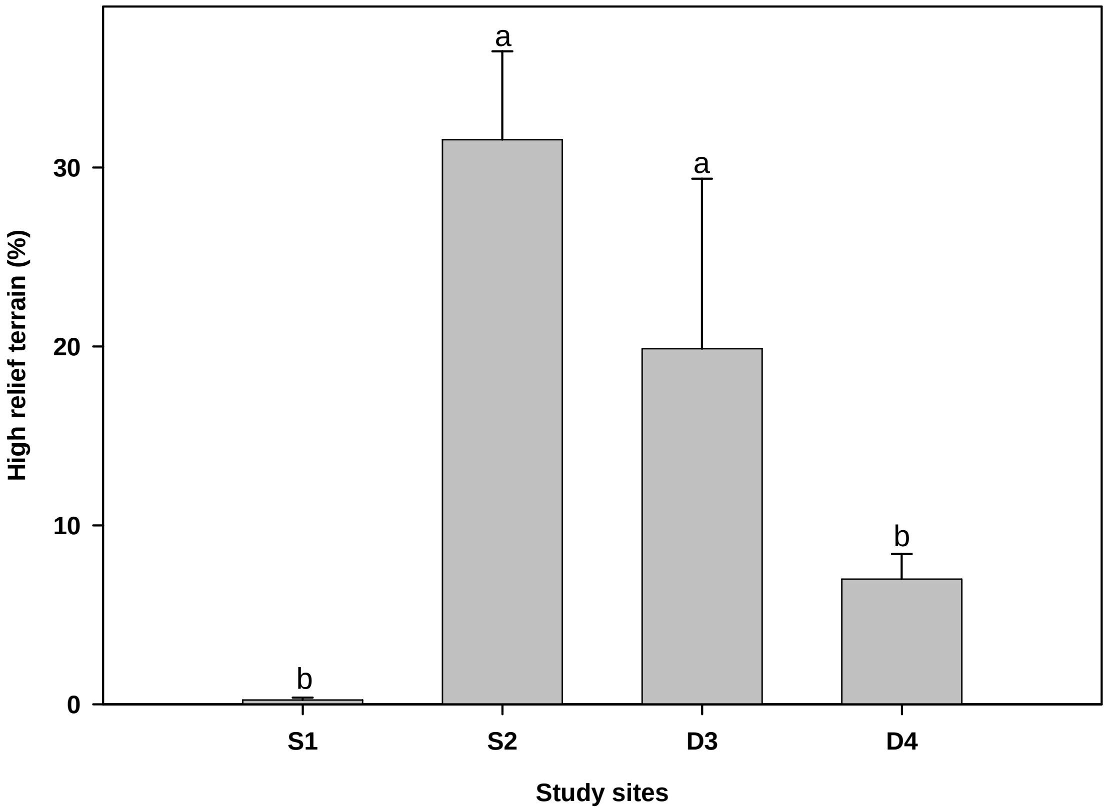

Figure 3.3. Proportion of high relief terrain (areas with a surface area index > 1,000) by study sites characterized by stable (S1, S2) and declining (D3, D4) Rio Grande wild turkey abundance.

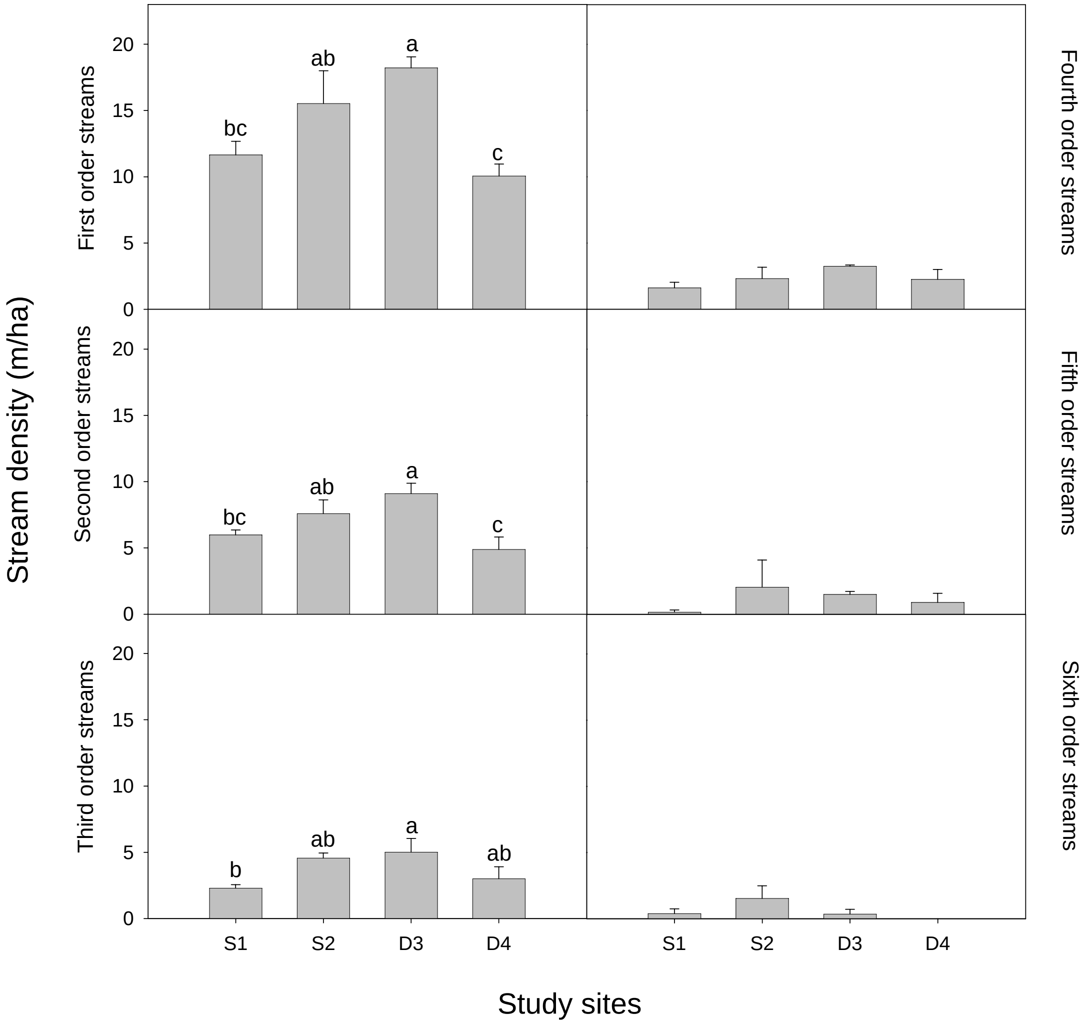

Figure 3.4. Stream density (m/ha) by study sites characterized by stable (S1, S2) and declining (D3, D4) Rio Grande wild turkey abundance.

Proportion and spatial distribution of woody cover in site D3 was significantly different from all other study sites. At the sample area and 50-m stream-buffer scales, site D3 had higher amounts of woody cover (66 and 73%, respectively) than all other study sites (Fig. 3.5). Woody cover in the sampled areas of sites S1, S2, and D4 ranged from 30 to

55%. At this scale, woody cover was concentrated in a few large patches in site D3 (MPS = 16.7 ha, PD = 0.04 patches/ha, LPI = 51%), whereas on sites S1, S2, and D4, woody cover was distributed in several small woody patches. For sites S1, S2, and D4, MPS ranged between 2 and 9 ha, PD between 0.06 and 0.18 ha, and LPI

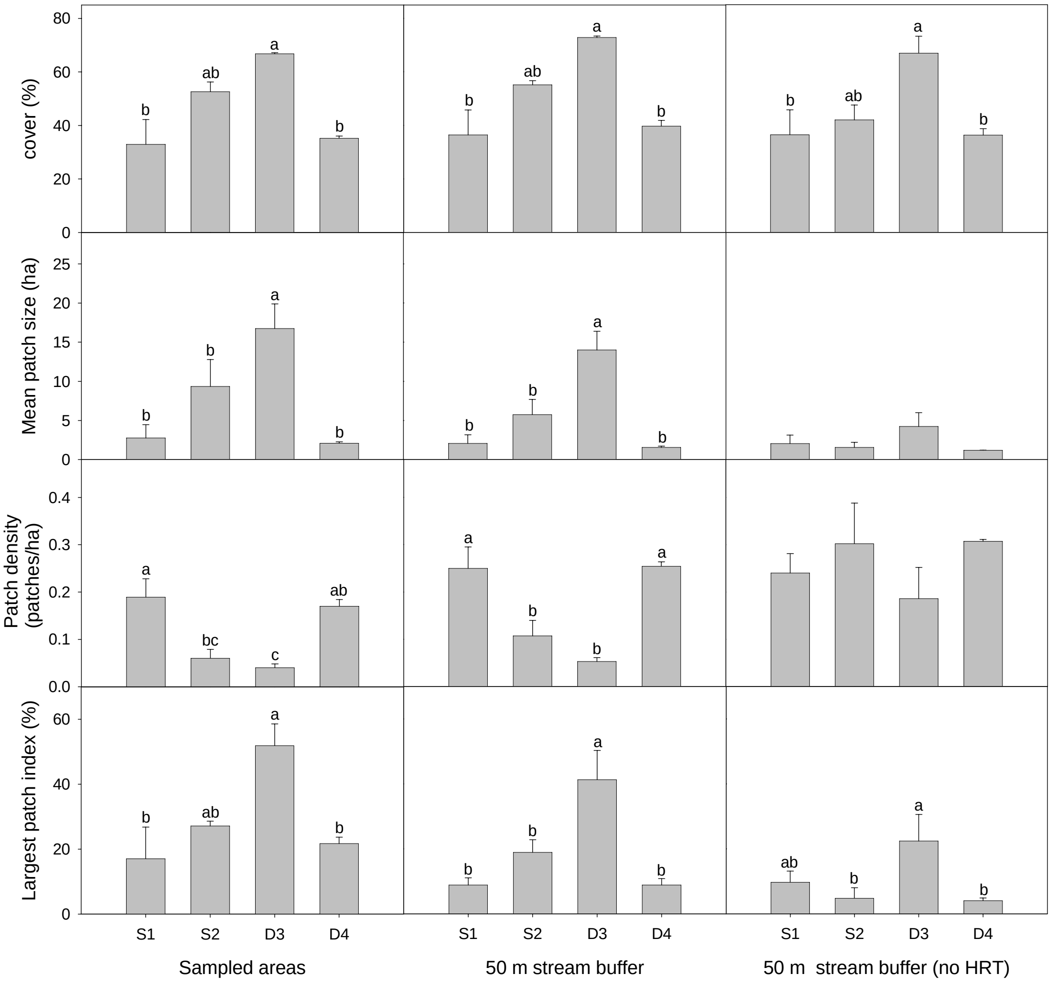

Figure 3.5. Woody cover and patch metrics for sampled areas in study sites, 50-m-stream buffers, and 50-m-stream buffer with no high relief terrain (HRT; areas with a surface area index > to 1,000) for study sites characterized by stable (S1, S2) and declining (D3, D4) Rio Grande wild turkey abundance.

between 17 and 27%. Spatial distribution of woody cover along riparian zones (50-m-stream buffers) was similar to sampled areas. When HRT was excluded from riparian zones, there was still a higher proportion of woody cover at site D3 (66%) than at all other sites (35–42%). However, spatial distribution of woody patches was not statistically different among study sites (Fig. 3.5). Spatial distribution of woody cover along riparian zones in HRT appeared to be concentrated in few large patches at D3, which likely negatively impacted RGWT roosting and dispersal habitat. The amount of woody cover at D3 was significantly higher than at each of the other three sites for all stream orders (Fig. 3.6). First order streams at S2 also had high proportions of woody cover (70.3%). Second, third and fourth order streams at S1, S2, and D4 had <70% woody cover. Proportion of usable space did not differ consistently between stable and declining sites. The highest proportion of usable habitat was found in S1 (99.7%) and the lowest proportion was found in S3 (16.1%) (Fig. 3.7).

Disturbance due to roads, croplands, improved pastures, and urban development was significantly higher at site D4 than at the other 3 study sites. Even though there were no statistical differences between sites, road density in site D4 (21 m/ha) was about twice that of site S1 (11 m/ha) (Fig. 3.8). The proportion of disturbed areas was significantly higher at site D4 (12.4%) than all other sites combined (3.7%). Road density in disturbed areas also was significantly higher at site D4 (5.3m/ha) than at all other sites combined (3.3 m/ha) (Fig. 3.8). The proportion of riparian zones disturbed by roads also was highest at site D4 because roads were built along riparian zones, especially in higher order streams. Roads in sites S1, S2, and D3, were built in the

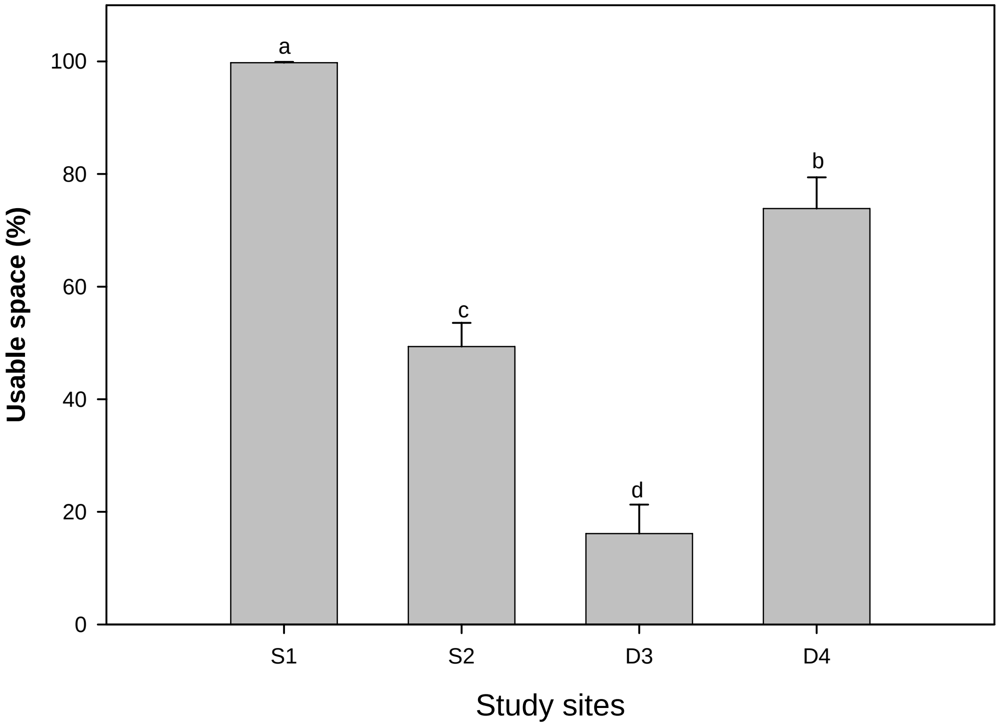

Figure 3.6. Proportion of space usable by RGWTs for study sites characterized by stable (S1, S2) and declining (D3, D4) RGWT abundance. These proportions correspond to bottomland areas, low relief terrain, and high relief terrain with suitable woody cover for RGWTs.

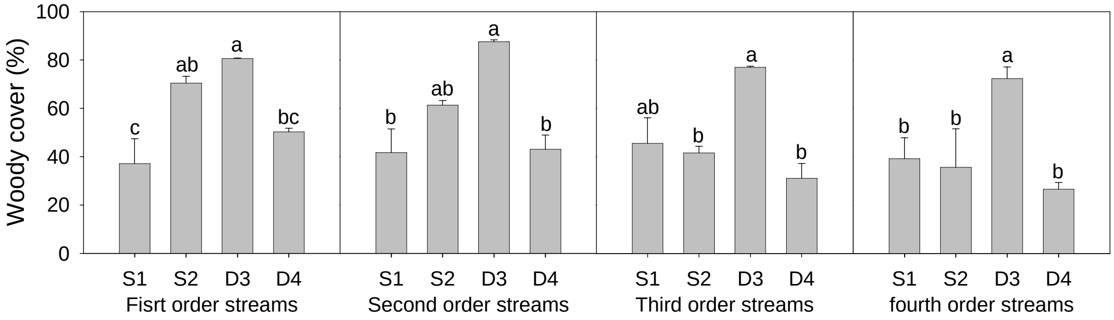

Figure 3.7. Proportion of woody cover by stream order for study sites characterized by stable (S1, S2) and declining (D3, D4) Rio Grande wild turkey (RGWT) abundance.

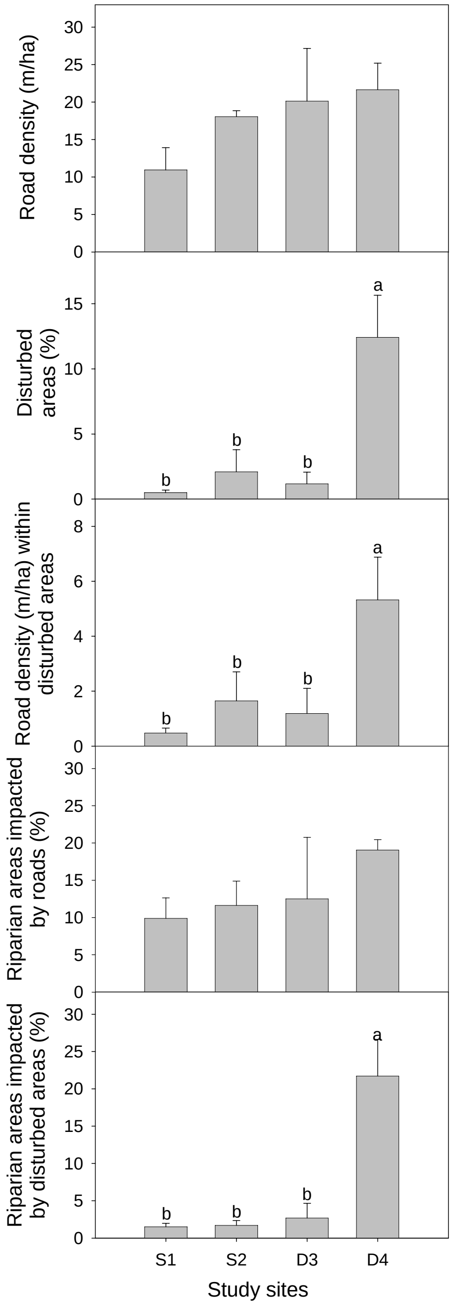

Figure 3.8. Proportion of disturbed areas for study sites characterized by stable (S1, S2) and declining (D3, D4) Rio Grande wild turkey abundance.

uplands, perpendicular to streams, and/or parallel to contour lines. Most of the disturbed areas (croplands, improved pastures, urban development) at site D4 also were located along riparian zones. This disturbance likely reduced the amount of woody cover suitable for RGWT roosting and nesting along riparian zones in site D4.

Discussion

The amount and spatial distribution of woody cover are important factors for RGWT feeding, roosting, and dispersal habitat. Areas with excessive amounts of woody cover would negatively impact on herbaceous cover and insects, which would limit sources of food for RGWTs as well as dispersal routes and roosting sites. Both sites S1 (32 and 25% woody cover in sampled areas and along streams, respectively) and S2 (52 and 55% woody cover in sampled areas and along streams, respectively) had woody cover that occurred in small patches and at high woody patch density, whereas site D3 (66 and 73% woody cover in sampled areas and along streams, respectively) had larger and fewer patches. The spatial distribution of woody cover in sites S1 and S2 likely provided a higher amount of herbaceous vegetation and insects than site D3 as a food source for RGWTs, as well as dispersal habitat to move through and across drainage systems.

The landscape-scale assessments corroborated field-scale studies that suggest RGWT habitat should have no more than 65–70% woody cover (Schorger 1966; Litton 1977; Beasom and Wilson 1992) and that, ideally, 50% open areas with well-interspersed woody cover patches would be beneficial. Patterns of woody cover along riparian zones in sites S1 and S2 are consistent with field-based studies in Texas that recognize the importance of drainage systems for RGWTs (Thomas et al. 1966; Gore 1973; Litton 1977; Palmer and Hurst 1995). Small patches of woody cover along riparian zones furnish escape and dispersal routes as well as provide food and cover (Walker 1949, 1950; Litton 1977). Roosting areas are often located near creeks, rivers and intermittent or dry drainages, and they are important to RGWTs because they provide “home range” during the winter and are essential to maintain turkey populations (Haucke 1975; Litton and Harwell 1995). Litton (1977) concluded that herbaceous vegetation and insects are important sources of food for RGWTs especially during spring and summer. Between 2001 and 2003, Randel (2003) found that invertebrate biomass was 5 times greater in sites where populations were stable (sites S1 and S2) than in sites where populations had declined (sites D3 and D4).

The spatial pattern of woody cover in HRT is important for RGWT habitat. Suitable amounts and spatial distribution of woody cover in HRT are critical for RGWT feeding, roosting, and dispersal through and across drainage systems. Ecological-site composition was similar in study sites S2 and D3, and the proportion of HRT was not statistically different between sites (Fig. 3.2). Compared to site S2, however, site D3 did not provide suitable habitat conditions for RGWTs especially in HRT due to high woody cover along riparian zones and, at the study area scale in general (Fig. 3.5). Excessive amounts of woody cover in HRT would have reduced the amount and diversity of herbaceous vegetation and insects, and restricted RGWTs to bottomland, low-relief terrain. A small proportion of open areas in site D3, limited to bottomland, low-relief terrain, combined with high proportions of woody cover in HRT may have resulted in limited amounts of usable space for RGWTs, resulting in a more intensive use of available resources (seeds and insects as food source) by RGWTs (Guthery 1997; Schaap 2005). According to the U.S. Department of Agriculture (USDA 2004), HRT in steep rocky ecological sites tend to have a higher diversity of herbaceous vegetation than flatter areas, but high proportions of woody cover decrease the amount and diversity of herbaceous vegetation species. This may negatively impact food sources for RGWTs, especially poults, by decreasing the amount of available seeds and insects. This observation is consistent with the results of Randel (2003) who found that site D3 had significantly lower amounts of insects than sites S1 and D4. Analysis of bottomlands, woody vegetation, and its relationship with HRT, demonstrated that site D3 provided only 16% usable space for RGWTs, whereas site S2 provided 50% usable space (Fig. 3.7). It is assumed that HRT in site S2 allowed RGWTs to move along riparian zones and use uplands to move from one drainage system to the other, thus providing them large amounts of usable space. Whereas, high woody cover combined with a limited bottomland and low-relief terrain in site D3 may have limited the amounts of usable space for RGWTs on this site.

Disturbances, such as those associated with improved pastures, urban areas, and roads near streams, can negatively impact RGWT habitat. Although there were no statistically significant differences between the amount and spatial distribution of woody cover in site D4 and in sites S1 and S2, disturbances associated with improved pastures, urban development, and roads were much higher in site D4 (12.43% of areas affected) than in the other sites (< 1%) and likely negatively impacted RGWT populations in site D4. Areas cleared for improved pastures undoubtedly reduced the amount of woody patches that could be used by RGWTs for roosting, nesting, and dispersal. This also may have resulted in decreased herbaceous vegetation diversity, negatively impacting the amount of food sources available to RGWTs. Roads associated with urban development and road density near streams were significantly higher in site D (19%) than in all other sites (11–12%). The roads in sites S1, S2, and D3 were built in upland areas and/or perpendicular to streams and contour lines, whereas in site D4 roads ran parallel to streams, thus increasing the proportion of RGWT habitat impacted. Gore (1973) and Lindzey and Wanless (1973) observed that human disturbance is an important factor influencing wild turkey populations. Gore (1973) observed that land transformed to improved pastures negatively impact RGWT populations. Quinton et al. (1980) maintained that open areas had ample amounts of grasses, forbs, succulents, and insects frequently ingested by turkeys, but the lack of woody patches and disturbance would limit the use of these areas.

Although the study sites were characterized by different ecological-site compositions, all have the potential to sustain RGWT populations if the amount and pattern of woody cover present allows the development of herbaceous vegetation in open areas (USDA 2004). HRT could be a limiting factor for RGWT habitat if proportions of woody cover were not suitable for RGWTs. Schaap (2005) found that RGWTs were confined to smaller areas in site D3 than in site S2 due to limitations in the amounts of usable space. This had a negative impact in RGWT populations because multiple broods had to use the same range, thus depleting available resources faster in site D3 than in S1 and S2. If suitable grasses and open areas interspersed with woody vegetation were present in HRT, potentially more usable space might be available to RGWTs for feeding poults during brood rearing. These areas also could be used by RGWT dispersal from bottomland to upland habitat and across drainage systems.

Stream density did not appear to limit RGWT habitat in these sites, but the proportion and spatial distribution of woody cover along streams is important to RGWTs. The analysis of woody cover along streams by stream order showed that site D3 had significantly higher proportion of woody cover than all other sites (Fig. 3.6). Compared to other sites, first-order streams in site S2 had greater amounts of woody cover than did second-, third-, and fourth-order streams on this site. Since stream networks are important for RGWT dispersal, this could limit RGWT dispersal habitat in site S2, and may explain its sensitivity compared to site S1. The amount of woody cover decreased as stream order increased in site D4. This is consistent with the high proportion of disturbed areas along higher-order streams in this site as compared to all others.

The amount and spatial distribution of woody cover in both stable sites appeared to be suitable for providing sufficient food sources for RGWTs as well as roosting and dispersal habitat. However, site S2 was likely more sensitive to changes in woody cover than site S1 as the increased amount of woody cover in the HRT portion of site S2 could substantially reduce the usable space for RGWTs by reducing both the suitable habitat in HRT and the connectivity between suitable habitats in the riparian areas and those in the gentle terrain of the uplands. Increased woody cover in site D3 likely reduced the availability of food sources and the amount of usable space for RGWTs, confining them to smaller areas and thus limiting feeding, roosting, and dispersal habitat. Human disturbance appears to have significantly impacted RGWT habitat in site D4. Even though the proportion and spatial distribution of woody cover in site D4 was similar to those sites S1 and S2, removal of cover for improved pastures, and other human activities, along streams have probably had negative impacts on RGWTs.

Disturbance and a high proportion of woody cover are important factors impacting RGWT populations in regions where turkey numbers have declined. These observations are similar to previous studies in other study areas of the Edwards Plateau (Walker 1949, 1950; Gore 1973; Quinton et al. 1980; Beasom and Wilson 1992) as well as for these specific sites (Randel 2003; Schaap 2005). Further, the amount and spatial distribution of woody cover vegetation in HRT seem critical to RGWT roosting, feeding, and dispersal habitat. Therefore, proper management of woody cover along riparian zones and high relief areas is important if one wishes to maintain RGWT populations. In addition, it may also be important for managers to focus on increasing the amount of usable space for RGWTs, particularly in HRT, rather than only on improving areas currently occupied by RGWTs.

CHAPTER IV

A GIS-BASED HABITAT-SUITABILITY MODEL FOR RIO GRANDE WILD TURKEYS IN THE EDWARDS PLATEAU OF TEXAS

Introduction

Habitat-suitability models (HSM) have been widely used to assess habitat quality for wildlife species (Schamberger et al. 1982; Brooks 1997; Kliskey et al. 1999). These models are tools designed to quantify habitat quality using habitat attributes deemed important to wildlife species (Schamberger and O'Neil 1986; García and Armbruster 1997; Kliskey et al. 1999). Habitat-suitability models are designed for use in planning and management, and they are probably one of the most important tools for conservation planning and environmental impact assessment (Schamberger and O'Neil 1986; Brooks 1997). With the integration with geographic information systems (GIS) and spatial databases, HSMs have become even more useful for the development of new databases and decision-making support (Debeljak et al. 2001).

The use of GIS and remote sensing has provided cost efficient and highly suitable analytical environments for the development of HSM (Aspinall and Veitch 1993; Conner and Leopold 1998). Remote sensing and GIS have been successfully used in habitat analysis (Aspinall and Veitch 1993; García and Armbruster 1997; Radeloff et al. 1999; Gerrard et al. 2001; Osborne et al. 2001) and HSM development (Lancia et al. 1986; Donovan et al. 1987; Pereira and Itami 1991; Özesmi and Mitsch 1997; Riitters et al. 1997; Conner and Leopold 1998; Kliskey et al. 1999; Lai et al. 2000; Store and Kangas 2001; Gurnell et al. 2002) to produce new information by combining and analyzing spatial data from different sources, for larger areas, and at multiple scales (Riitters et al. 1997;Wu and Smeins 2000; Luck 2002a, 2002b; Store and Jokimäki 2003).

In recent years, several studies have developed HSM at the landscape level (Palmeirim 1988; Riitters et al. 1997; With and King 2001; Lawler and Edwards 2002). These studies were based on the premise that spatial characteristics, such as the amount and spatial arrangement of habitat patches at the landscape level, are important in determining species-habitat suitability. Mazerolle and Villard (1999) reviewed 61 studies where spatial patterns at the patch and landscape level were used for HSM development. Their results indicated that landscape characteristics could be significant predictors of species presence and abundance. They suggested that landscape characteristics would improve HSM and conservation strategies if scale was properly defined. Almost 50% of the studies reviewed by Mazerolle and Villard (1999) included birds as a focal taxon.

Williamson and Koeln (1980) developed one of the first published HSM for wild turkeys (*Meleagris gallopavo*). Since then, various HSMs have been developed for eastern wild turkeys (*Meleagris gallopavo silvestris*) (EWT) (Schroeder 1985; Donovan et al. 1987; Fleming and Porter 2001) and Merriam's wild turkey (*M.g. merriami*) (Rumble and Anderson 1995). Williamson and Koeln (1980) used a computerized habitat evaluation system to produce a habitat-suitability map for wild turkeys. Donovan et al. (1987) used GIS to evaluate EWT habitat suitability, and Fleming and Porter (2001) introduced a landscape approach for EWT in New York. In the case of the (RGWT, *M.g. intermedia*), several studies have addressed habitat characteristics in Texas (Walker 1949, 1950; Litton and Harwell 1995; Randel 2003; Schaap 2005) and across North America (Schorger 1966; Beasom and Wilson 1992; Hennen and Lutz 2001). However, there is only one HSM developed for RGWT, and it is for the western Cross Timbers region of Texas (Miller 2002).

There is no HSM developed for Rio Grande wild turkey RGWT in the Edwards Plateau of Texas. Moreover, the HSMs previously cited for wild turkeys have not been validated or tested, and those that have been validated, have not been validated or tested with independent datasets (Pereira and Itami 1991; Brooks 1997). Therefore, there is a need to gain reliable knowledge regarding RGWT habitat factors, more specifically, those related to breeding habitat in the Edwards Plateau of Texas. The overall goal of this study was to develop and evaluate a remote sensing and GIS-based HSM for female RGWTs during the breeding season, which would allow the assessment of the spatial distribution of suitable habitat in these study areas. Specific objectives included: (1) the identification of landscape metrics that were related to important habitat factors for female RGWT during the breeding season; (2) the development of an HSM based on GIS and remote sensing data; and, (3) the evaluation of the model by testing it in three different locations using three independent datasets for RGWT in different years.

Methods

Study areas

Four study areas were delineated based on winter-roost counts and landowner interviews as part of a larger study that proposed to address the spatial extent and degree of the decline in RGWT abundance in the Southern Edwards Plateau of Texas (Peterson, personal communication). Two sites were identified as sites where RGWT populations remained stable (S1 and S2) and two sites were identified as sites where populations have declined (D3 and D4) in the last 30 years (Schaap 2005). The sizes for these study areas were 75,358 ha for S1 (30°01’N, 99°18’W), 29,018 ha for site S2 (29°49’N, 99°45’W), 200,089 ha for site D3 (29°52’N, 99°25’W), and 27,668 ha for site D4 (29°39’N, 99°06’W) (Fig. 4.1).

Data collection

Landsat TM imagery (30 m resolution) from April 2000 was acquired from the Global Land Cover Facility (University of Maryland, United States) and then classified using an unsupervised classification (Leica Geosystems 2003) into three cover classes: woody, non-woody and water cover. An accuracy assessment was done using available DOQ imagery for the study area. We randomly generated 200 points and visually assessed the

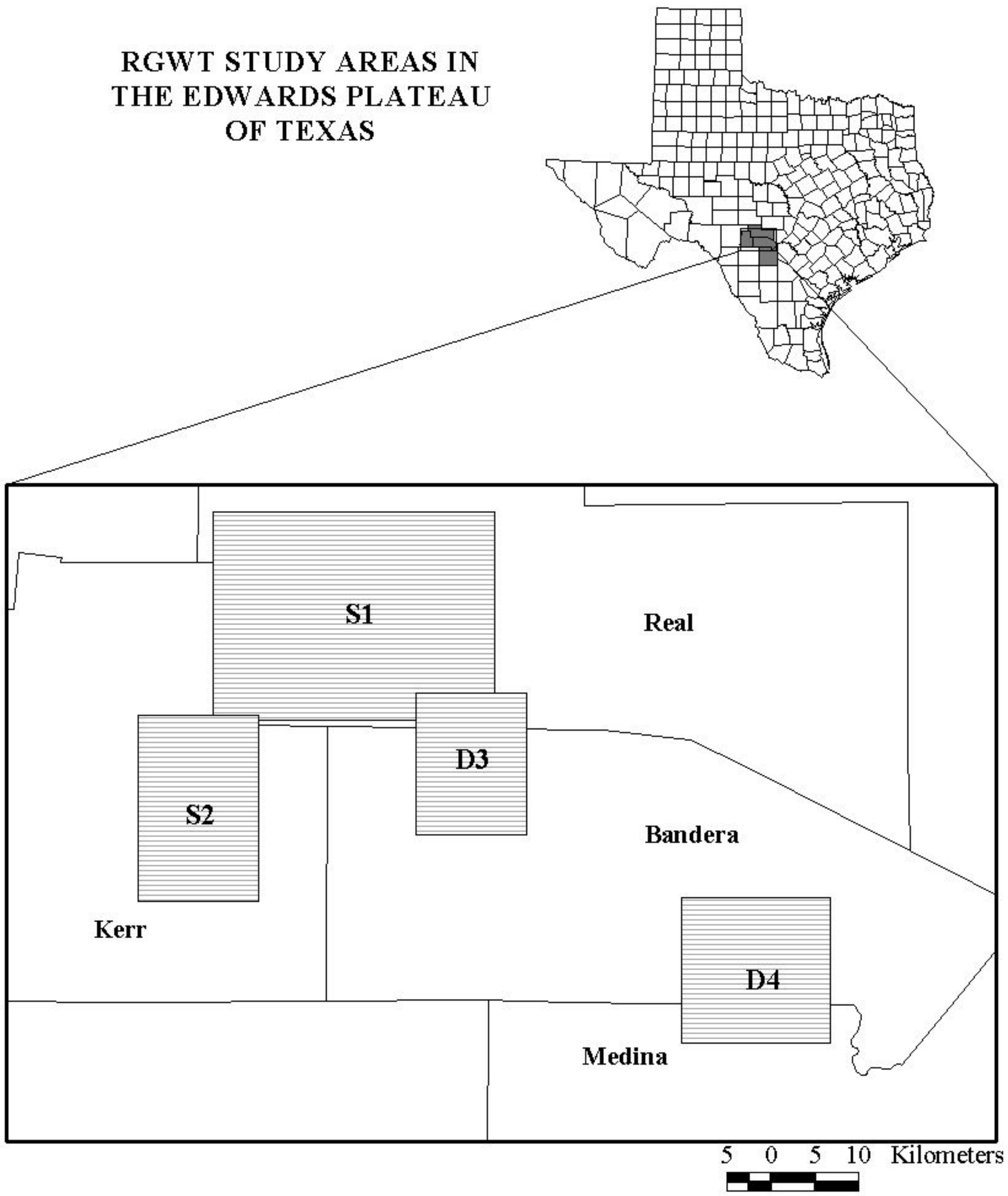

Figure 4.1. Study area location for the development and testing of a habitat-suitability model for RGWT in the Edwards Plateau of Texas. S1= site 1,S2= site 2, D3= site 3, and D4= site 4.

accuracy of the classified pixel on the DOQ. The overall accuracy for the classification was 87% (Congalton 1991). Available digital orthophoto quadrangles (DOQs) from 1995 (1 m resolution) were obtained from Texas Natural Resources Information Systems (TNRIS) clearinghouse. These DOQs were used to manually digitize human-induced disturbed areas (croplands, improved pastures and urban development). Digital elevation models (DEMs) were obtained from TNRIS. These DEMs were used to derive surface area indices (SAI) (Jenness 2004). Surface area indices with values > 1,000 were classified as high relief terrain (HRT). The combination of these layers resulted in a raster layer (30 m resolution) with six classes: woody cover, low relief terrain (WCLRT); woody cover, high relief terrain (WCHRT); non-woody cover, low relief terrain (NWCLRT); non-woody cover, high relief terrain (NWCHRT); disturbed area (DIST); and water. A second raster layer was derived with four classes: woody cover (WC), non-woody cover (NWC), DIST, and water.

Habitat model development

Nesting and brood survival are critical to maintain RGWT populations (Everett et al. 1980; Randel 2003). A HSM is usually developed based on life requisites such as food, cover and reproduction components (Schamberger and O'Neil 1986; Rho 2003). A landscape-scale HSM for female RGWT was developed based on two important periods during the breeding season for RGWT: nesting and brood rearing (Schaap 2005). During the nesting period, cover was the limiting life requisite component, and during the brood rearing period, cover and food were the limiting life requisites (Schaap and Silvy, personal communication). To rate each life requisite component, landscape metrics were used to describe relevant habitat variables (Fleming and Porter 2001; Rho 2003) to RGWT in the southeastern portion of the Edwards Plateau of Texas.

Habitat-suitability model for nesting (cover)

Nesting habitat is critical to RGWT population viability (Randel 2003). The amount of nesting cover is associated with increased nesting success (Hohensee and Wallace 2001). Female turkeys select nest sites with more dense vegetation than surrounding areas, shorter vegetation height, greater litter depth and cover, and less forbs and grass cover (Schmutz et al. 1989; Randel 2003). Low-visibility indices associated with cover height <0.45m increase the occurrence of nesting areas (Cook 1972a; Baker 1979; Ransom et al. 1987). The amount of visual obstruction as well as the height and shade of vegetation over the center of the nest bowl are critical (Hohensee and Wallace 2001; Lehman et al. 2002). In Colorado, RGWT nest sites have greater canopy cover, more shrubs, fewer grasses and greater understory cover (Schmutz et al.1989). In South Dakota, shrub patches are important nesting cover in prairie woodland habitat (Lehman et al. 2002). Human-induced disturbance such as overgrazing also can have an impact on RGWT nesting (Gore 1973). Human-induced disturbance (croplands, improved pastures, urban development) was significantly higher at site D4, where RGWT populations had declined, than at other study sites (Chapter III).

Female turkeys select nest sites with more dense vegetation than surrounding areas, shorter vegetation height, greater litter depth and cover, and less forbs and grass cover (Randel 2003). In the southeastern portion of the Edwards Plateau of Texas, these nesting conditions are typically met near the edge of woody cover patches and non-woody areas (Schaap 2005). Small woody patches or large woody patches with high edge distance will provide adequate woody cover, dense vegetation and visual

Table 4.1. Ratings of habitat suitability for nesting cover component.

Woody cover (%)	LPI 2 (%)	ED (m/ha)	Disturbance (%)	Cover rating	Cover rating if HRT >55%
0-10	<70	>50	<15	Medium	Low
			15-20	Low	Very low
			<20	Very low	Very low
		<50	any	Low	Very low
			<15	Medium	Low
			15-20	Low	Low
	70-100	Any	>20	Very low	Very low
10-35	<70	>75	<5	Very high	High
			5-10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		50-75	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		<50	<15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
	70-100	Any	<20	Low	Very low
			>20	Very low	Very low

Table 4.1. Continued.

Woody cover (%)	LPI 2 (%)	ED (m/ha)	Disturbance (%)	Cover rating	Cover rating if HRT >55%
35-55	<20	>75	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		50-75	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		<50	<20	Low	Very low
			>20	Very low	Very low
	20-70	>125	<5	Very high	High
			5-10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		75-125	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		50-75	<15	Medium	Low
			115-20	Low	Very low
			>20	Very low	Very low
		<50	<20	Low	Very low
			>20	Very low	Very low
	70-100	Any	Any	Very low	Very low
55-70	Any	Any	<20	Low	Very low
			>20	Very low	Very low
70-100	Any	Any	Any	Very low	Very low

obstruction for nesting habitat. A high proportion of woody cover reduces the amount of edge while increasing the probability of larger and denser woody patches and reducing litter depth and cover, thus decreasing the amount of suitable areas for nesting.

Habitat suitability for nesting cover was determined based on the proportion of woody cover (PWC), the largest patch index proportion related to woody cover (LPI2), the amount of edge density (ED), DIST, and the proportion of woody cover in HRT (Table 4.1). Areas where the proportion of woody cover ranged between 10% and 35% were rated as very highly suitable, and an area's cover rating decreased if PWC < 10% or > 70% of the landscape. The value of LPI2 was calculated by dividing the largest patch index (LPI) by the PWC. This proportion (LPI2) was related to the total area of woody cover and not to the total area of the landscape. The value of LPI2 provided an alternative measure of aggregation without explicitly describing spatial distribution of woody patches. Higher values of LPI2 (> 70%) will decrease nesting cover habitat suitability. At least 75m/ha of ED were required to have very high suitability conditions and these decreased as ED decreased. Disturbance had a negative impact on RGWT habitat (Gore 1973). As the proportion of human-induced disturbed areas increased, habitat suitability decreased. High relief terrain is not a limiting factor to RGWT unless the PWC in the area is too high (> 55%). In that case cover ratings decrease by one category.

Habitat-suitability model for brood rearing (cover)

Brood-rearing habitat must have woody cover; however, densely wooded areas may not be used by RGWT (Beasom and Wilson 1992). Woody areas are important during brood rearing to provide overhead concealment from avian predators, escape cover once poults can fly, and shade to maintain thermoneutrality (Miller 1993). Female turkeys and their broods typically loaf in wooded habitats from mid-morning until late afternoon. Good visibility and overhead concealment are important in loafing sites for broods. Brood-rearing hens use rangelands that have greater visual obstruction and are closer to woody cover types. Herbaceous vegetation is a key component of brood habitat that provides both insects and hiding cover essential to poults survival and growth (Miller 1993; Randel 2003).

There is very little or no information about the amount and spatial distribution of woody cover at the landscape level that is relevant to RGWT hens and broods in the Edwards Plateau of Texas. Expert opinions (Schaap and Silvy, personal communication) and feedback were used to develop a landscape-level HSM for brood rearing cover component using metrics such as PWC, LPI2, DIST and proportion of HRT (Table 4.2). The habitat for brood rearing cover is considered excellent when the proportion of woody cover ranges between 10% and 35% woody cover. Values higher and lower than this range decrease habitat suitability. Highest suitability was found when LPI2 values were < 25% and habitat suitability decrease as LPI2 increased. As the proportion of human-disturbed areas increased, habitat suitability decreased. High-relief terrain is not a limiting factor unless the PWC in these areas is > 55%. In that case cover ratings decrease by one category.

Table 4.2. Ratings of habitat suitability for the brood-rearing cover component.

Woody cover (%)	LPI 2 (%)	Disturbance	Cover rating	Cover rating if HRT >55%
0-10	<25	<10	High	Medium
		10-15	Medium	Low
		15-20	Low	Very low
		>20	Very low	Very low
	25-70	<10	High	Medium
		10-15	Medium	Low
		15-20	Low	Very low
		>20	Very low	Very low
	>70	<20	Low	Very low
		>20	Very low	Very low
10-35	<25	<5	Very high	High
		5-10	High	Medium
		10-15	Medium	Low
		15-20	Low	Very low
		>20	Very low	Very low
	25-70	<10	High	Medium
		10-15	Medium	Low
		15-20	Low	Very low
		>20	Very low	Very low
	>70	<20	Low	Very low
		>20	Very low	Very low
35-55	<25	<10	High	Medium
		20-15	Medium	Low
		15-20	Low	Very low
		>20	Very Low	Very low
	25-70	<10	High	Medium
		10-15	Medium	Low
		15-20	Low	Very low
		>20	Very low	Very low
	>70	<20	Low	Very low
		>20	Very low	Very low
55-100	Any	<20	Low	Very low
		>20	Very low	Very low

Habitat-suitability model for brood rearing (food)

Poults require large amounts of food, mainly insects, which are an important source of protein for young wild turkeys (Schmutz et al. 1990; Healy 1985; Hennen and Lutz 1996; Randel 2003). Wild turkey poults feed on insects for the first two to four weeks of their life and then switch to a primarily vegetative diet (Schmutz et al. 1990). Turkey broods typically feed until mid-morning in open herbaceous vegetation, loaf in woody-cover areas until late afternoon and feed again until they move to roost sites in the evening (Miller 1993). Areas with an abundance of insects, cover capable of hiding poults, and unobstructed hen vision were considered good brood-rearing habitat (Randel 2003). Invertebrate abundance, poults feed rate, and vegetation density were significantly correlated (Healy 1985; Schmutz et al.1990). Therefore, a key component of brood-rearing habitat is herbaceous vegetation, which provides both insects and hiding cover essential to poults survival and growth (Hennen 1999).

Good feeding habitat consists of open grassland areas with well-interspersed woody patches. High proportions of woody cover in the Edwards Plateau of Texas reduce the amount and diversity of non-woody-cover areas (Schaap, personal communication). Open areas with herbaceous vegetation and little or no woody cover are not used by RGWT broods, in spite of a high abundance of insects (Quinton et al. 1980). Habitat suitability for brood-rearing cover was determined based on the amount and spatial distribution of woody cover using PWC, mean patch size (MPS) and patch density (PD) metrics. Disturbed areas and the PWC in HRT also were incorporated into the model (Table 4.3). Optimal feeding areas had 10-35% woody cover with small patches (MPS < 1 ha), high PD (> 0.16 patches/ha), very low disturbance (DIST < 5%) and suitable HRT woody cover (< 55%). As MPS increases and PD decreases with higher PWC, the proportion of grassland decreases. As disturbance increases, habitat suitability also decreases. If PWC is > 55% in HRT, the food rating decreases by one category.

Habitat-suitability model execution

The HSM was applied to the four study areas (S1,S2,D3, and D4). For each study area, a moving window analysis (Riitters et al. 1997; Lai et al. 2000; Rho 2003) was run for both raster layers at two scales relevant to RGWT habitat: 3500-ha moving windows (largest seasonal range for female RGWT habitat during breeding season in the Edwards Plateau of Texas) and 550-ha moving windows (shortest seasonal range for female RGWT habitat during breeding season in the Edwards Plateau of Texas) (Schaap 2005). For each moving window, Patch Analyst (GRID) (Elkie et al. 1999) was used to calculate metrics that were used to develop the HSM for RGWT in the Edwards Plateau of Texas: PWC, LPI, LPI2, MPS, PD, ED, and DIST. These values were assigned to the core rectangle (300x300m^2) of each moving window (Rho 2003). Habitat-suitability ratings were calculated for the different life requisites for each core rectangle.

Table 4.3. Ratings of habitat suitability for the brood-rearing food component.

Woody cover (%)	MPS	PD	Disturbance	Food rating	Cover rating if HRT >55%
0-10	<4	> 0.12	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.08-0.12	<15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.04-0.08	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	4-10	>0.08	<15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.04-0.08	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	10-15	>0.04	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	>15	Any	Any	Very low	Very low
10-35	<1	>0.16	<5	Very high	High
			5-10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.12-.16	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.08-0.12	<15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.04-0.08	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	1-4	> 0.12	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.08-0.12	<15	Medium	Low

Table 4.3. Continued.

Woody cover (%)	MPS	PD	Disturbance	Food rating	Cover rating if HRT >55%
10-35	1-4	0.08-0.12	15-20	Low	Very low
			>20	Very low	Very low
		0.04-0.08	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	4-10	>0.08	<15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.04-0.08	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	10-15	>0.04	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	>15	Any	Any	Very low	Very low
35-55	<10	>0.08	<10	High	Medium
			10-15	Medium	Low
			15-20	Low	Very low
			>20	Very low	Very low
		0.04-0.08	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	10-15	>0.04	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	>15	Any	Any	Very low	Very low
55-70	<15	>0.04	<20	Low	Very low
			>20	Very low	Very low
		<0.04	Any	Very low	Very low
	>15	Any	Any	Very low	Very low
70-100	Any	Any	Any	Very low	Very low

These suitability ratings, extrapolated from the core rectangles to the moving window and assigned the highest rating, were assigned to the overlapping windows to create habitat-suitability maps.

Habitat- suitability model evaluation

The HSMs were calibrated and validated for each life requisite using seasonal ranges for adult female RGWTs in S1. Unlike most HSMs, which use abundance data for evaluation (Schamberger and O'Neil 1986; Brooks 1997), seasonal ranges with minimal overlap were selected and the proportion of high and very high (HVH) suitability areas in each seasonal range determined to evaluate the performance of each individual life requisite model and the overall habitat-suitability model. Seasonal ranges in S1 were available for 3 years. Seven seasonal ranges in the first year (Y1) were used to calibrate the suitability criteria associated with the landscape metrics in each individual model, eight seasonal ranges from the second year (Y2) were used to validate each individual model, and seven seasonal ranges in the third year (Y3) were use to validate the combination of the three individual models into one breeding season model and validate it. Means and standard errors for all seasonal ranges within year were calculated and compared between years.

Independent seasonal-range datasets in different locations were then used to assess the validity, transportability and generality of the model (Brooks 1997; Rho 2003; Perotto et al. 2004) using the same approach. Seasonal ranges were available for 2 years (Y2 and Y3) in S2 and D4 and for 3 years (Y1, Y2 and Y3) in D3. The HVH proportions between years within sites and between sites for all years were compared using the Kruskal-Wallis test with a significance level of 0.05.

Results

The highest proportion of HVH categories in S1 were observed at the 3500-ha scale in the brood-rearing cover (91.9%), brood-rearing food (92.6%) and overall model (91.4%) (Fig. 4.2). Proportions of HVH areas were lower at the 550-ha scale than at the 3500-ha scale (Fig. 4.3). In S2 (Fig. 4.4) the proportion of HVH areas ranged from 58.2% in the overall habitat model to 73.7% in brood-rearing food component at the 550-ha scale, and from 54.8% in the brood-rearing food component to 94.1% in the brood-rearing cover component at the 3500-ha scale. The lowest proportion of HVH areas in all the study sites was observed in D3 (Fig. 4.5) at the 550-ha scale. The highest (62.5%) proportions in D3 were observed for the brood-rearing food component and the lowest (56.9%) for the overall model (Fig. 4.3). At the 3500-ha scale, only high categories(25.6%) were detected for the nesting cover component. No HVH areas were observed in the brood-rearing food component or the overall model. In D4 (Fig. 4.6), HVH areas accounted for 75% and 93.7% of the study areas at the 550-ha scale and 3500-ha scale respectively (Fig. 4.3). At the 3500-ha scale, very high suitable areas were not found in D4 in the brood-rearing food component.

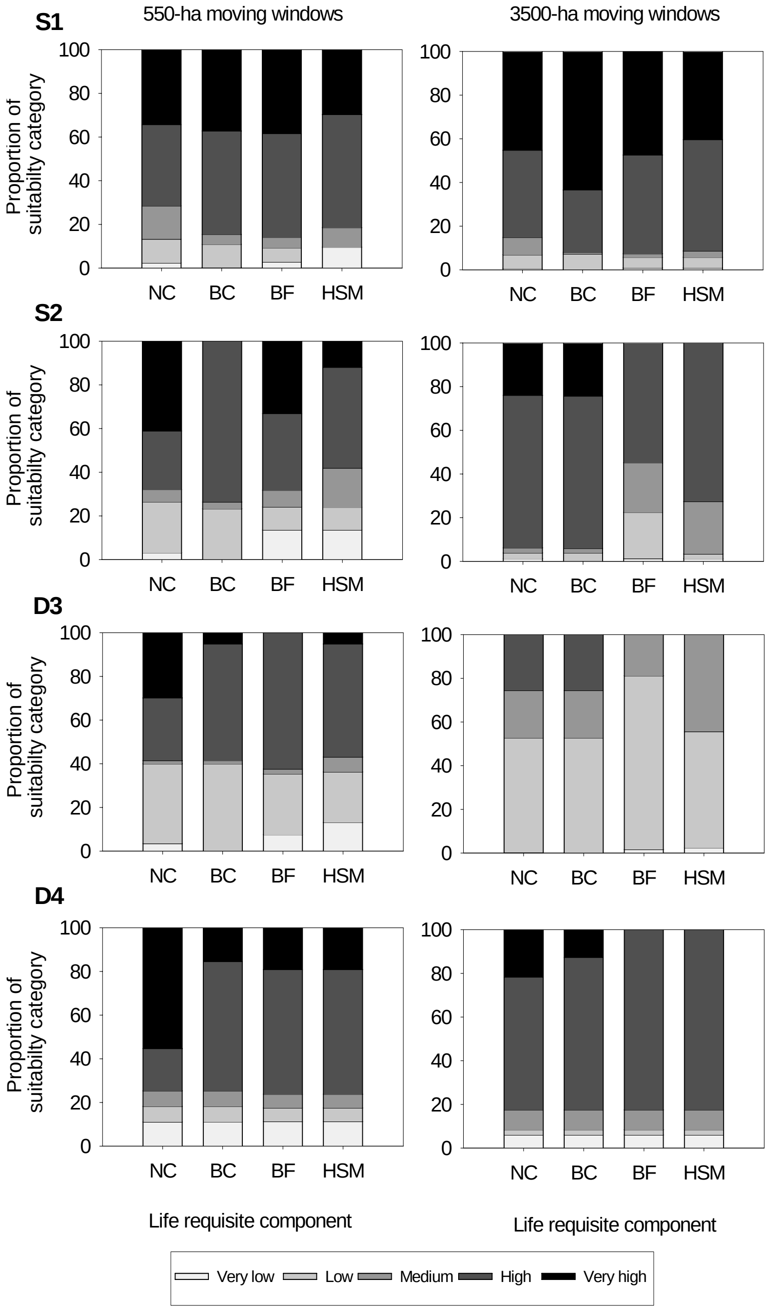

Figure 4.2. Proportion of areas (%) of different suitability categories in each study site (S1 and S2, stable sites; D3 and D4, declining sites) for each life-requisite component (NC, nesting cover; BC, brood-rearing cover; BF, brood-rearing food; and HSM, overall habitat-suitability model).

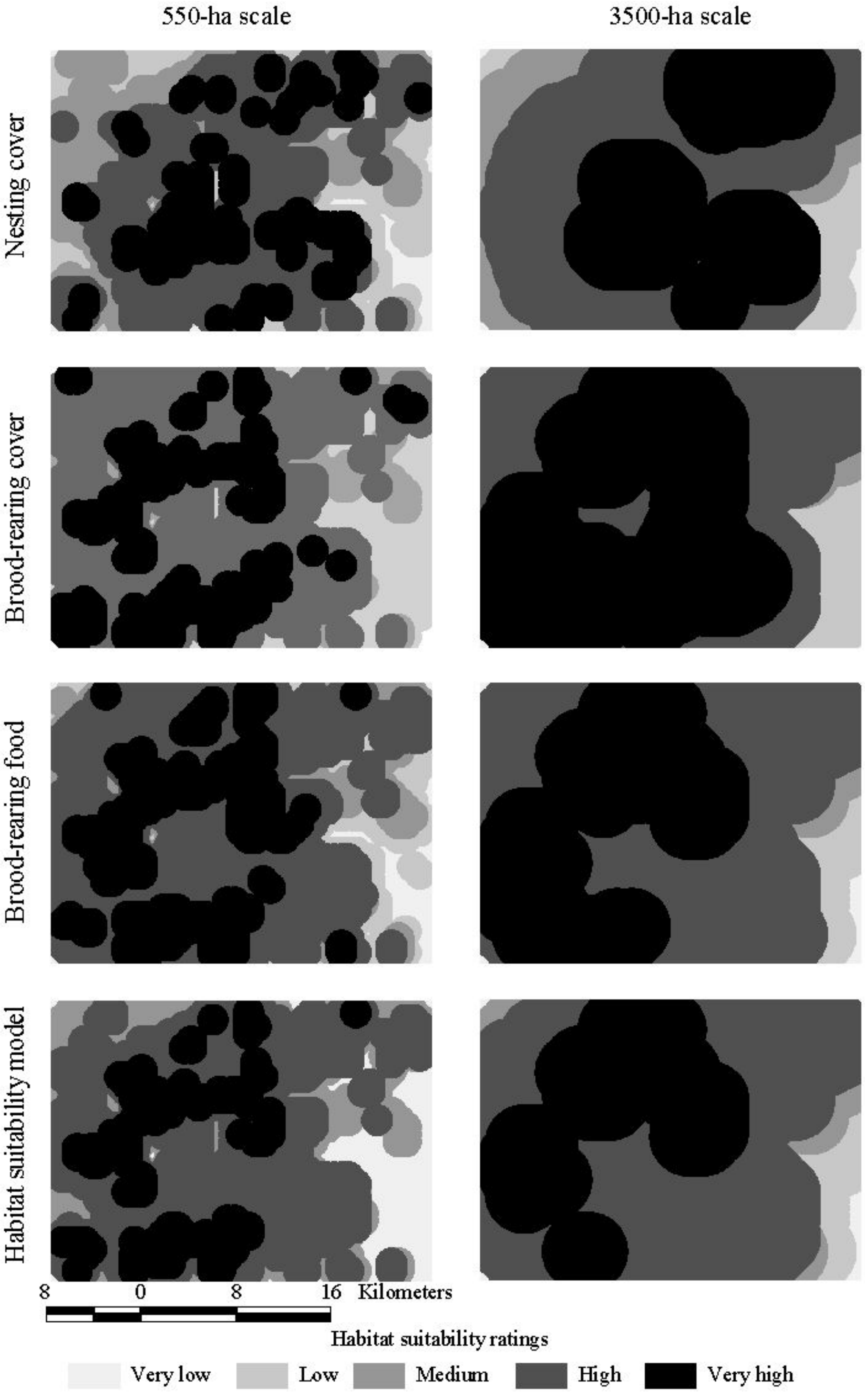

Figure 4.3. Habitat-suitability model for site S1 for all life-requisite components and overall habitat suitability for RGWT.

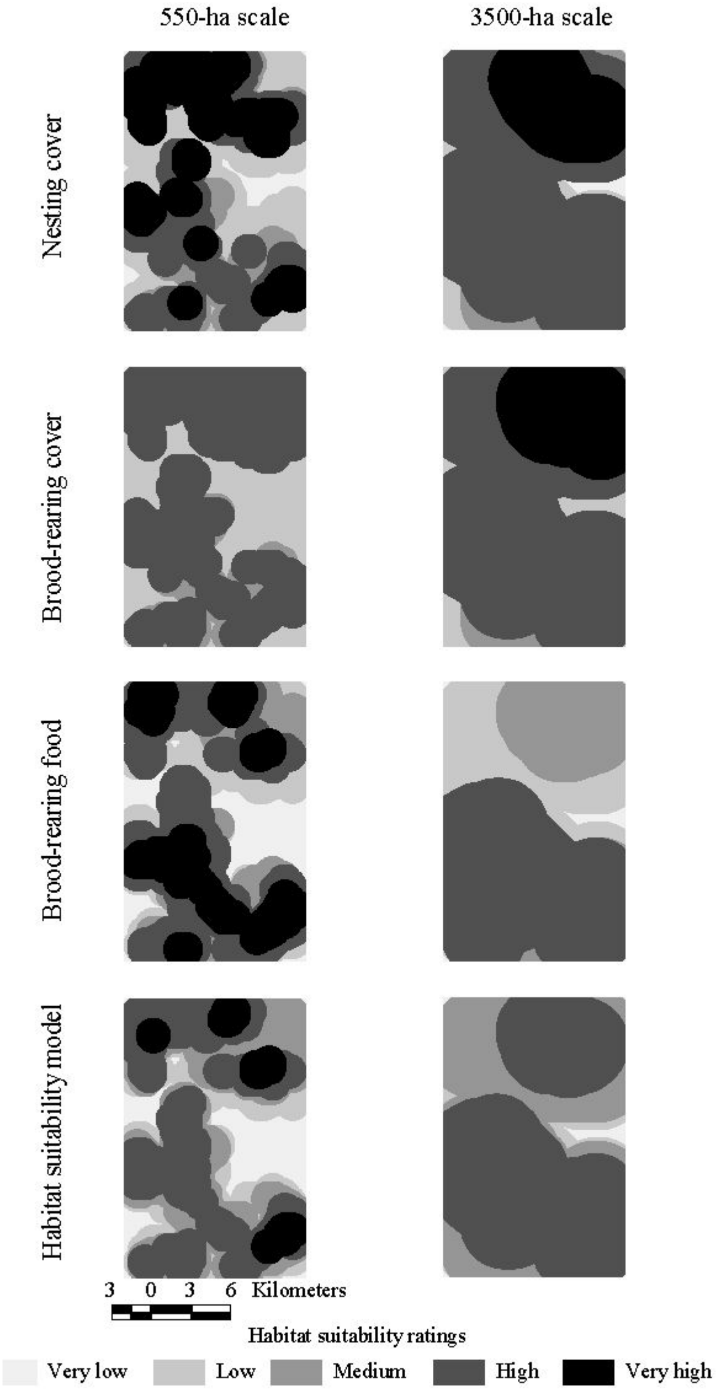

Figure 4.4. Habitat-suitability model for site S2 for all life-requisite components and overall habitat suitability for RGWT.

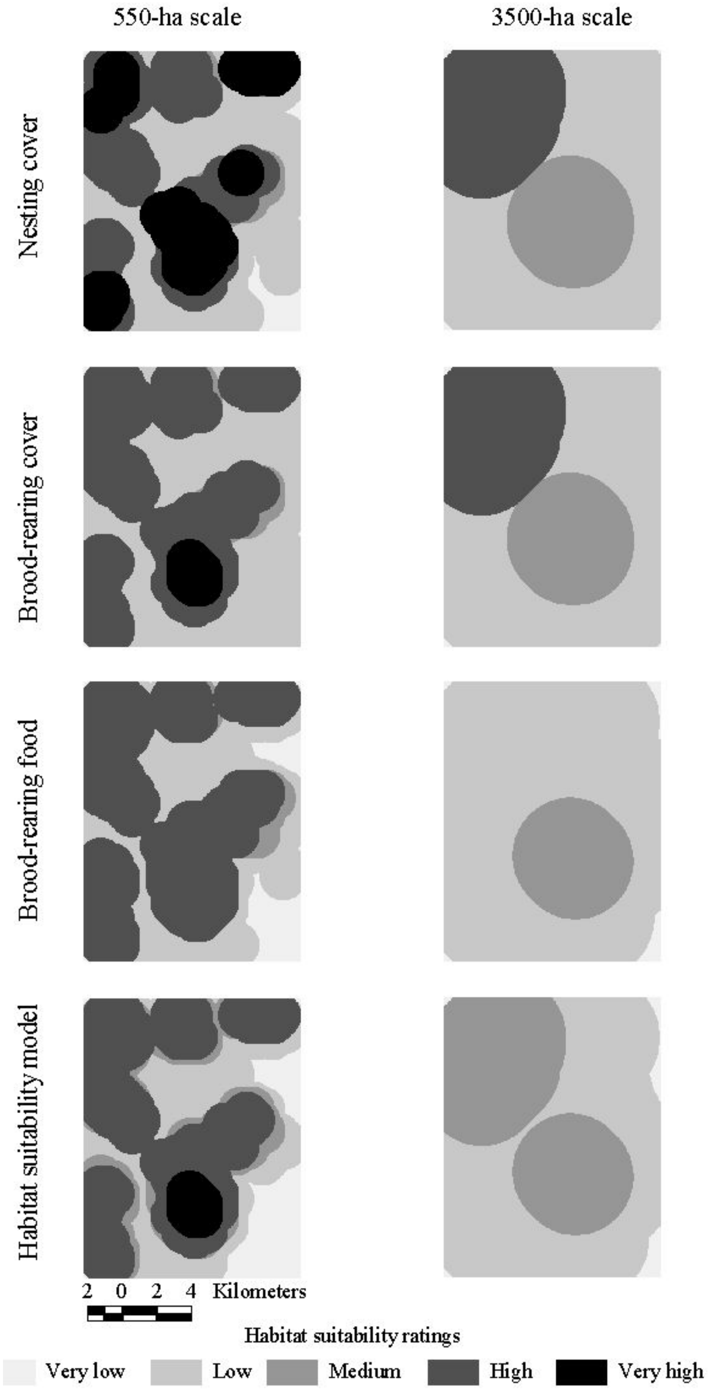

Figure 4.5. Habitat-suitability model for site D3 for all life-requisite components and overall habitat suitability for RGWT.

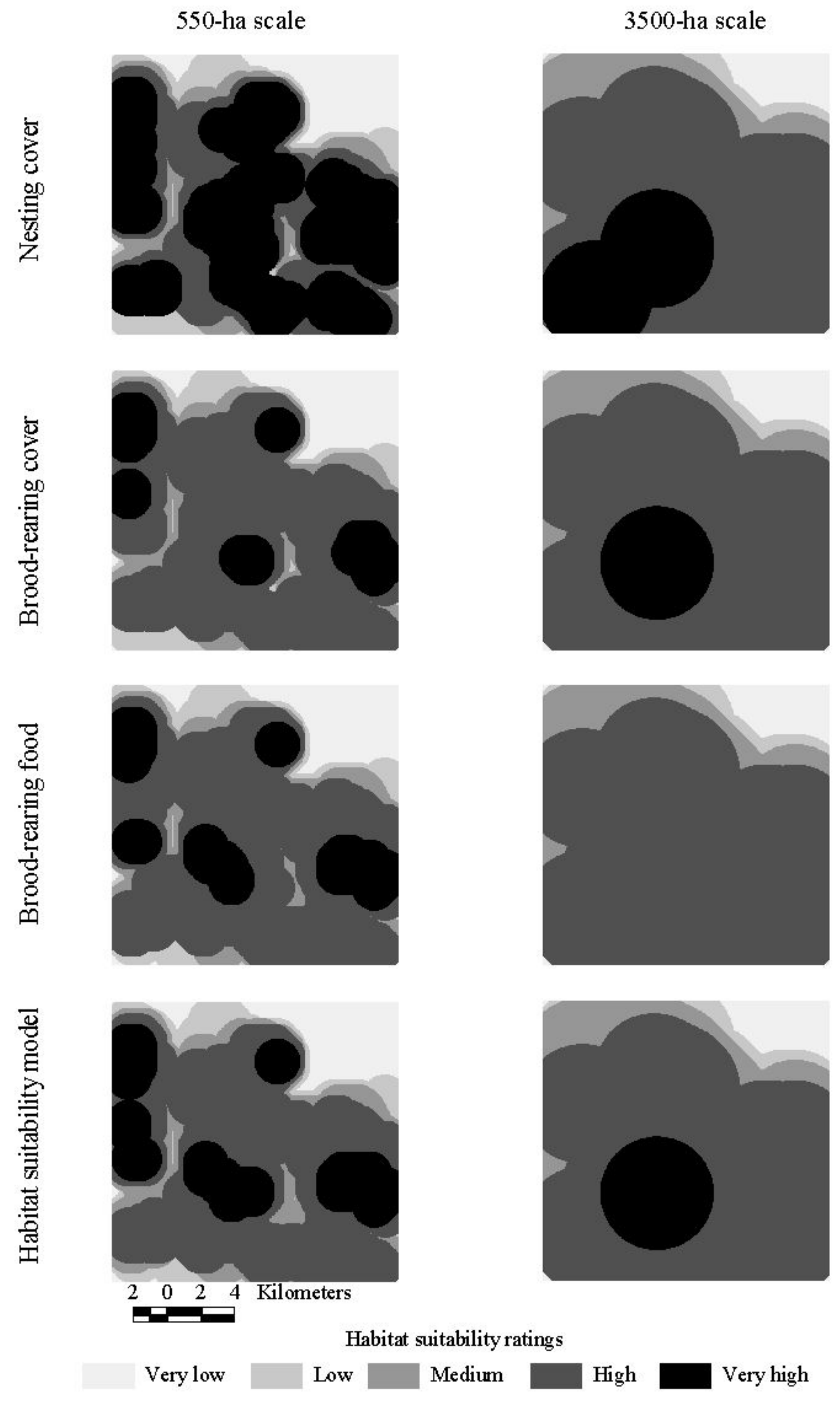

Figure 4.6. Habitat-suitability model for site D4 for all life-requisite components and overall habitat suitability for RGWT.

There were no significant differences in any of the individual models or the overall HSM in each site when compared between years. The proportion of HVH areas comprised > 95% of the adult female seasonal ranges in S1 for all years, at both scales, for all life-requisite components and the overall HSM (Fig. 4.7). In S2 (Fig. 4.7) at the 550-ha scale, proportions of HVH were lower for nesting cover (x = 85.5%) and overall HSM (x = 83.2%) than brood-rearing cover (x = 96.4%) and brood-rearing feeding (x = 93.4%). At the 3,500-ha scale, female adult seasonal ranges HVH areas were > 99% of the total area. In D3, seasonal ranges consistently had 72% to 74% of HVH areas in each individual model and the overall HSM at the 550-ha scale. However, at the 3,500-ha scale, seasonal ranges had < 15% of the total area with HVH categories for nesting cover and brood-rearing cover component models, and there were no HVH areas in the brood-rearing food component model and overall HSM. At the 550-ha scale at site D4 that adult female seasonal ranges were composed of 84% to 93% HVH areas (Fig. 4.7) in each component model and the overall HSM. At the 3,500-ha scale, seasonal ranges had > 95% with HVH areas for all life requisite component models and the overall HSM.

The comparison of seasonal HVH areas for the individual models between sites showed significant differences between D3 and all the other sites at both scales (Fig. 4.8). At the 550-ha scale, D3 was significantly lower (72% - 74% HVH areas) than all other sites (> 85% HVH areas). At the 3,500-ha scale, S1, S2 and D4 had seasonal ranges with > 98% HVH areas while D3 had only 14.1% HVH in seasonal ranges for the nesting cover and brood-rearing components and no HVH areas for the brood-rearing food component and overall HSM.

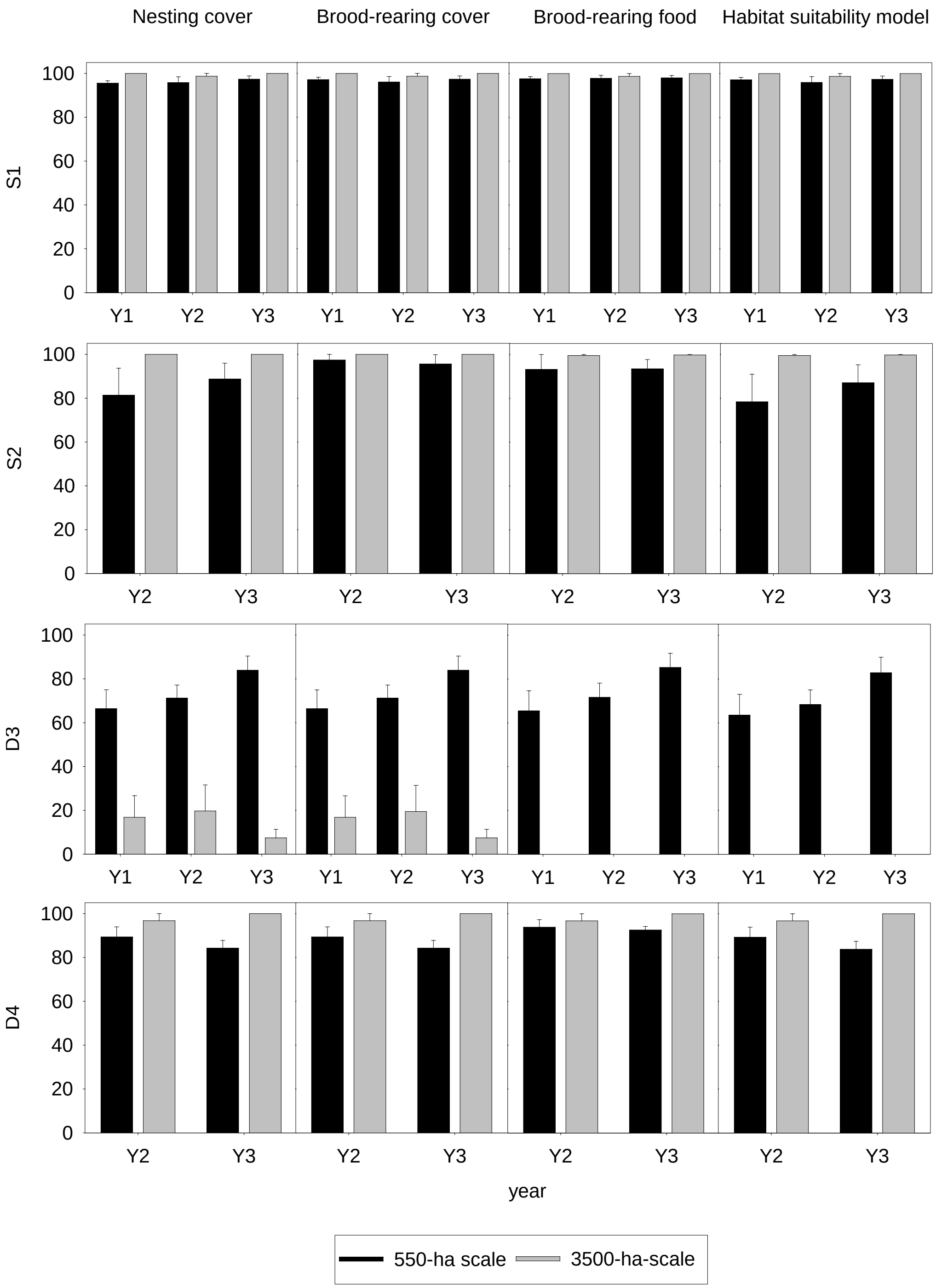

Figure 4.7. Proportion of high- and very high-suitability areas in female RGWT seasonal ranges in each study site compared by year for each life requisite component and overall habitat-suitability model. No significant differences were found between years in any study site.

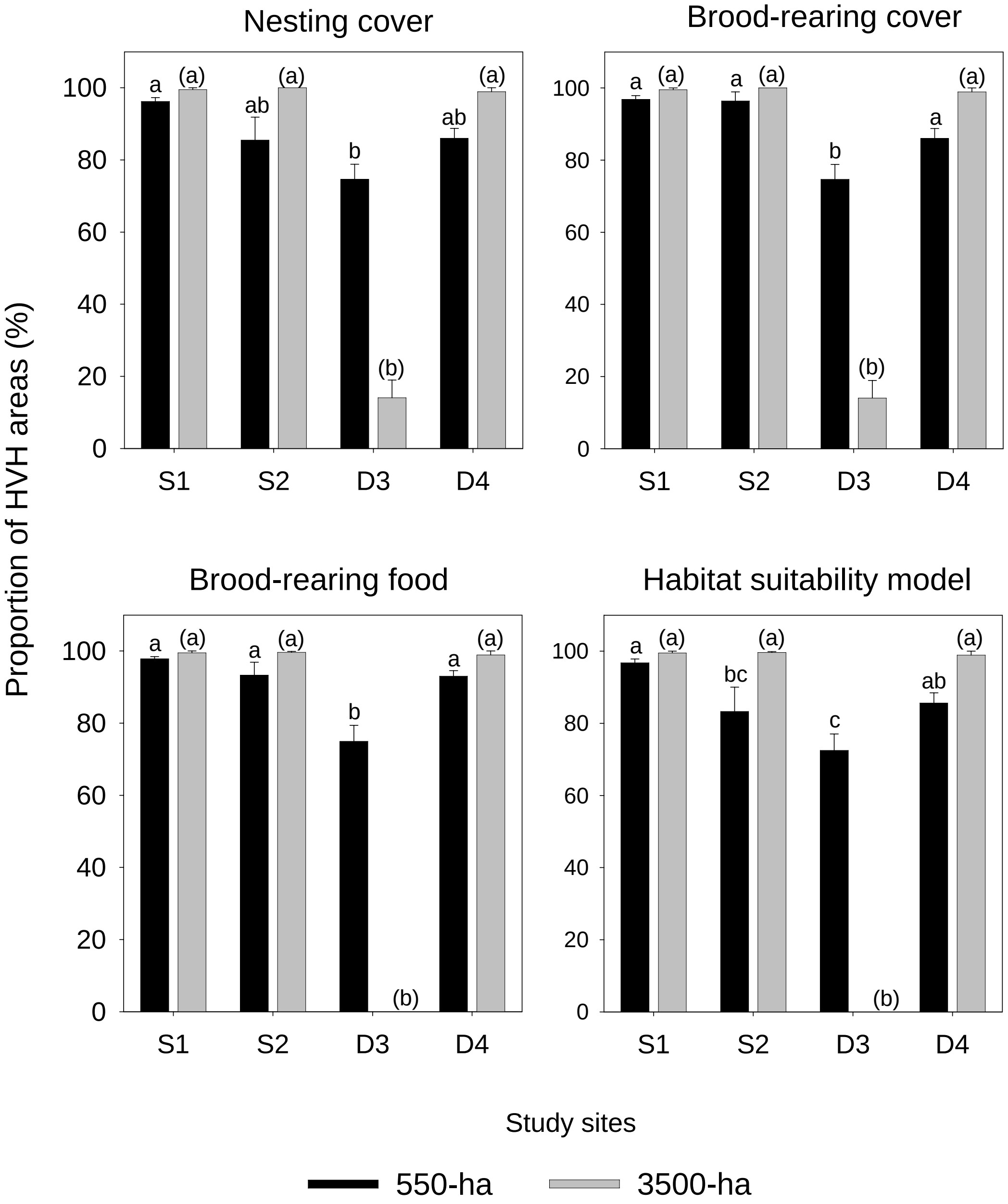

Figure 4.8. Proportion of high- and very high-suitability areas in female RGWT seasonal ranges by study site for life-requisite components and overall habitat-suitability model at 550-ha and 3,500-ha scales.

Discussion

The habitat-suitability model for adult female RGWT during the breeding season is a remote-sensing and GIS-based model that presents several advantages over previous documented habitat models for wild turkeys (Williamson and Koeln 1980; Rumble and Anderson 1995; Schroeder 1985; Donovan et al. 1987; Fleming and Porter 2001; Miller 2002). First, this model used landscape attributes as habitat variables to develop a habitat-suitability model. Second, the use of two scales relevant to RGWT provided important information about the HVH suitable areas for female RGWT in stable and declining sites in the Edwards Plateau. Third, the model can potentially characterize HVH habitat for adult female RGWT during the breeding season in the Edwards Plateau of Texas.

This habitat-suitability model was based on land cover attributes that were important to RGWT at the landscape level. Compared to traditional models for wild turkeys, which were developed at fine scales (Schroeder 1985; Rumble and Anderson 1995), this model was developed for larger-scale assessment using GIS and remote sensing. The use of landscape attributes provided information about the spatial characteristics of RGWT habitat and their importance in determining habitat suitability for the species at the landscape scales (Fleming and Porter 2001; With and King 2001; Lawler and Edwards 2002).

The use of two different scales was an important component of the model development. Based on habitat characteristics, species respond to habitat features at different scales (Riitters et al. 1997; Rho 2003). Schaap (2005) observed that RGWT used smaller seasonal ranges in declining sites than in stable sites, in the same study areas used to develop the habitat-suitability model. This model was developed using two scales based on seasonal ranges in declining (550 ha) and stable (3,500 ha) sites. The model detected HVH areas for all study sites at the 550-ha scale. However, at the 3,500-ha scale, the model did not detect very-high-suitability areas in D3 for any of the model component. It detected a low proportion of high-suitability areas (25%) in the nesting cover component and brood-rearing component and it identified no high-suitability areas for the brood-rearing food component or overall HSM. Site D3 has been defined as a site where RGWT populations have been declining for the last 30 years (Randel 2003; Schaap 2005). Mean annual ranges in D3 (1500 ha) were smaller than the mean-annual ranges in S1 (2800 ha) (Schaap 2005). The results from the HSM based on seasonal ranges observed by Schaap (2005) for adult female RGWT, coincided with areas identified in field studies as good habitat for RGWT (N. Silvy and M. Peterson, Texas A&M University, personal communication). Therefore, the use of landscape attributes metrics at different spatial scales relevant to female RGWT during the breeding season provides important information about the availability of HVH suitable habitat for the species in our study. Furthermore, this suggests that multiple-scale approach should be considered in all habitat-suitability assessment because single-scale assessment can yield potentially erroneous conclusions.

One of the challenges in habitat-suitability indices (HSI) is the use of independent datasets for testing the validity of a model (Schamberger and O'Neil 1986;

Brooks 1997). Abundance and especially density data (Brooks 1997; Hirzel et al. 2001) are often used in evaluation of the model. The habitat-suitability models of this study were evaluated in four independent sites based on sets of independent seasonal ranges. This habitat-suitability model consistently identified HVH suitability habitat for adult female RGWT during the breeding season in the Edwards Plateau of Texas. The HSMs showed the amount of high-quality-breeding habitat in seasonal ranges was high at the 550-ha scale (> 85% HVH areas) and very high at the 3,500-ha scale (> 98% HVH areas) in all study sites except D3. The amount of high quality breeding habitat in D3 was lower (≤ 74% HVH areas) at the 550-ha scale and very low at the 3,500-ha scale (< 15% HVH areas). This model and its performance demonstrated the usefulness of landscape attributes in habitat model development and habitat studies for wild turkeys and, potentially, other species.

Although the habitat-suitability model performed well as evaluated using the known seasonal ranges, further study to evaluate the model using spatially explicit RGWT abundance data in replicated landscapes is needed to comprehensively validate the habitat-suitability model. Spatial patterns of habitat of different suitabilities within seasonal ranges and their influence on RGWT behavior also should be examined in future studies. Theses studies would provide new insight into management strategies for landowners and managers to maintain and increase the amount of suitable habitat available to RGWT.

CHAPTER V

SUMMARY AND CONCLUSIONS

Impacts of flooding induced changes on Rio Grande wild turkey habitat

During the summer of 1978, remnants of tropical storm Amelia precipitated severe flooding along the Sabinal, Guadalupe, and Medina rivers of Texas, causing heavy loss of life and property. In less than 24 hours, rainfall in ≥ 500 mm, fed the headwaters of the rivers causing flashfloods. The flooded area corresponds with areas where wild turkey abundance has been declining since the late 1970s. Thus, it is possible that landscape changes caused by this flood may have contributed to the decline in Rio Grande wild turkey (RGWT) abundance by altering the spatial configuration of woody cover suitable for roosting, breeding, and dispersal along the streams and bottomlands associated with the North Prong Medina River. The objective of this study was to quantify landscape changes that resulted from the flooding of 1978 along the North Prong Medina River and its tributaries to determine their potential impact on RGWT habitat. The hypotheses were that (1) the amount of woody cover decreased significantly near the streams due to the flood of 1978, and that (2) suitable habitat was fragmented and connectivity reduced, which resulted in decreased overall habitat suitability of the area for RGWTs.

The study area consisted of the middle reaches of the North Prong Medina River near the boundary of Bandera and Kerr counties, Texas. Aerial photography for 1972, 1984, and 1995 were classified and used in the analyses at two spatial scales: the bottomland of the North Prong Medina River and its tributaries, where the impact of flooding potentially extended; and in more detail, the riparian zones where roosting habitat typically was concentrated and the affects of flooding greatest.

A large proportion of the bottomland in the North Prong Medina River consisted of poor or sub-optimal habitat quality for RGWT. The amount of woody cover did not change significantly following the flooding of 1978 but the connectivity of adequate habitat for wild turkeys was reduced. The flooding of 1978 reduced the amount of woody cover in riparian zones of higher order streams. Such disturbance in higher-order streams resulted in the fragmentation of woody patches, reduction of connectivity between patches, and overall decreases in the amount of suitable habitat, limiting areas for roosting, feeding, breeding, and dispersal of RGWT. Results suggest that the flooding of 1978 likely contributed to the decline of RGWT in the study area. There appears to have been a recovery process of the bottomland landscape in the 17 years since the flood occurred. There has been a partial recovery of woody cover along the riparian zones and bottomland areas of the North Prong Medina River which may benefit RGWT habitat.

Landscape characteristics of stable and declining sites

Open areas, well interspersed with woody cover, are important to RGWT habitat. Habitat for RGWTs should contain a maximum of 65–70% woody cover. Optimal habitat should consist of 50% open areas with well-interspersed woody cover for roosting, feeding and dispersal. High proportions of woody cover reduce suitable habitat for RGWT. Human and natural disturbances also affect RGWT populations. Land used for recreational purposes, camping areas, highways, industrial parks, and urban and rural development negatively affects RGWT populations as well as overgrazing and improved pastures. The objective of this study was to quantify and compare landscape characteristics of sites with stable and declining populations of RGWTs in the Edwards Plateau of Texas to better understand why RGWT numbers have decreased in the southeastern portion of this region. Two hypotheses were tested that (1) the proportion and spatial distribution of woody cover was different between sites with stable and declining populations, and (2) disturbance was significantly higher in sites where populations had declined than in sites where populations had remained stable.

The study areas were located in the southeastern portion of the Edwards Plateau in Kerr, Real, Bandera, and Medina counties, Texas. Regions supporting stable and declining RGWT populations were delineated based on winter roost counts and landowner interviews. Two sites each were selected for the regions with stable (sites S1 and S2) and declining (sites D3 and D4) RGWT abundance. Ecological sites, stream density, percentage of high relief terrain (HRT) woody cover metrics, proportion of usable space, road density, road density in disturbed areas, proportion of streams impacted by roads and proportion of streams impacted by disturbed areas were compared between sites.

High proportions of woody cover are important factors impacting RGWT populations in regions where turkey numbers have declined. The amount and spatial distribution of woody cover vegetation in HRT seem critical to RGWT roosting, feeding, and dispersal habitat. Therefore, proper management of woody cover along riparian zones and high relief areas is important if one wishes to maintain RGWT populations. Human disturbance appeared to have significantly impacted RGWT habitat. Even if the proportion and spatial distribution of woody cover is suitable, significant amounts of disturbance, such as removal of cover for improved pastures, and urban development, roads, and other human activity along streams, can have negative impacts on RGWT habitat.

Habitat-suitability model for female Rio Grande wild turkeys

Habitat suitability models (HSM) have been widely used to assess habitat quality for wildlife species. These models are tools designed to quantify habitat quality using habitat attributes deemed important to wildlife species. However, there is no HSM developed for RGWT in the Edwards Plateau of Texas. The objective of this study was to develop and evaluate a remote sensing and GIS-based HSM for female RGWTs during the breeding season, which would allow the assessment of the spatial distribution of suitable habitat in these study areas. An HSM was developed using GIS and remote sensing data and landscape metrics related to important habitat factors for female RGWT during the breeding season. The model was calibrated based on data associated with seasonal ranges with minimal overlap from one study site and then tested in three different study sites with independent datasets for RGWT in three different years.

The habitat suitability model developed for female RGWT during the breeding season performed consistently well in characterizing suitable habitat for the species in the study areas. Assessment using landscape metrics and land cover attributes at different scales provided useful information on the suitability and pattern of RGWT habitat in the four study sites, which demonstrated the usefulness of landscape attributes in habitat modeling studies for wild turkeys and likely other species.

Although the habitat suitability model performed well as evaluated using the known seasonal ranges, further study to evaluate the model using spatially explicit RGWT abundance data in replicated landscapes is needed to comprehensively validate the habitat suitability model. Spatial patterns of habitat of different suitabilities within seasonal ranges and their influence on RGWT behavior should also be examined in future studies. Theses studies would provide new insight into management strategies for landowners and managers to maintain and increase the amount of suitable habitat available to RGWT.

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