OCCASIONAL PAPERS

Museum of Texas Tech University

Number 201 — 14 December 2000

ECOTOURISM AND CONSERVATION:

RICHNESS OF TERRESTRIAL VERTEBRATES ACROSS TEXAS

With a global human population of 6 billion and rising, the habitat for many species is being lost at an unprecedented rate. The 20 plus million residents of Texas are rapidly altering native habitat largely by removal or fragmentation. An objective of the Texas GAP Analysis Project was to develop fine-scale distribution maps for terrestrial vertebrates of Texas. As a first step we examined published range maps to determine areas of high biological diversity (biodiversity) that would be of interest to ecotourists, conservationists, landowners, and natural resource managers. A map depicting the seven major geographic regions was used as a backdrop to analyze distribution of 908 terrestrial vertebrates of Texas. This map was part of a Geographical Information System including soils, vegetation, and elevations used to define habitat for terrestrial vertebrates. Species richness ranged from a low of 378 in the Piney Woods to a high of 514 in the South Texas Plains. These maps provide a guide to the biodiversity of Texas and therefore reflect the potential for expansion of ecotourism. Ecotourism is one means available to landowners to develop an economically sustainable lifestyle and yet conserve natural resources for generations to come. In a state with only 3.2% of its area in public ownership, the importance of private landowner stewardship to maintain biodiversity is essential. Access to accurate information on biodiversity is critical to economic development and conservation biology.

Front cover: The seven major geographic regions of Texas (Texas Parks and Wildlife Department, 1999).

Ecotourism and Conservation: Richness of Terrestrial Vertebrates across Texas

Eric A. Holt, Kelly E. Allen, Nick C. Parker, and Robert J. Baker

Wilson (1998) predicted that the world contains between 5 and 30 million species; however, he also recognizes that this number may be as high as 100 million (Wilson, 1999). Of these species only about 1.4 million have been described by scientists (Wilson, 1999). In all corners of the world, humans have been dependent upon species for food and fiber. For example, at a global population of 5 billion, more than 40% of the world's primary net production has been converted for use by humans (Ehrlich, 1988). Now, with a population of 6 billion and rising, the habitat for many species is being lost at an unprecedented rate. In fact, the extinction of species today is estimated to be 100 to 1,000 times above the background rate (Tuxill, 1998).

As European explorers, and later settlers, moved across the United States they, like the native peoples, relied heavily on resident vertebrates, especially large mammals, as their primary food source (Bakeless, 1964). Bison (*Bos bison*), pronghorn antelope (*Antilocapra americana*), and white-tailed deer (*Odocoileus virginianus*) were prominent game species taken in Texas by explorers and settlers (Doughtry, 1989). In addition, other vertebrates including small mammals [e.g., rabbits (*Sylvilagus* sp.), birds [e.g., quail (*Colinus virginianus* and *Callipepla squamata*), and ducks (*Anas* sp., *Aythya* sp., etc.)] were also utilized heavily as food sources. Early Texans learned firsthand the distributions of these game species and other groups of vertebrates that directly affected their lives, such as predators and poisonous reptiles, by direct observation. In contrast, today's Texas explorer relies on range maps published in established field guides, brochures, or on the Internet to identify where, and when, they may discover their particular vertebrates, invertebrates or plants of interest.

The first systematic biological collection of the flora and fauna of Texas was conducted by Vernon Bailey during the period of 1896 to 1905 (Bailey, 1905). Since then, a century of work has led to the production of range maps in Texas for mammals (e.g., Davis and Schmidly, 1994), amphibians (e.g., Garrett and Barker, 1994), reptiles (e.g., Garret and Barker, 1994; Tennant, 1998), and birds (e.g., Rappole and Blacklock, 1994; Kutac, 1998). These range maps are based on voucher specimens housed in museum collections, data collected during biological surveys, large scale ecological boundaries, and expert opinion.

An objective of the Texas Gap Analysis Project (TX-GAP)(Parker et al., 1998) and a component of the National Gap Analysis Program (Scott et al., 1993; Csutti, 1996), was to develop fine-scale distribution maps for the terrestrial vertebrates living in Texas. These distribution maps are based primarily on wildlife habitat relationship models that incorporate spatial data on vegetation, soil, elevation, temperature, precipitation, and other environmental factors influencing the distribution of species. These distribution maps improve upon existing range maps by identifying the habitat within the range extent where the species are expected to be found (Scott et al., 1993). Although range maps, as opposed to distribution maps, are too course to meet the resolution requirements of TX-GAP, they are useful for evaluating the distribution of species at larger resolutions (Holt 1999, MS thesis). The objective of this study was to use published range maps of terrestrial vertebrates to determine areas of high biological diversity (biodiversity) that would be of interest to ecotourists, conservationists, landowners, and natural resource managers.

Methods

A geographic information system (GIS) was used to digitize, store, and analyze range maps from Davis and Schmidly (1994), Rappole and Blacklock (1994), Garret and Barker (1994), and Tennant (1998). These electronic range maps were overlaid to produce five composite maps— one each for mammals, am-

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phibians, reptiles, birds, and a composite of vertebrate diversity. The 908 vertebrate species chosen were selected based on criteria as follows:

1. resident within the state of Texas,
2. have been known to breed within the state of Texas within the past 30 years,
3. native to Texas, and
4. exist as free-ranging wild populations.

These criteria eliminated exotic and introduced species such as feral pigs (*Sus scrofa*); species maintained only in captivity, such as bison; and species such as the hairy-legged vampire bat (*Diphylla ecaudata*), found only rarely in Texas as an immigrant from Mexico (Davis and Schmidly, 1994). Information regarding these criteria was obtained from Texas Parks and Wildlife (1997), Kutac (1998), Davis and Schmidly (1994), Rappole and Blacklock (1994), Garret and Barker (1994), and Tennant (1998).

Maps of environmental factors influencing the distribution of vertebrates were downloaded from the Texas Natural Resource Information Service (TNRIS) (<http://www.tnris.state.tx.us>) and printed for comparison of spatial patterns in soils (Fig. 1), vegetation (Fig. 2), and elevations (Fig. 3). The soil map, developed by the U.S. Department of Agriculture, Natural Resources Conservation Service as the STATSGO (U.S. Department of Agriculture, 1994) database, and the elevation map, prepared by the U.S. Geological Survey (U.S. Department of Interior, 1990), were obtained from TNRIS. A map depicting the seven major geographic regions of Texas was digitized (Fig. 4) from Texas Parks and Wildlife Department (1999) and used as the backdrop to analyze distribution of vertebrates.

RESULTS AND DISCUSSION

Overlaying range maps for the 908 terrestrial vertebrate species in Texas indicates that vertebrate richness ranged from a low of 378 species in the Pineywoods of East Texas to a high of 514 species in the South Texas Plains (Fig. 5 and Table 1). At the taxonomic class level, mammalian richness ranged from 55 species in the Pineywoods to 96 species in the Big Bend (Fig. 6). Amphibian richness was lowest (n = 20 species) in the Panhandle Plains and highest (n = 48 species) in the Prairies and Lakes Region (Fig. 7). Reptile richness ranged from 67 species in the Pineywoods to 109 species in the South Texas Plains (Fig. 8) and avian richness was lowest (n = 194 species) in the Panhandle Plains and highest (n = 283 species) in the South Texas Plains (Fig. 9).

The eastern edge of the Edwards Plateau of Central Texas, the northwestern edge of the South Plains region, and the Big Bend area are clearly demarked by spatial patterns in soil, vegetation, and elevations. These regions contain a high diversity, not only in geomorphology, but also of vertebrate species. Agriculture and urbanization along the Balconies Fault has dramatically altered habitat on the eastern edge of the Edwards Plateau and agricultural development along the Rio Grande has altered habitat in the sparsely populated western regions.

All areas of the state contain vertebrates, invertebrates and plants of interest to landowners, conservationists, scientists, birders, hikers, photographers, and hunters. Biologically diverse areas containing large populations of humans are the areas likely to experience the greatest change due to population growth. The establishment of conservation reserves, parks, wildlife refuges, and easements to limit future development would likely be most effective if placed in areas of high biodiversity with potential for future commercial development of open space. At the same time, these areas are also prime spots for the development of ecotourism or travel oriented around natural sites, native species, and traditional cultural practices (Tuxill, 1998). Ranchers, farmers, and even absentee landowners are realizing the economic potential of ecotourism. Honey (1999) presents several definitions of ecotourism and subcomponents including nature tourism, wildlife tourism, and adventure tourism. Ecotourism has been narrowly defined as travel "to relatively undisturbed or uncontaminated natural areas with the specific object of studying, admiring, and enjoying the scenery of its wild plants and animals, as well as any existing cultural aspects found in these areas" and also as travel "to learn about and appreciate the environment" (Honey 1999). We use the term ecotourism in its broadest definition to include travel,

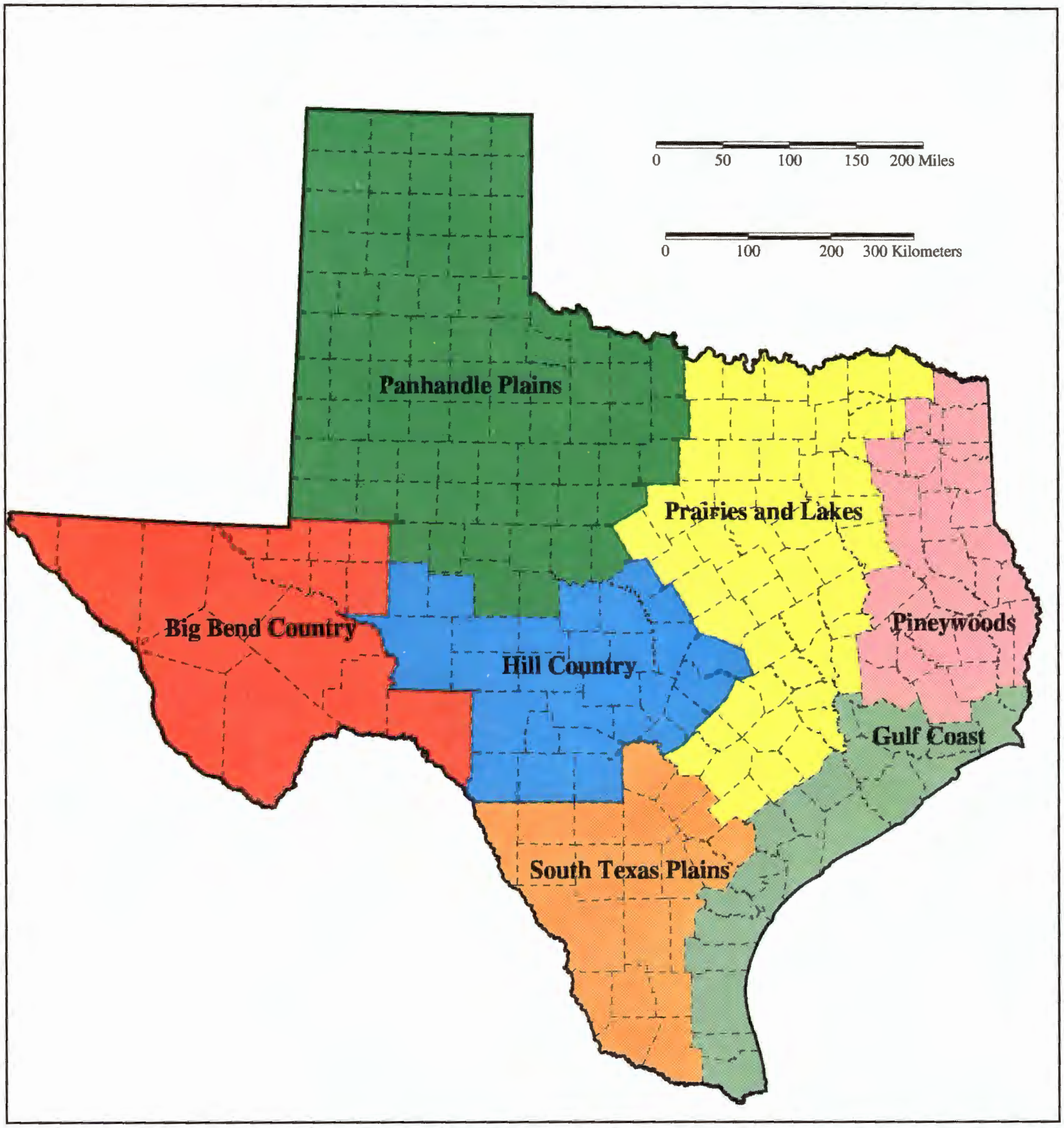

Figure 1.—The seven major geographic regions of Texas (Texas Parks and Wildlife Department, 1999).

outdoor recreation and other activities which can be conducted in a sustainable environment. On some West Texas ranches such as the Old Alazan Ranch (Robinson, 1999), the Cibolo Creek Ranch (Morrison, 1999), the Prude Ranch, and the Y.O. Ranch (Banks, 1999), the revenue from ecotourism today is increasingly important and, in some cases, may exceed the revenue from traditional ranching activities. Tourism is now the number one industry in Texas and has the potential for tremendous expansion. Nationwide in 1991, 108.7 individuals in the U.S. participated in outdoor recreation and spent a total of $59 billion (U.S. Department of Interior et al., 1993*a*). In 1991, 35.6 million anglers spent $24 billion and 14.1 million hunters spent $12 billion. An additional 76.1 million (73.9 million residents and 30 million non-residents) partici-

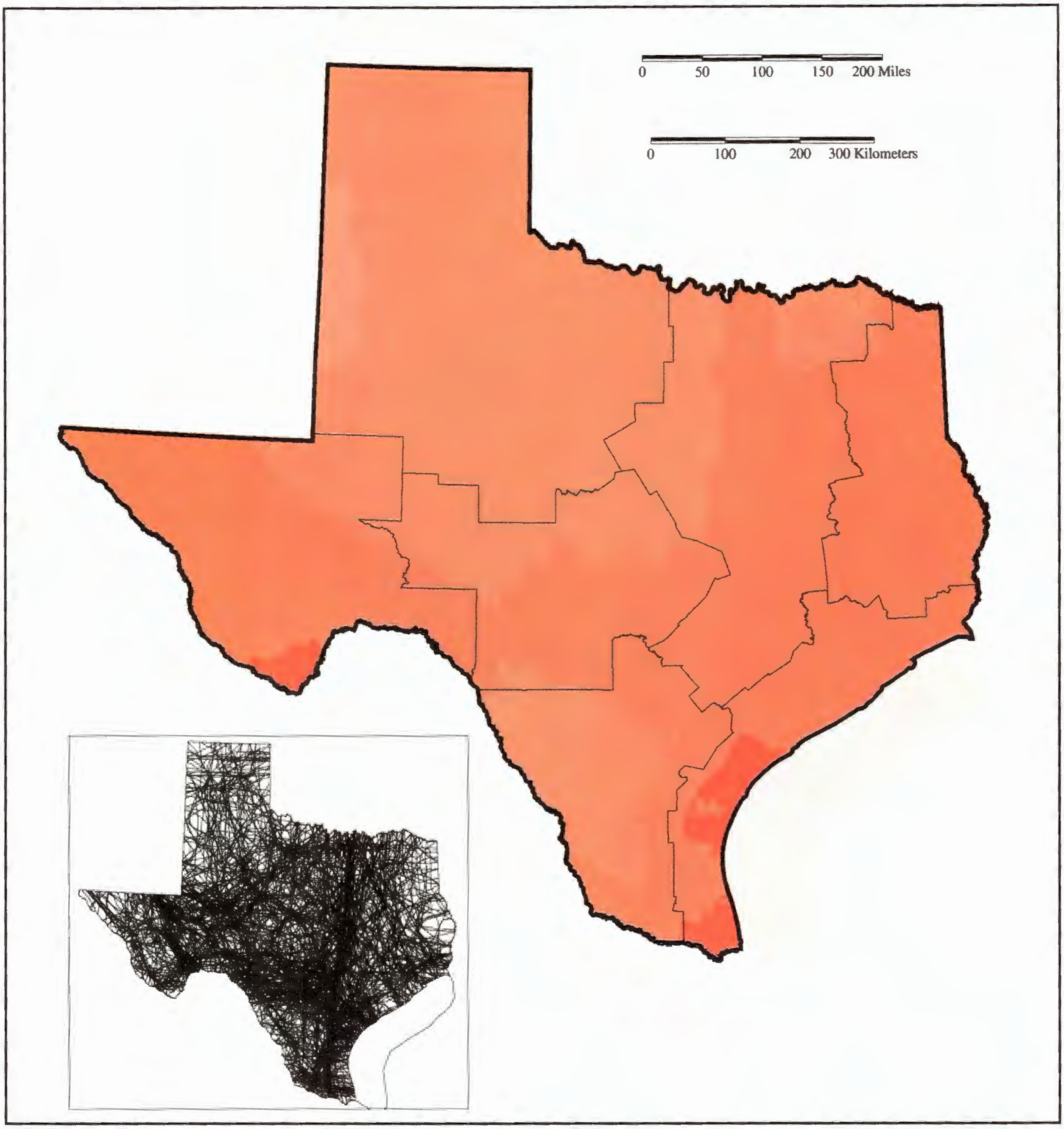

Figure 2.—The vertebrate diversity of Texas. Species richness increases from low to high with increased shading. The inset represents the range extent for 908 vertebrate species.

pated in non-consumptive outdoor recreation and spent a total of $18.1 billion in pursuit of their sport.

The economic impact of travel, of both tourists and non-tourists, in Texas was $22.6 billion in 1995 (Texas Department of Economic Development, 1996) and $34.6 billion in 1998 compared to the cash receipts from agriculture of $13 billion ($5 billion crops, $8 billion livestock), and the $12.8 billion of energy and mining (Rylander, 1999). In 1997 Texas had the second greatest number of tourists, (160 million) in the nation. These tourists spent over $16 billion, of which 67% (over $10 billion) was for leisure travel. In 1998, 34% of the visitors to Texas participated in out-

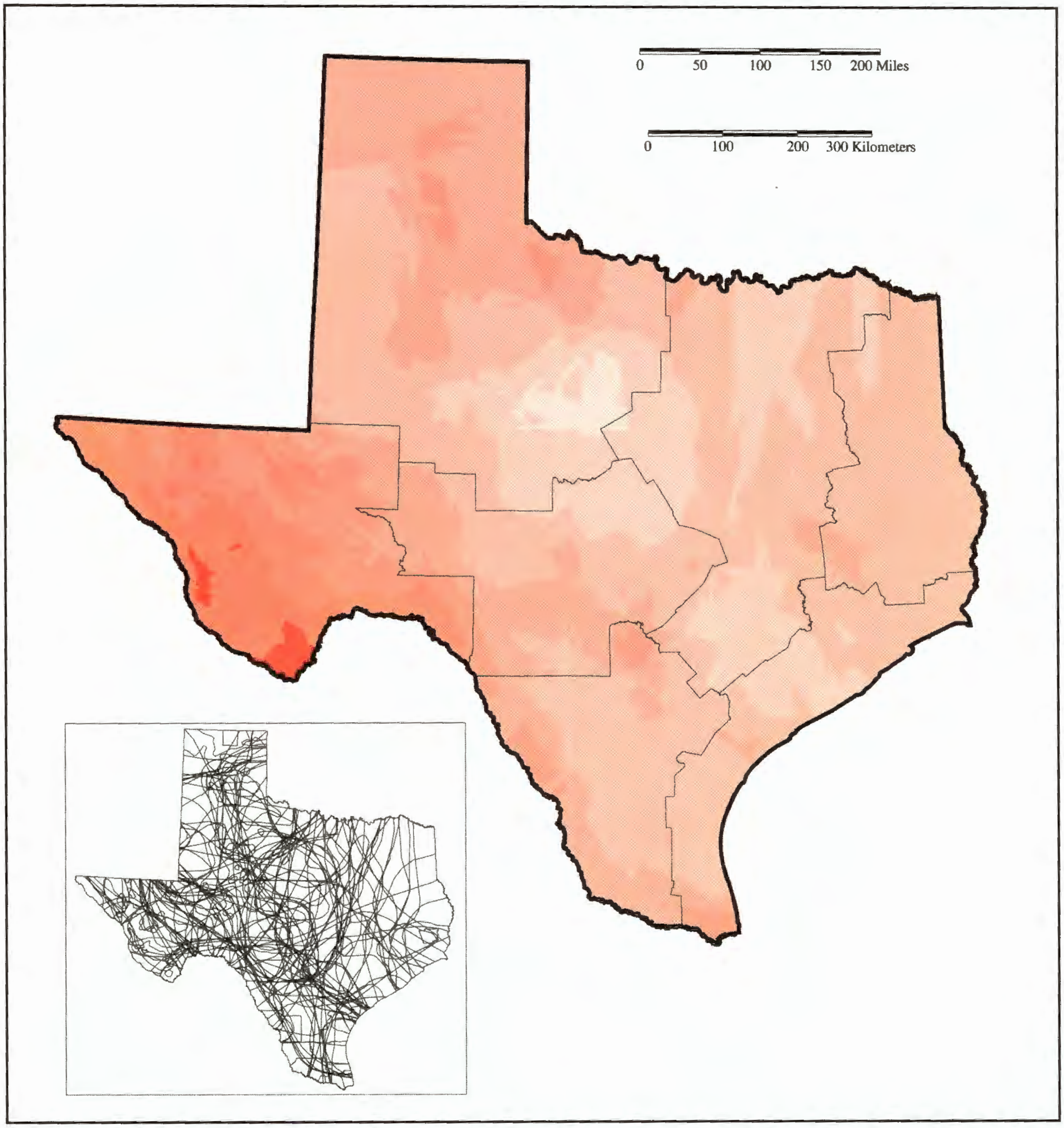

Figure 3.—The mammal diversity of Texas. Species richness increases from low to high with increased shading. The inset represents the composite range extent for all Texas mammals (Davis and Schmidly, 1994).

door sports, touring and nature activities, while an additional 17% participated in cultural activities including visits to historical sites (See the Texas Travel Facts booklet January 2000, or contact Texas Department of Economic Development; Tourism Division; P.O. Box 12728; Austin, TX 78711-2728 for additional data on travel in Texas).

In 1991, 2,650,000 anglers in Texas spent $1.47 billion pursuing their sport while 1,018,000 hunters spent $1.0 billion for equipment and trip related expenses (U.S. Department of Interior et al., 1993*b*). The 4,016,000 participants of non-consumptive wildlife recreation spent $877 million for equipment, trips, and related activities. Economic data and days of par-

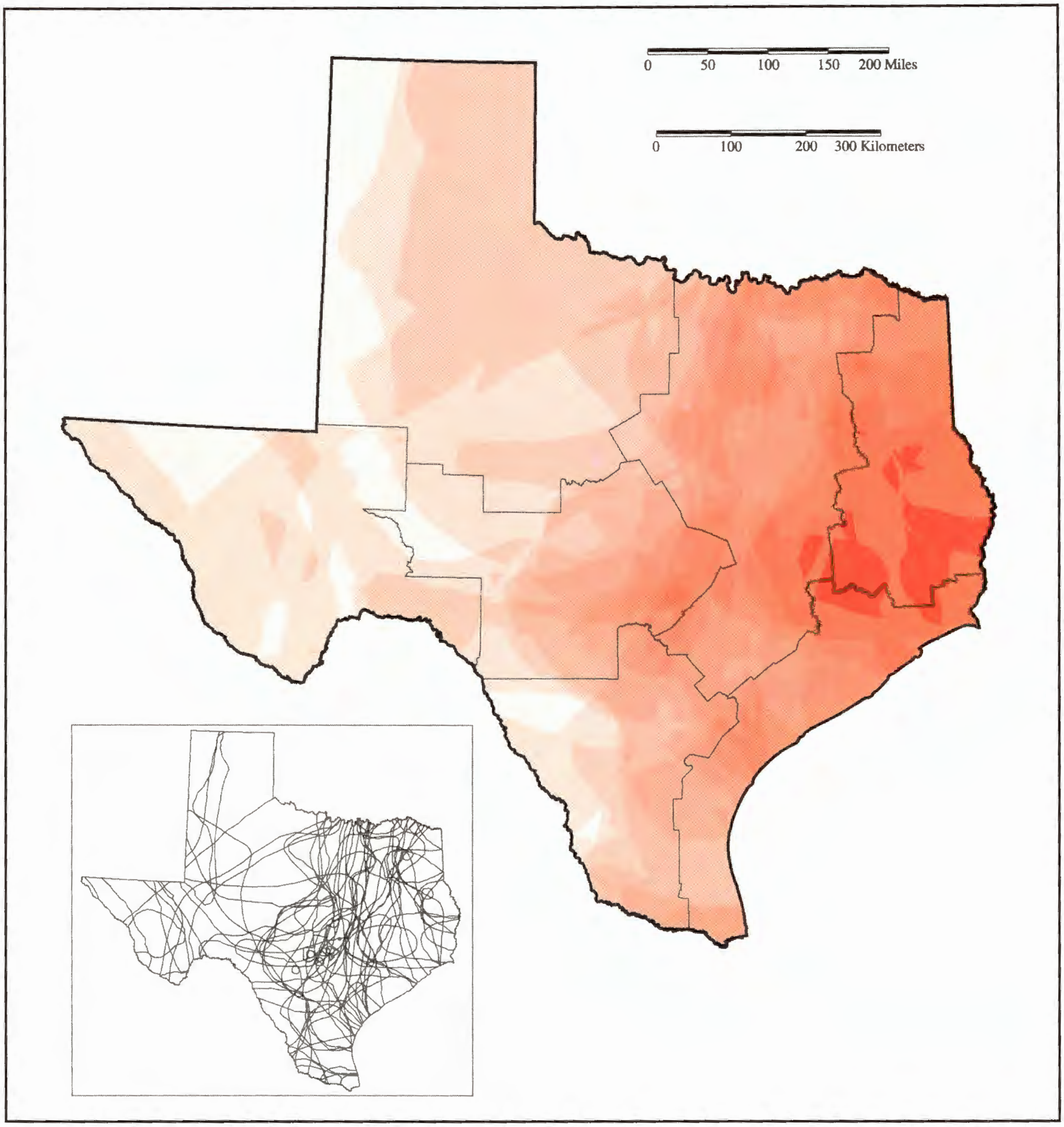

Figure 4.—The amphibian diversity of Texas. Species richness increases from low to high with increased shading. The inset represents the composite range extents for all Texas amphibians (Garret and Barker, 1994).

ticipation (Table 2) have been compiled and analyzed for participants of bass fishing, deer hunting, and wildlife watching (U.S. Department of Interior, 1994). However, no data were found to reflect a full range of outdoor activities including cattle-driving, roping, skeet shooting, horseback riding, floating rivers, hayrides, geological tours, spelunking, hiking, camping, and photography reported as activities on Texas ranches (Banks, 1999).

The biological and geological resources of Texas are prime attractions for ecotourists. The 20 million residents of Texas today are expected to expand to 34 million by 2030 (Ramos and Plocheck, 1999) and will

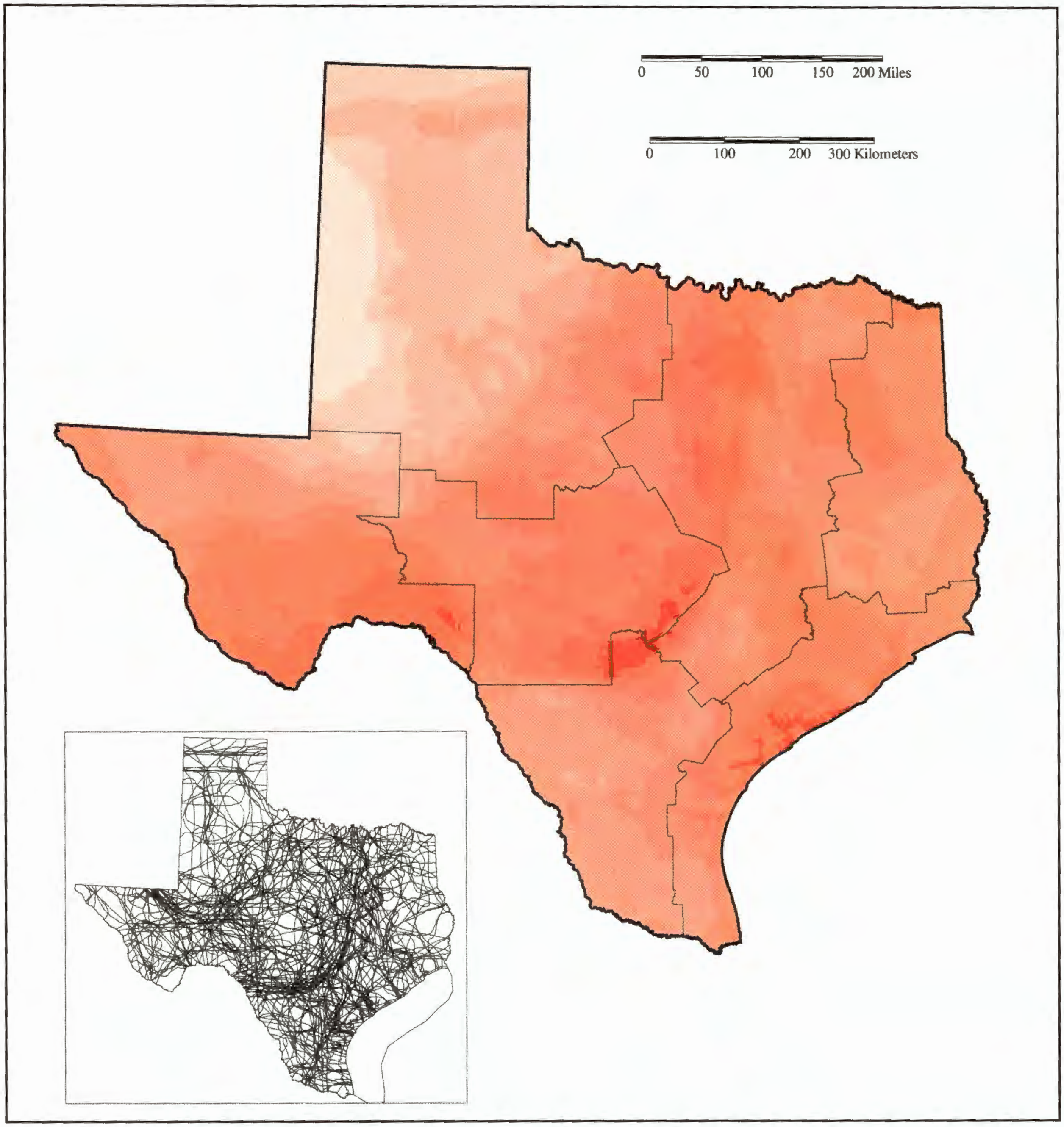

Figure 5.—The reptile diversity of Texas. Species richness increases from low to high with increased shading. The inset represents the composite range extent for all Texas reptiles (Garret and Barker, 1994; Tennant, 1998).

increasingly seek opportunities to experience Texas and its rich biodiversity. The maps published herein provide a guide to the biodiversity of vertebrates in Texas and therefore, the potential for expansion of ecotourism.

Ecotourism benefits not only those directly involved with the economic activity, but all of society through the preservation of biodiversity (Cairncross, 1992). Worldwide, approximately 1 billion hectares (6%) of the earth's surface is designated as protected habitat (Tuxill, 1998). However, in Texas only about 2.2 million hectares (3.2%) are set aside as public lands for conservation and management of natural resources (Dept. of Interior, U.S. Fish & Wildlife Service, 1992).

Table 1.—Vertebrate species by taxonomic group and vertebrate biodiversity (total of vertebrate species) for the seven major geographic regions.

Vertebrates	Big Bend Country	Gulf Coast	Hill Country	Panhandle Plains	Pineywoods	Prairies & Lakes	South Texas Plains
Amphibians	22	43	37	20	34	48	40
Birds	232	277	239	194	222	227	283
Mammals	96	79	90	82	55	70	82
Reptiles	89	95	101	84	67	96	109
Vertebrate biodiversity	439	494	467	380	378	441	514

Additionally, The Nature Conservancy of Texas (TNC) owns about 40,485 ha (personal communication, David Wolf, TNC, Austin, Texas) and, combined with federal and state lands, about 3.4% of total land in Texas is afforded some type of protection.

The need to protect biodiversity in Texas was recognized over 100 years ago. The first game law in Texas became effective February 1860 and prohibited quail hunting on Galveston Island for 2 years (Tuxill, 1998). However, by the eve of the Great Depression and the dust bowl days of the 1930s, the need for a national program in conservation was recognized. In September 1937 the Pittman-Robinson Act was signed establishing a state and federal program for conservation of America's wildlife (Kallman et al., 1987). Since then, state and federal programs have restored wildlife throughout the nation, but especially in Texas--the biological crossroads of North America (Doughtry, 1989). Activities on private lands that economically benefit landowners, as well as wildlife, include the Conservation Reserve Program (CRP) and the Wetland Reserve Program (WRP). Many private landowners in Texas directly improve habitat for white-tailed deer, quail and other game species and, in doing so, indirectly provide habitat improvement for non-game wildlife and native plants. These programs and actions by private landowners are credited as having a major component to the recent increase in duck populations (Young, 2000) and the economic activity resulting from land leased for hunting game species.

Today, the burgeoning human population, combined with urban expansion, is the greatest threat to biodiversity. The best incentive for conservation of biodiversity is establishing an economic benefit to those who conserve and protect those resources. The benefit of a high economic value can be seen in elephant populations in Zimbabwe, where harvest by hunting brings substantial economic benefit to the people (Campbell et al. 1996). The people protect elephant herds because they are a valuable resource and provide financial support for the basic needs of society (Child 1993). Alternately, in Kenya, elephants are not hunted, but still serve as a major economic factor (Leakey 1993; Honey 1999).

It is fairly easy to envision how land owners with large tracks of land can develop bird watching tours, packaged hunts, and even trespass privileges that could serve as a source of income from their property. However, for smaller landowners, the problem is more complex. In the Texas Panhandle, organized pheasant hunts provided by the Lions Clubs and Chambers of Commerce might be appropriate models for small landowners. In these examples, many landowners agree to permit trespassing and hunting privileges marketed by the organizing group. In the case of bird watching, a group of hotels or a Chamber of Commerce might organize bird watching or other outdoor activities. The hosting organization can handle the advertising, serve as a source for information as to where different species and activities can be enjoyed, and even locate personal guides, if appropriate. The activities of the organizing group would boost the local economy in several ways including hotel occupation, increased restaurant use, and general tourist activities. Small landowners can share some of the income for package

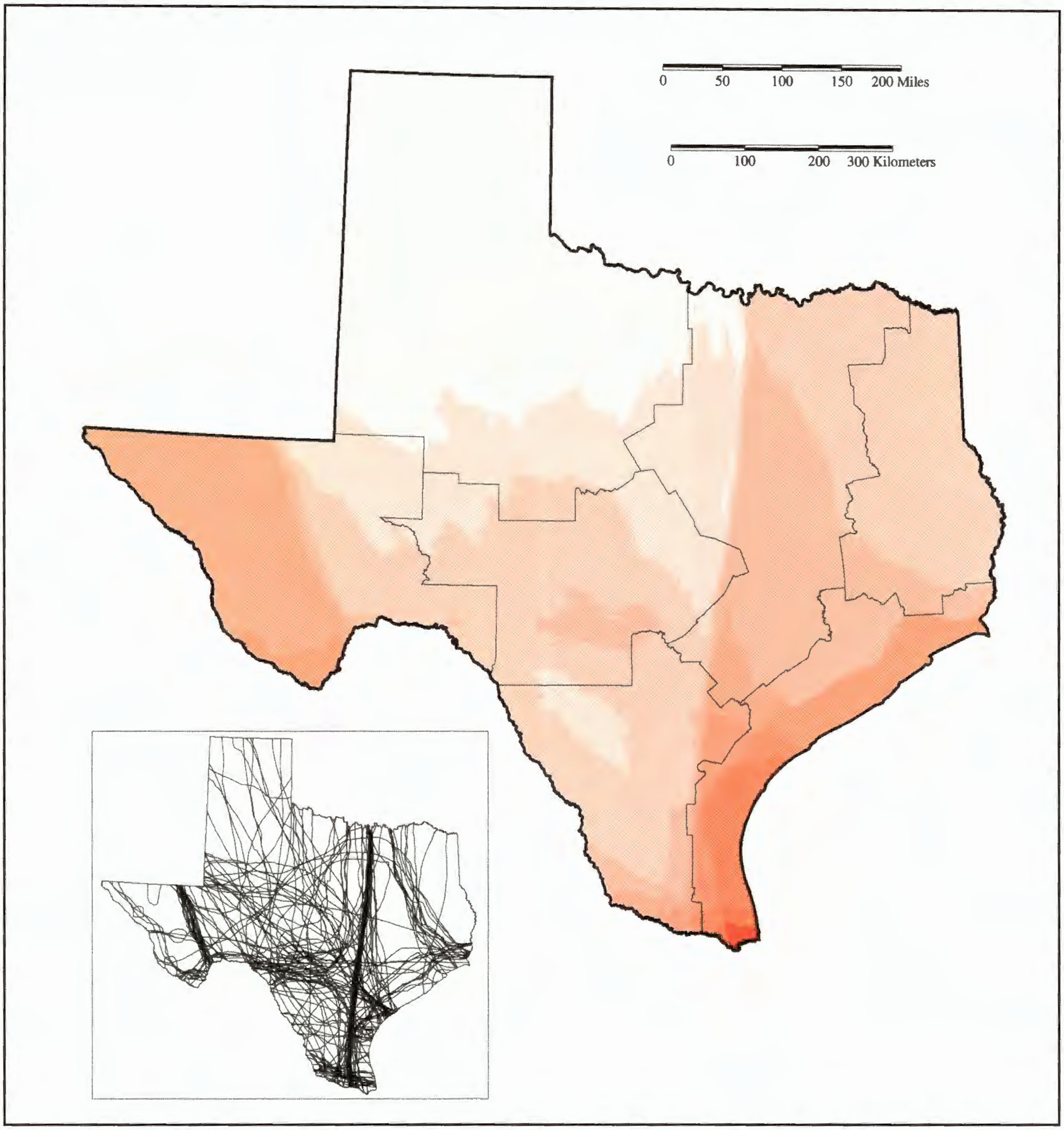

Figure 6.—The avian diversity of Texas. Species richness increases from low to high with increased shading. The inset represents the composite range extent for all resident birds of Texas (Rappole and Blacklock, 1994).

activities without making a large investment. For all involved, conservation for biodiversity becomes economically beneficial.

The more species, especially rare and uncommon taxa, that are present on private land the more desirable trespass privileges become to bird watchers. Areas with a paucity of species may still be attractive to birdwatchers if the endemic species are rare. An example is the attraction of birdwatchers to the lesser prairie chicken found only in the Panhandle of Texas, an area with the second lowest level of vertebrates biodiversity. The Panhandle is the only place in Texas where the lesser prairie chicken can be viewed in its

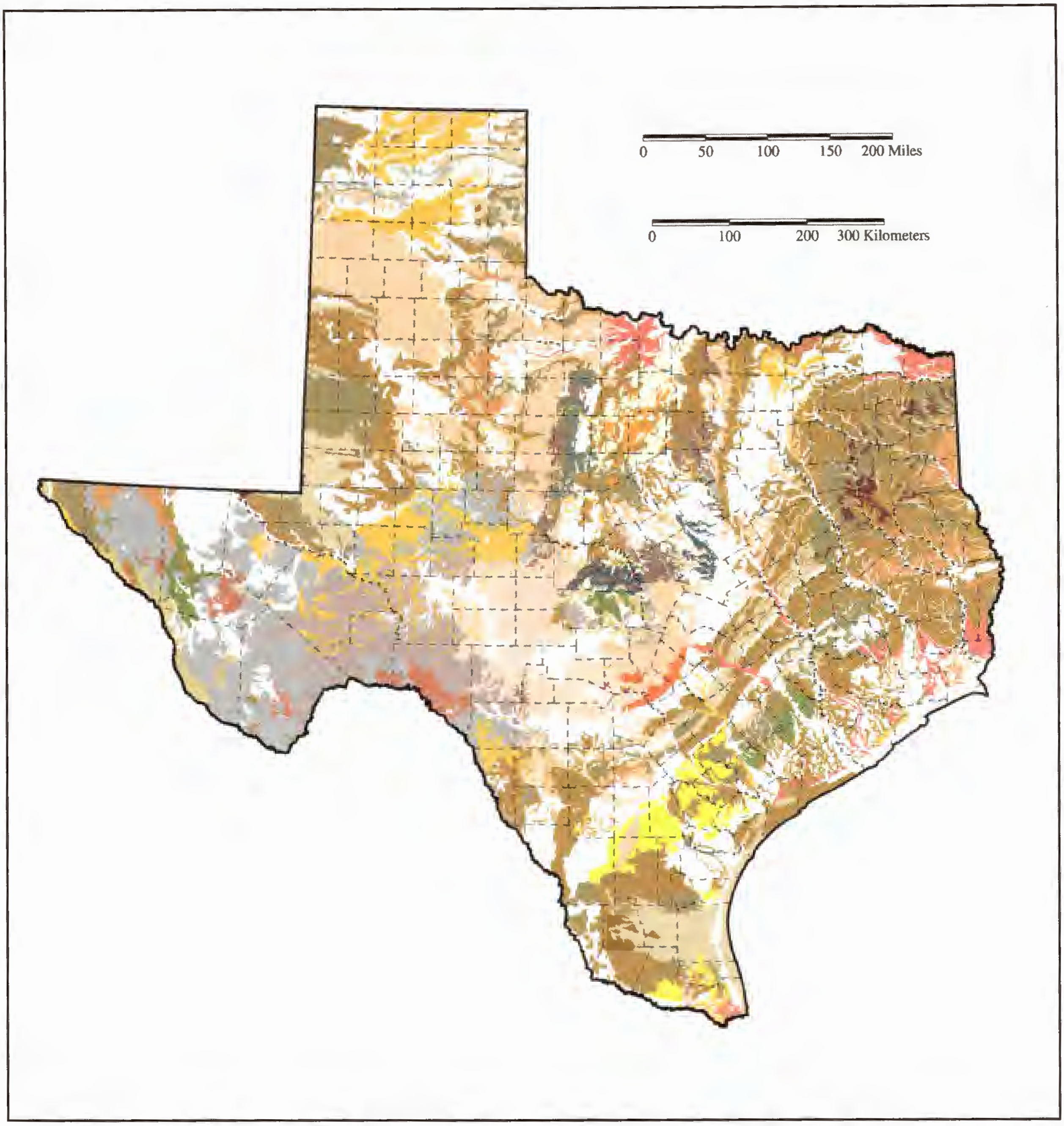

Figure 7.—The soil types of Texas. Soil types are highly diverse across the state and serve as an important factor supporting the biodiversity of Texas. Soil types and their description can be found at the website of http://www.tnris.state.tx.us. The soil map was developed by the U.S. Department of Agriculture, Natural Resources Conservation Service and provided through TNRIS.

native habitat. Therefore, successful landowners will manage their property to produce viable habitat. A byproduct of ecotourism will be that landowners will become interested in becoming better educated concerning wildlife identification, habitat requirements and principles of ecology and wildlife conservation.

The success of programs of the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department are dependent in Texas upon strong support and cooperation of private landowners. Neither state nor federal resources are adequate enough to purchase and set aside the quantity of land needed to insure conser-

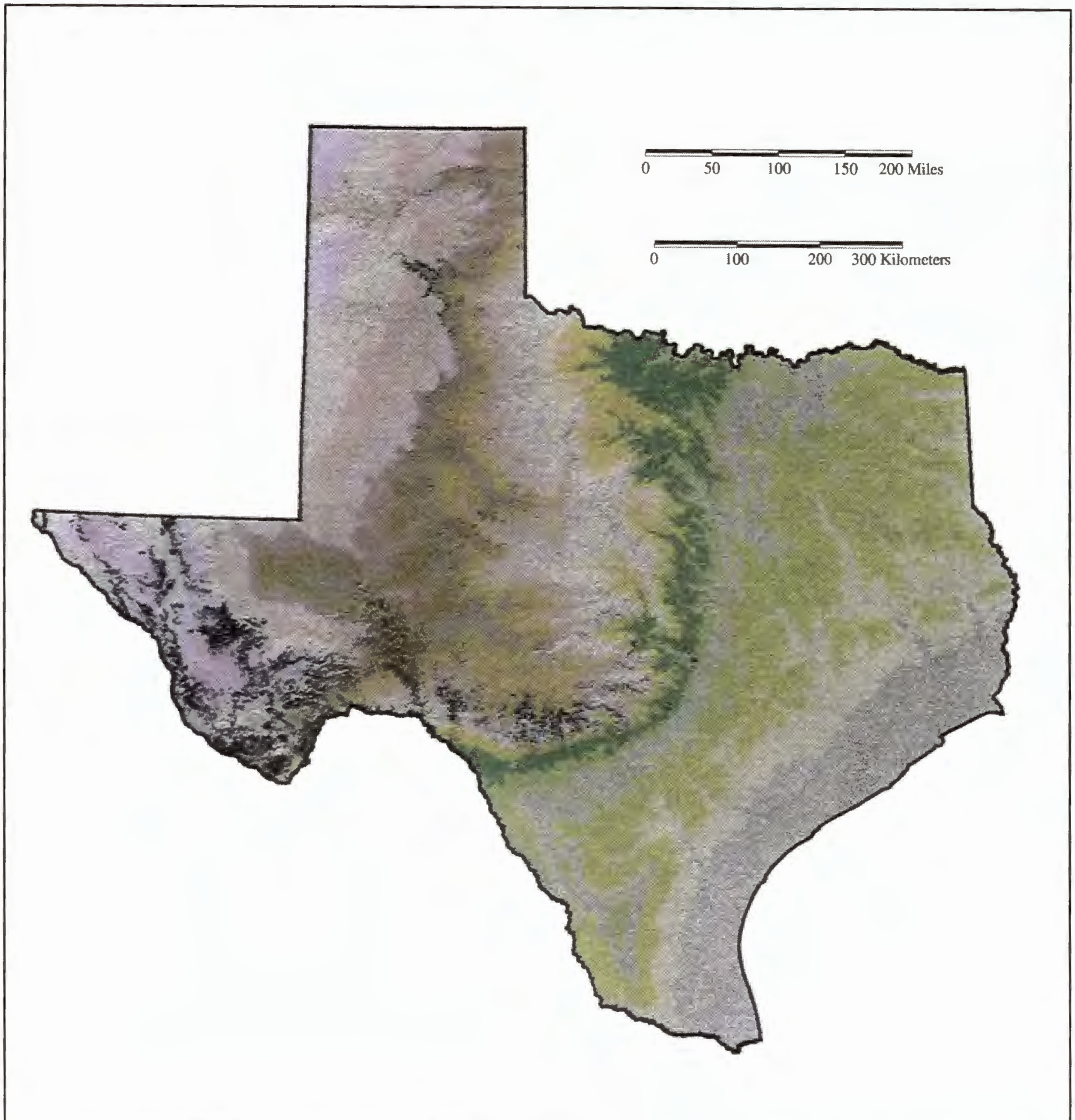

Figure 8.—Digital Elevation Model (DEM) of Texas. Elevation in Texas ranges from sea level on the coast to 2660 m (8,749 ft.) in the Guadelupe Mountains. DEMs were prepared by the U.S. Geological Survey and obtained from TNRIS http://www.tnris.state.tx.us.

vation of biodiversity. It can be argued that every society before ours collapsed when local natural resources were exhausted (Hughes, 1994). Today we have the knowledge and ability to document the rapid loss of biodiversity and the option to do something about it. For example, the Internet provides all interested personnel, from legislatures to school children, with information on natural resources such as vegetation <http://www.tcru.ttu.edu/txgap/vegetation/index.html>, or The Mammals of Texas (Davis and Schmidly, 1994) in a rapidly accessible electronic version <http://www.nsrl.ttu.edu/tmot1/>. Society has a

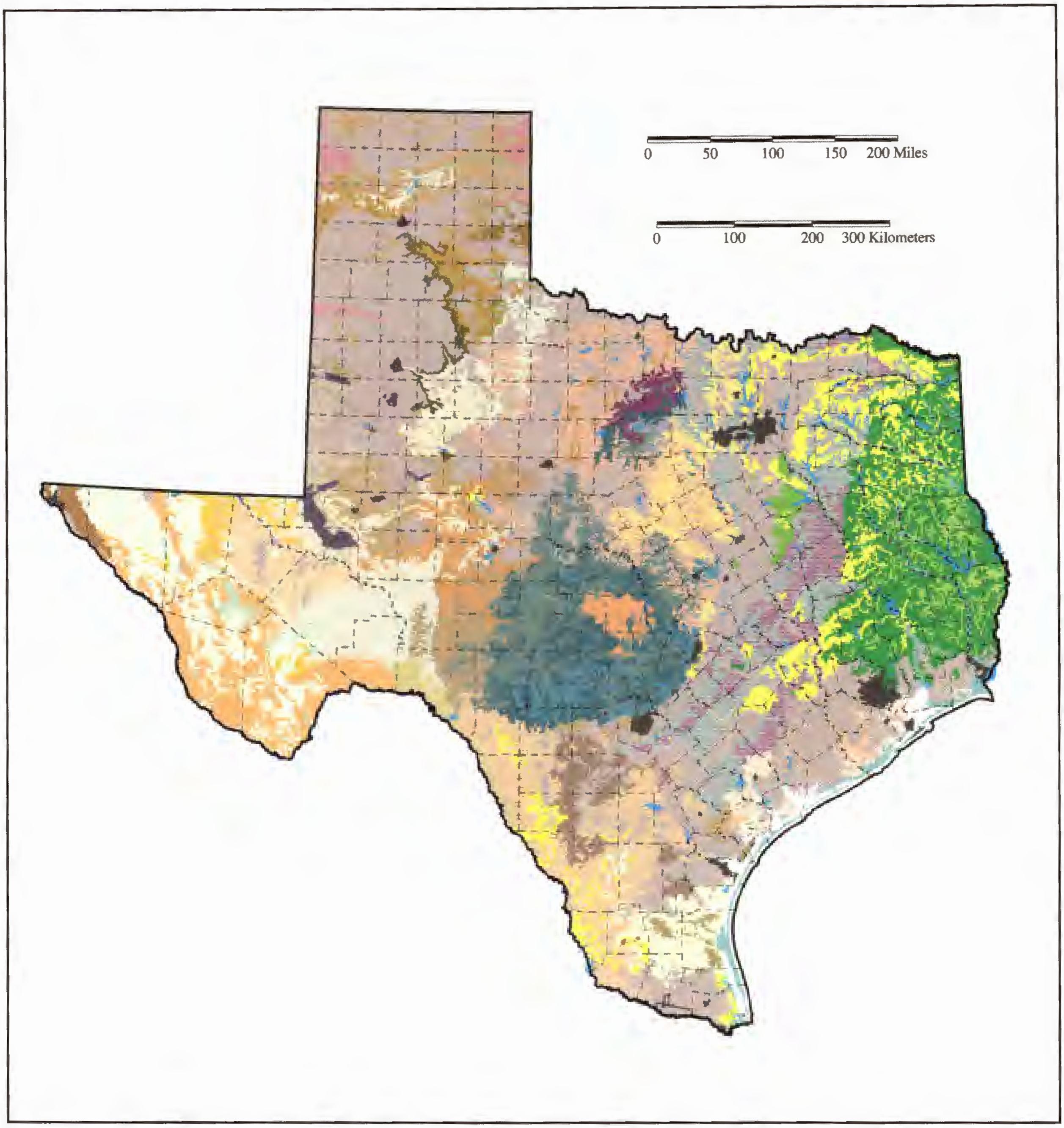

Figure 9.—The vegetation types of Texas. As is the case for vertebrate diversity, rich and diverse flora across Texas is the basis for ecotourism and a valuable resource for aesthetic activities. Digital data were prepared by Texas Parks and Wildlife and obtained from TNRIS http://www.tnris.state.tx.us.

vested interest in maintaining a healthy environment that is rich in biological diversity. However, in Texas, biodiversity can only be maintained with the cooperation of private landowners. If private landowners can be counted on to preserve the biodiversity of Texas then it will be necessary to make conservation economically beneficial. Ecotourism is one means the landowners can share these resources for generations to come, maintain their heritage, and adapt to a new and economically sustainable lifestyle. Access to ac-

Table 2.—Net economic value ($) of wildlife related recreation and the average days of participation for each participant in Texas for 1991.

	Annual			Daily	
Activity	Mean n	S.E.	90% confidence interval	Net economic value per day ($)	Average days (No.)/yr
Bass fishing	519	82	384-654	35	15.0
Deer hunting	556	79	425-686	53	10.4
Wildlife watching	400	55	309-491	31	13.1

curate biological information and relational databases (Baker et al. 1998; Parker et al. 1998) with biological and related issues is critical to economic development of ecotourism and conservation biology. Presentation of biological data in spatial and temporal context provides understanding and insight into complex ecosystem function (Baker et al. 1996) and in the human population (Krapf 1998). The databases and biological information referenced here provide the tools necessary for landowners, agencies and the public to make informed decisions and develop sustainable ecotourism. We hope this paper serves this need to some extent.

ACKNOWLEDGMENTS

We thank David J. Schmidly and Clyde Jones of Texas Tech University and Linda Campbell of Texas Parks and Wildlife for constructive exchanges and review of the manuscript; Eric Schultz for design of the cover; and Sheri Haskell for GIS support. This research was jointly supported by the U.S. Geological Survey-Biological Resources Division through the National GAP Analysis Program and Texas Tech University through the Natural Science Research Laboratory. The Texas Cooperative Fish and Wildlife Research Unit is jointly sponsored by Texas Parks and Wildlife Department, Texas Tech University, U.S. Geological Survey-Biological Resources Division, and the Wildlife Management Institute.

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It was through the efforts of Horn Professor J Knox Jones, as director of Academic Publications, that Texas Tech University initiated several publications series including the Occasional Papers of the Museum. This and future editions in the series are a memorial to his dedication to excellence in academic publications. Professor Jones enjoyed editing scientific publications and served the scientific community as an editor for the Journal of Mammalogy, Evolution, The Texas Journal of Science, Occasional Papers of the Museum, and Special Publications of the Museum. It is with special fondness that we remember Dr. J Knox Jones.

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Layout and Design: Jacqueline B. Chavez
Cover Design: Eric Schultz

This book was set in Times New Roman and printed on acid-free paper that meets the guidelines for permanence and durability of the Committee on Production Guidelines for Book Longevity of the Council on Library Resources.

Printed: 14 December 2000

Library of Congress Cataloging-in-Publication Data

Occasional Papers, Number 201
Series Editor: Robert J. Baker

Ecotourism and Conservation: Richness of Terrestrial Vertebrates Across Texas
Eric A. Holt, Kelly E. Allen, Nick C. Parker, and Robert J. Baker

ISSN 0169-0237

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Lubbock, TX 79409-3191 USA
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