A GEOGRAPHIC ANALYSIS OF THE STATUS OF MOUNTAIN LIONS IN OKLAHOMA

By

JASON RICHARD PIKE

Bachelor of Science

Southeastern Oklahoma State University

Durant, Oklahoma

1994

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1997

A GEOGRAPHIC ANALYSIS OF THE STATUS

OF MOUNTAIN LIONS IN

OKLAHOMA

Thesis Approved:

James H. Shaw

Thesis Adviser

J. M. Inslee Jr.

Ronald E. Masters

Thomas C. Collins

Dean of the Graduate College

PREFACE

I sincerely wish to express my appreciation to my committee members--Drs. James H. Shaw (my graduate adviser), David M. Leslie, Jr., and Ronald E. Masters--for their helpful comments and criticism throughout my education at Oklahoma State University. My appreciation also is extended toward Michael Shaw of the Oklahoma Department of Wildlife Conservation for his unending willingness to help out where he could. I would also like to thank Dr. Carla Goad of the Department of Statistics for her helpful instructions in the final analysis of this project. I would like to thank the Oklahoma Department of Wildlife Conservation and Wildlife Forever for providing me with this research opportunity and their generous financial support.

A very special thanks goes to Dr. David Waits of the Department of Geography. Without his time and patience, this project would not have been possible. A very special thanks is extended to Dr. Maurice Hornocker, under whom I became encouraged to pursue graduate studies with large carnivores. I would also like to give my special

thanks to my wife, Beth, for her unending support of my graduate studies, her toleration of my long hours at the office, and her love and understanding throughout all of this madness! Thanks also go to my parents, Rick and Jo Carole Pike, for their support and encouragement; they have always supported me and encouraged me to do my best in everything.

Finally, I would like to thank the Department of Zoology and the Oklahoma Cooperative Fish and Wildlife Research Unit for supporting this project during the last two and a half years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The following two chapters of this thesis are written in the format required of manuscripts submitted to the Proceedings of the Oklahoma Academy of Science (Chapter II) and the Wildlife Society Bulletin (Chapter III). Chapter II is entitled "The Mountain Lion in Oklahoma and Surrounding States: A Literature Review," and Chapter III is entitled "A Geographic Analysis of the Status of Mountain Lions in Oklahoma."

CHAPTER II

THE MOUNTAIN LION IN OKLAHOMA AND SURROUNDING STATES: A LITERATURE REVIEW

Abstract: I investigated the historic distribution of the mountain lion in Oklahoma and surrounding areas based on previous publications. Historically, the mountain lion occurred throughout Oklahoma but was most abundant in the western and southwestern regions of the state. Mountain lion population trends in Oklahoma and surrounding areas indicate that mountain lions may be attempting to reinhabit Oklahoma.

The Mountain Lion in Oklahoma

The mountain lion (*Puma concolor*) is a very adaptable predator. Historically, it ranged across all of North America, but today viable populations are confined mainly to the mountainous West. Although the mountain lion has been studied extensively in the western region of its range (1, 2, 3), relatively few studies have been conducted in its eastern and central range (4, 5). Of the 6 states that border Oklahoma; Colorado, New Mexico, and Texas have huntable populations of mountain lions. Therefore, it is reasonable for mountain lions to reinhabit Oklahoma when conditions are conducive to their habits. I compiled literature that describes the history of the mountain lion in Oklahoma and the surrounding areas.

Young and Goldman (6) authored one of the first books dedicated solely to the mountain lion. In their writings, they describe the mountain lion in Oklahoma to be of the subspecies *Felis concolor stanleyana*, which ranged throughout most of Oklahoma and Texas. Young and Goldman (6) stated that *Felis concolor coryi* ranged mostly in the southeastern United States, and *F. c. hippolestes* occurred mainly in Colorado, Iowa, Kansas, Missouri, Nebraska, South Dakota,

and Wyoming. The methods by which Young and Goldman (6) developed their distribution map for mountain lion subspecies in the United States were not described in their text. One must be cautious when interpreting this map. Many boundaries of the different subspecies that they list are defined only by state lines. Nevertheless, Young and Goldman (6) accomplished a work that sparked much interest in the mountain lion.

Young and Goldman (6) described encounters of mountain lions by early explorers in present day Oklahoma and surrounding areas. Most of these accounts originated from western and southwestern Oklahoma, although some exist for other areas of the state. One detailed account reported of 2 mountain lions being killed in southwestern Oklahoma (7). One account by Mead (8) indicated that mountain lions were occasionally found in Kansas but were more abundant in Indian Territory (present day Oklahoma). Caire et al. (9) stated that reports by Abert (10) in 1845-1846 appear to be the earliest documented cases of mountain lions in Oklahoma. The majority of the accounts originated from the western and southwestern regions of Oklahoma (9). Documented reports continued through the turn of the

century (6).

In 1957, the Oklahoma Department of Wildlife Conservation listed the mountain lion as a game species with a closed season. This gave the mountain lion protected status. Until this time, the mountain lion had no hunting season or protection in Oklahoma. In March 1953, tracks of a mountain lion were documented by Oklahoma State University's mammalogist, Dr. Bryan P. Glass, southeast of Canton Reservoir, Canton, Oklahoma (11). During the years 1961 - 1965, repeated accounts of lion sightings were made in northeastern Oklahoma (9). In April 1968, remains of a yearling female mountain lion were found in McIntosh County in eastern Oklahoma (12). Bissonette and Maughan (13) reported that a mountain lion was observed at two different occasions near Stringtown, Oklahoma and that an adult with cubs was reported in Sequoyah, Oklahoma, in 1974. Based on these occurrences, Bissonette and Maughn (13) concluded that the mountain lion did occur in parts of Oklahoma. In September 1984 on Oklahoma's Wichita Mountains Wildlife Refuge, a lion was observed by the refuge manager (9). Many undocumented observations have been received since 1984 from the southeastern

region of Oklahoma including McCurtain, Pushmataha, and LeFlore counties (Heck, pers. comm). The Oklahoma Department of Wildlife Conservation's furbearer biologist kept records of mountain lion sightings in Oklahoma since 1987. These records included 46 sightings of mountain lions in Oklahoma with 2 lion mortalities (one of which was not documented) within this time frame (Hoagland, pers. comm.). In addition, 1 mountain lion skull was found in McCurtain County, Oklahoma, within the past 5 years (Heck, pers. comm.).

Pike (14) concluded that sightings and sign (tracks, kills, scat, etc.) of mountain lions were closely associated with the western and southwestern regions of Oklahoma. Additionally, sightings and sign of mountain lions have generally increased with years and total deer harvest statewide (14). Since 1985, sightings of mountain lions and mountain lion sign occurred significantly more in the Central Rolling Red Plains ecoregion (15) than in any other ecoregion in Oklahoma. The Central Rolling Red Plains ecoregion is in the western region of Oklahoma and is 60% rangeland. Characteristics of the Central Rolling Red Plains ecoregion appear to be conducive to immigration by mountain lions from other western states due to large blocks of

private land holdings and a low human population density.

The Mountain Lion in Surrounding States

The mountain lion was thought to be extinct in Arkansas until 1969 when an adult lion was killed ca. 6 miles east of Hamburg, Ashley County (16). As in Oklahoma, the mountain lion in Arkansas appears to be reestablishing populations. Sealander and Gipson (16) attributed this to an increasing population of white-tailed deer (*Odocoileus virginianus*), reduced hunting pressure, and removal of the rural population in contiguous blocks of national forest land. McBride et al. (17) suggest that Arkansas may be a suitable place for reintroductions of mountain lion in the future; however, their surveys of >1,161,140 ha failed to produce any evidence of a wild breeding population of mountain lions in Arkansas.

Hoover and Henderson (18) reported 2 documented cases and numerous undocumented sightings of mountain lions in Kansas, but the last verified mortality of a mountain lion in Kansas was in Ellis County in 1904 (19). The mountain lion has received considerable attention in Kansas, including the establishment of a clearinghouse for sightings of mountain lions at Kansas State University (19). Some

biologists maintain that mountain lions in Kansas are a product of a population existing in the Ozark, Ouachita, and Mark Twain national forests of Missouri and Arkansas (16, 20).

Mountain lions occupy an extensive range in Texas (21, 22, 23). As in other states surrounding Oklahoma, sightings and mortalities of mountain lions appear to be increasing in Texas (21). Russ (21) documented this increasing trend in sightings and mortalities of mountain lions from 1983 to 1994. Texas possesses a viable population of mountain lions (21) that does not have any protective status and can be hunted at any time of the year (21). As in other regions in the United States that are inhabited by the mountain lion, they are recognized as filling a very important ecological role in Texas.

Conclusions

There is little doubt that the mountain lion historically occurred in Oklahoma and the surrounding areas, and there is evidence that mountain lions are reestablishing themselves in their historic range in Oklahoma (14). Mountain lions are an important predator in North American ecosystems (24), and it is equally important to allow this carnivore the opportunity to immigrate back to it's original domain.

Biodiversity is a priority of many natural resource state agencies, and the mountain lion in Oklahoma could serve as a keystone species for sound management and protection of our native fauna.

References

1. Hornocker, M.G., *An analysis of mountain lion predation upon mule deer and Elk in the Idaho primitive area.* Wildl. Monog. (1970) 39 pp.
2. Ackerman, B.B., F.G. Lindzey, and T.P. Hemker, *Cougar food habits in southern Utah.* J. Wildl. Manage. **48**, 147-155 (1984).
3. Logan, K.A., *Mountain lion population and habitat characteristics in the Big Horn Mountains of Wyoming.* M.S. Thesis, Univ. Wyoming, Laramie (1983) 101 pp.
4. Maehr, D.S., R.C. Belden, E.D. Land, and L. Wilkins, *Food habits of panthers in southwest Florida.* J. Wildl. Manage. **54**, 420-423 (1990).
5. Barone, M.A., M.E. Roelke, J.G. Howard, J.L. Brown, A.E. Anderson, and D.E. Wildt, *Reproductive characteristics of male florida panthers:comparative studies from Florida, Texas, Colorado, Latin America, and North American zoos.* J. Mamm. **75**, 150-162 (1994).
6. Young, S.P., and E.A. Goldman, *The puma: mysterious American cat.* Dover Publications, New York (1946) 358 pp.

7. Marcy, R.B., *Exploration of the Red River of Louisiana in year 1852*, by Randolph B. March, Capt. 1st Inf., U.S. Army, assisted by George B. McClellan, Brev. Capt., U.S. Engr. 32nd Congr., 2nd Sess., Sen. Ex. Doc. 54:11, (1853) 50-59 pp.

8. Mead, J.R., *Felis concolor.* Trans. 30th and 31st Annual meeting, Kans. Acad. Sci., 1897-1898. 278-279 (1899).

9. Caire, W., J.D. Tyler, B.P. Glass, and M.A. Mares., *Mammals of Oklahoma*, Univeristy of Oklahoma Press, Norman (1989) 567 pp.

10. Abert, J.W., *Journal of J.W. Abert from Bent's Fort to St. Louis in 1845.* U.S. Senate Doc. 8, 29th Congr., 1st Sess, (1845-46).

11. Merrifield, G.C., *Occurrence of a mountain lion in Oklahoma.* Proc. Okla. Aca. Sci. (1953) 57 pp.

12. Lewis, J.C., *Evidence of mountain lions in the Ozarks and adjacent areas*, 1948-1968. J. Mamm. **50**, 371-372 (1969).

13. Bissonette, J.A., and O.E. Maughan, *Southeastern Oklahoma coal investigations: endangered species.* Proj. No. 14-16-002-77-080 to U.S. Fish and Wildlife Service. Okla. Coop. Fish and Wildl. Res. Unit, Oklahoma State Univ., Stillwater, (1978) 101

pp.

14. Pike, J.R., *A geographic analysis of mountain lion sightings in Oklahoma*. M.S. Thesis, Okla. State Univ., Stillwater, OK (1997), in press.

15. U.S.D.A. (United States Department of Agriculture)-Soil Conservation Service, *Land resource regions and major resource areas of the United States, Agricultural handbook 296.* Washington, D.C.

16. Sealander, J.A., and P.S. Gipson, *Status of the mountain lion in Arkansas*. Proc. Ark. Aca. Sci. **27**, 38-40 (1973).

17. McBride, R.T., R.M. McBride, J.L. Cashman, and D.S. Maehr, *Do mountain lions exist in Arkansas?* Proc Annu. Conf. Southeast. Fish and Wildl. Agencies. **47**, 394-402 (1993).

18. Hoover, D.E., and F.R. Henderson. *Puma in Kansas?* Division of Biology, Kansas State Univ., Manhattan (1990) 2 pp.

19. Tischendorf, J.W., and F.R. Henderson., *The puma in the central mountains and Great Plains.* Pages 99-102 *in* R.E. Masters and J.G. Huggins, ed. Twelfth Great Plains Wildl. Damage Control Workshop Proc., Published by Noble

Foundation, Ardmore, Okla., (1995).

20. Tischendorf, J.W., *The puma in the central mountains and Great Plains-a synopsis*. Blue Jay. **52**, 218-223 (1994).

21. Russ, W.B., *The status of mountain lions in Texas*. In press.

22. Bailey, V., *Biological survey of Texas*. N. Amer. Fauna. **25**, 1-222 (1905).

23. Engstrom, M.D., and T.C. Maxwell, Records of mountain lion (Felis concolor) from the Edwards Plateau of Texas. Texas J. of Sci. **40**, 450-452 (1988).

24. Hornocker, M.G. An anlaysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Wildl. Monog. **21**, 1-39 (1970).

CHAPTER III

A GEOGRAPHIC ANALYSIS OF THE STATUS OF MOUNTAIN LIONS IN OKLAHOMA

Abstract: We investigated the geographic distribution of sightings and sign of mountain lions (Puma concolor) in Oklahoma. Sightings of mountain lions and their sign are increasing in Oklahoma and several other western and midwestern states. Mail survey questionnaires were sent to natural resource professionals throughout Oklahoma to gather temporal and spatial information on sightings of mountain lions from 1985 to 1995. Geographic information systems (GIS) technology was used to compare sighting locations in the state with different geographic features such as ecoregions, deer harvest, human population densities, locations of licensed mountain lion breeders and/or owners, and generalized topography. Sightings and sign of mountain lions were observed significantly more in the Central Rolling Red Plains and the Central Great Plains ecoregions of western Oklahoma than elsewhere in the state. Sightings of mountain lions

have increased with total deer harvest statewide. Surveys can be used as a valuable method to assess the status of rare wildlife species when other methods are unapplicable and when those receiving the survey are qualified.

Key words: Puma concolor, Geographic Information Systems, mountain lion, Oklahoma, sightings.

INTRODUCTION

Many studies have been conducted on the mountain lion in their western range, but relatively few have been conducted in their eastern and central range (Berg 1981, Ackerman 1982, Hemker et al. 1984, Koehler and Hornocker 1991). Oklahoma has climate and landscape conditions typical of both western and eastern states, and methods that yield viable information on mountain lions for Oklahoma's wildlife managers also may be applicable for personnel in other areas were mountain lion populations appear to be increasing (M. G. Shaw, Okla. Dep. Wildl. Conserv., pers. commun.).

The mountain lion historically occurred throughout Oklahoma (Young and Goldman 1946). With European settlement, the mountain

lion became virtually extirpated from Oklahoma in the 1800's because of bounty hunting and habitat loss. Sightings of mountain lions have increased in Oklahoma as they have in several other western and midwestern states (W.B. Russ, Tex. Parks and Wildl. Dep., unpubl. data). The increase of a large carnivore in a state of almost entirely private land offers a practical challenge for its conservation and a unique opportunity to test ecological hypotheses applicable to mountain lions in other states. Belden and Hagedorn (1993) recommend that further studies be initiated on techniques for establishing viable populations of mountain lions that are compatible with the expanding human population. Mountain lion sightings (inferring occurrences of mountain lions) in Oklahoma may be related to the abundance of white-tailed deer (*Odocoileus virginianus*), their principal prey (Anderson 1983), or other conditions related to landscape, human population, ecoregions, or location of licensed mountain lion owners and/or breeders (exotic game ranchers).

We collected base-line data to assist wildlife managers in Oklahoma (as well as other states) in planning management regimes for maintaining or increasing mountain lion populations. Our

objectives were to: (1) develop a statewide database of mountain lion sightings in Oklahoma; (2) determine areas in Oklahoma with high incidents of mountain lion sightings; (3) compare location and frequency of mountain lion sightings in different geographic features. Null hypotheses were that mountain lion sightings were not correlated with: (1) deer hunter harvest trends; (2) size of the human population; (3) ecoregions; and (4) generalized statewide topography. An additional hypothesis was that locations of sightings and sign of mountain lions were not associated with the locations of licensed mountain lion breeders and/or owners in Oklahoma.

METHODS

Mail Survey Questionnaire

Previous studies have used mail survey systems to obtain sighting information on a variety of wildlife research subjects (Berg et al. 1983, Groves 1988, Miller and Reintjes 1995). Tewes and Everett (1982) requested sighting locations from trappers to determine the status of the ocelot (Felis pardalis) and jaguarundi (Felis yagouaroundi) in Texas. Quinn (1995) demonstrated that sightings were partially effective for his study of coyote (Canis latrans) use of

urban habitat, and Stoms et al. (1993) used sightings of California condors (Gymnogyps californianus) to evaluate habitat use. Quinn (1995) stated that sightings can be a useful method in wildlife research, especially in large-scale studies, but the usefulness of sightings in any research depended on the study questions.

A mail survey questionnaire system was developed to gather locational and temporal information on sightings and sign (tracks, scat, kills, etc.) of mountain lions in Oklahoma. The mail survey questionnaire (Appendix A) and cover letter (Appendix B) were modeled after Berg (1981). In our survey, several questions were modified from Berg's (1981) original survey. We only surveyed qualified people in the state, due to uncertain reliability of responses from common hunters, trappers, campers, hikers, etc. (Van Dyke and Brocke 1987; McBride 1993). We considered natural resource professionals in Oklahoma as qualified (Belden 1986).

We sought a thourough statewide mailing of qualified people, so a random sample of the population was not used. We obtained mailing lists for different agencies involved with the conservation of natural resources by directly contacting the agency and requesting a

complete employee directory. In most cases, agencies complied with our request. We were able to discriminate between those that received surveys and those that did not among agency employees based on job descriptions provided by the employee directories. For example, individuals that had a job description as secretarial, janitorial, etc. were not sent a survey. To illicit a high response rate, letterhead and envelopes from the Oklahoma Department of Wildlife Conservation (ODWC) were used. We presumed that this would illicit more interest in the study and increase response rate. Twenty-five percent of our survey population was employed by the ODWC; the remainder was divided among 3 private agencies, 5 state agencies, and 4 federal agencies (Table 1).

When receiving sighting information, one must be cautious to avoid misidentification of research subjects--in our study, mountain lions and mountain lion sign. We attempted to correct for this by restricting the survey to qualified people. A system for ranking responses was integrated into the survey. Question 1 asked the respondent to report information on mountain lions seen directly by him/her. We considered Question 1 to be the most reliable type of

sighting. Question 2 asked the respondent to report information on mountain lions seen by another reliable individual that the respondent knew. Question 2 was the second most reliable type of sighting. Questions 3 and 4 asked the respondent to report information on sightings of mountain lion sign either by the respondent or another reliable individual, respectively. We rejected a survey if it referred to black mountain lions. We could find only 1 reference to a melanistic mountain lion (Tinsley 1987); therefore, we consider it unlikely that melanistic mountain lions were common enough to be observed.

A map of the state that depicted counties, major highway systems, and major rivers and lakes was included in the survey (Appendix C). Each survey question that requested information on sightings and sign of mountain lions also requested the respondent to report the date(s) (month and year if possible) and the location(s) of the sighting(s). The respondent was asked to place a different symbol, depending on the question being answered, on the map depicting the location(s) of the sighting(s). We also followed Berg's (1981) recommendation of printing the map of the state on the back of the last page of the survey. This eliminated any chance of people

returning their survey without enclosing the map. A postage-paid envelope was enclosed in the survey packet. We assumed that this would increase the probability that potential respondents would return the questionnaire.

All surveys (n = 1,013) were mailed 20 March 1996. A second mailing and a reminder mailing were not used due to funding constraints of the project. When the surveys were received, they were sorted according to types of questions answered, and the data were entered into the GIS by county.

Geographic Information System

Base maps for the GIS coverages were obtained from Environmental Systems Research Institute, Inc. (Redlands, CA) on CD - ROM. The base map for Oklahoma and its counties was downloaded directly from ArcView 2.1 to ArcInfo (Environmental Systems Research Institute, Inc., Redlands, CA). Six coverages composed the GIS database. Major Land Resource Areas (MLRA) (Fig. 1) as defined by the Natural Resource Conservation Service (NRCS) (U.S.D.A. 1981) were digitized into ARC/INFO from a 1:250,000 scale map. Each ecoregion was assigned its appropriate

attribute (ecoregion type) within ArcView 2.1. Ecoregions as defined by Omernik (1987) (Fig. 2) comprised the second type of coverage used in the analysis. Ecoregions were digitized into ARC/INFO from a 1:250,000 scale map and assigned their ecoregion name in ArcView 2.1 for further analysis.

Deer harvest units (Fig. 3) as defined by the ODWC were used in the analysis for investigating the relationships between sightings of mountain lions and harvest of white-tailed deer. There were 11 deer harvest units in Oklahoma that were defined by 197 deer kill location units (DKLs). DKLs are of a smaller scale than deer harvest units; therefore, we chose to analyze sightings of mountain lions with only deer harvest units. DKL's were digitized into the GIS from 1:250,000 maps. To create the coverage for deer harvest units, the ArcEdit module in ArcInfo was employed. After the arc editing process was completed, total deer harvest for each harvest unit (obtained through check station records from the ODWC) for 1985-1995 was assigned to each unit by using ArcView 2.1. Counties of Oklahoma (n = 77) were obtained from ArcUSA CD-ROM by downloading the coverage directly from ArcView 2.1 to ArcInfo. We added density of human population

to each county (Wikle 1991) by using ArcView 2.1.

Generalized topography of the state was digitized into ArcInfo from 1:250,000 maps by Wikle (1991). For analysis, we combined the state into 3 elevational regions: 87-305, 305-610, and 610-1516 m above sea level, based on Wikle's (1991) original map (Fig. 4). The appropriate attributes were added to each topographic region in ArcView 2.1., which permitted analysis of relationships between topographic elevations and sightings and sign of mountain lions.

After surveys were received and sorted by types of questions answered, locational information of the sightings was entered into ArcView 2.1 by on-screen digitizing. The appropriate attributes (i.e., date of sighting, additional information) were assigned to each point representing a sighting in ArcView 2.1. For surveys with no sightings, the location of the survey respondent was entered into the GIS through ArcView 2.1, which permitted evaluation of the GIS coverages and locations of where no sightings were being reported. To permit comparisons between the sighting locations and the GIS coverages, ArcView 2.1 was used. After the combination of the sightings and the coverage of analysis was complete in ArcView 2.1, data were edited

and analyzed in Statistical Analysis System (SAS Institute, Inc. 1992).

Data Analysis

For analysis, responses were grouped into 2 categories: sightings and sign of mountain lions. Distributions of sightings and sign relative to ecoregions, deer harvest units, topographic regions, and human population density per km^2 were evaluated with chi-square test (Zar 1984), followed by Bonferroni confidence intervals (Neu et al. 1974; Byers et al. 1984), to identify areas of presence and absence based on area ($P < 0.05$). Tabulation of mountain lion sightings and sign indicated that some ecoregions lacked or had a small number of observations. Therefore, to avoid cells with zeroes and minimize those with <5 expected observations (Cockran 1954), we combined 4 ecoregions into adjacent ecoregions within the main MLRA coverage, which yielded 10 ecoregions as opposed to the 14 original ecoregions developed by the NRCS (U.S.D.A. 1981). We combined 4 of Omernik's original ecoregions (Omernik 1987) into adjacent ecoregions to give 7 ecoregions as opposed to the 11 original ecoregions. We combined one ecoregion with another only if they had similar vegetation, climate, and patterns of landownership (U.S.D.A.

1981).

Regression analysis (Steel and Torrie 1980) was used to determine if a relationship between mountain lion sightings and total deer harvest statewide from 1985 to 1995 existed. Because many studies of mountain lion diets report that white-tailed deer are the most frequent item in the stomach and scat (Anderson 1983), we hypothesized that the frequency of sightings of mountain lions were related to harvest statewide. We expected that total sightings would increase as total deer harvest increased from year to year. A logarithmic function was used to transform the number of sightings of mountain lions to improve normality of the data (Neter et al. 1990). Due to a small sample size, observations of mountain lion sign relative to total deer harvest per year could not be evaluated.

We used descriptive statistics to examine the change in numbers of sightings and sign among years. Because surveys were mailed on 20 March 1996, some sightings ($\underline{n}$ = 28) or sign ($\underline{n}$ = 11) of mountain lions occurred in 1996. For the purpose of analysis, we combined observations that occurred in 1996 with data of 1995, except for regression analysis between numbers of sightings of

mountain lions and total deer harvest.

For surveys that reported no sightings or sign of mountain lions, we used a chi-square analysis (Zar 1984) and Bonferroni confidence intervals to determine if negative responses originated in certain areas more than in others (Neu et al. 1974, Byers et al. 1984). The MLRA, Omernik, and deer harvest unit coverages were used in this analysis.

Regression analysis (Steel and Torrie 1980) was used to determine if a relationship between mountain lion sightings and human population density per km^2 existed. We used 1.9, 5.8, 11.6, 23.2, and 57.9 people per km^2 from Wikle's (1991) classes for the values in the regression analysis. We expected a negative relationship between numbers of sightings of mountain lions and human population density per km^2.

To test for the relationship between location of licensed mountain lion owners and breeders in the state and the location of mountain lion sightings and sign, we used a 16-km radius from each breeder and/or owner to calculate an area in which to count sighting or sign. That distance was based on previous findings of Belden and Hagedorn (1993) as the distance that translocated mountain lions

established the center of their home range from their release site. ArcView 2.1 was used to identify those sightings (either of mountain lions or mountain lion sign) that fell in the specified area around owners and/or breeders. To evaluate the occurrence of sightings of mountain lions and their sign relative to the areas of owners and/or breeders of mountain lions, chi-square analysis (Zar 1984) was used to determine if sightings or sign occurred at expected numbers based on area.

RESULTS

A total of 1,013 surveys was mailed to natural resource professionals in Oklahoma. Forty-six percent of the surveys was returned. A total of 272 surveys (59%) had negative responses for all questions. Sixty-six (24%) of the negative response surveys were omitted from the analysis because the respondent did not indicate his/her name and/or location. Forty-two surveys (9%) were rejected because respondents reported melanistic mountain lions (4%) or did not indicate where a sighting(s) occurred (5%). Seventy-three surveys (16%) contained answers to ≥ 1 of the questions. Twenty-five surveys (5%) had only answers to Question 1 (respondent-sighting); 29 (6%),

17 (3%), and 6 (1%) surveys contained answers to Question 2 (acquaintance-sighting), Question 3 (respondent-sign), and Question 4 (acquaintance-sign), respectively. The surveys that were returned yielded 73 answers to Question 1, 193 answers to Question 2, 53 answers to Question 3, and 34 answers to Question 4. After tabulating observations of mountain lion sign, 5 ecoregions of the MLRA coverage and 3 ecoregions of the Omernik coverage still contained cell values <5; those ecoregions were not combined with other ecoregions because of dissimilarities in their characteristics (U.S.D.A. 1981) and thus were not included in the analyses (Cockran 1954).

Sightings of Mountain Lions

Ecoregions and Topography. --For the MLRA coverage, more sightings occurred in the Central Rolling Red Plains ecoregion than were expected based on area ($X^2 = 25.92$, $P < 0.05$) (Table 2). The Southern High Plains ecoregion contained fewer sightings than were expected based on area ($P < 0.05$) (Table 2). Sightings in the remaining 8 ecoregions indicated that mountain lions occurred in expected proportions based on area (Table 2). For Omernik's ecoregions, more sightings occurred within the Central Great Plains

ecoregion than what was expected based on area ($X^2 = 20.45$, $P < 0.05$) (Table 3). The Arkansas Valley ecoregion contained fewer sightings than were expected. Sightings in the remaining 5 ecoregions indicated that mountain lions occurred in expected proportions based on area (Table 3). No differences were detected between sightings and the expected number based on area in the 3 categories of elevation ($P < 0.05$).

Deer Harvest and Sightings Among Years.--All but 1 of the 11 deer harvest units exhibited no differences between actual number of sightings and the expected number based on area (Table 4). Numbers of sightings of mountain lions were correlated positively with total number of deer harvested per year ($r^2 = 0.828$, $P < 0.0001$) (Fig. 5). There were more sightings of mountain lions reported for 1995 than for any other year ($n = 113$). The fewest number sightings of mountain lions were reported in 1985 ($n = 1$) (Fig. 6).

Human Population.--Chi-square analysis indicated a difference in observed numbers of sightings from the expected ($X^2 = 10.64$, $P < 0.05$), but Bonferroni confidence intervals did not detect which categories of human population density contained those differences.

Numbers of sightings of mountain lions were correlated negatively with density of the human population ($r^2 = 0.885$, $P < 0.05$) (Fig. 7).

Mountain Lion Sign

Ecoregions and Topography.-- For the MLRA coverage, more observations of mountain lion sign occurred in the Central Rolling Red Plains ecoregion than were expected based on area ($X^2 = 16.14$, $P < 0.05$) (Table 5). For Omernik's ecoregions, observations of mountain lion sign occurred in expected proportions based on area ($P = 0.2113$); however, more observations of mountain lion sign occurred in the Central Great Plains ecoregion ($n = 39$) than in the other ecoregions (Table 6). Observations of mountain lion sign occurred in expected proportions based on area in the 3 categories of elevation ($X^2 = 4.01$, $P = 0.1346$).

Deer Harvest and Sightings Among Years.--More mountain lion sign was observed in Deer Harvest Unit 2 and less mountain lion sign was observed in 3 of the 11 deer harvest units than expected based on area ($X^2 = 38.71$, $P < 0.05$) (Table 7). There were more observations of mountain lion sign observed in 1995 than in any other year ($n = 39$), and the fewest observations of mountain lion sign were

reported in 1985 and 1988 (Fig. 8).

Human Population.--Those counties with >38.6 people per km^2 contained more observations of mountain lion sign than expected based on area ($X^2 = 28.19$, $P < 0.05$) (Table 8). Those counties with 15.4-38.6 people per km^2 exhibited fewer observations of mountain lion sign than expected based on area ($X^2 = 28.19$, $P < 0.05$).

Negative Responses

For the MLRA coverage, the Ouachita Mountains and the Southern High Plains ecoregions contained fewer negative responses than expected based on area ($X^2 = 46.27$, $P < 0.001$) (Table 9). For Omernik's ecoregions, the Arkansas Valley ecoregion contained more negative responses ($n = 22$) than expected based on area ($X^2 = 51.59$, $P < 0.001$) (Table 10). The Ouachita Mountains/South Central Plains ($n = 4$) and the Western High Plains ($n = 7$) ecoregions both contained fewer negative responses than the expected based on area ($P < 0.001$) (Table 10). Chi-square analysis indicated that 2 of the 11 harvest units contained fewer negative responses than the expected based on area ($X^2 = 31.69$, $P < 0.001$) (Table 11).

Licensed Mountain Lion Owners and/or Breeders

Nineteen sightings of mountain lions occurred within 16 km of a licensed mountain lion owner and/or breeder. This value was less than the expected number of sightings (n=37) of mountain lions based on area. Seven observations of mountain lion sign occurred within 16 km of a licensed mountain lion owner and/or breeder. This value was less than the expected number of observations (n=12) of mountain lion sign based on area.

DISCUSSION

Sightings and sign of mountain lions in Oklahoma occurred more than expected in the western region of the state. Sightings of mountain lions and their sign were observed more frequently in the Central Rolling Red Plains ecoregion of the MLRA coverage. Therefore, we rejected the null hypothesis that sightings of mountain lions and their sign were not related to ecoregions. The Central Rolling Red Plains are characterized by about 60% rangeland and 35% cropland (U.S.D.A. 1981). The Central Rolling Red Plains supports mid- and tall grasses and is located in western Oklahoma. Because >50% of this ecoregion is rangeland, it is exposed to less human disturbance than an area that is heavily cultivated or

urbanized. Most rangeland is comprised of relatively large, contiguous tracts of private land holdings. We expected sightings and sign of mountain lions to occur more in these areas because mountain lions selected against areas that contain frequent human disturbance (Van Dyke et al. 1986). Areas with large tracts of rangeland will have less human disturbance than areas with highly fragmented landscapes. Mountain lions have been documented to prey on domestic livestock (Shaw 1979). Domestic livestock on Oklahoma rangelands may be serving as an attractant to mountain lions.

Sightings of mountain lions occurred more than expected in the Central Great Plains ecoregion of Omernik's (1987) map. Observations of mountain lion sign also occurred more than expected in this area, but not significantly. This ecoregion is in the western region of Oklahoma and is exposed to less human disturbance than other areas.

Sightings of mountain lions were positively correlated with total deer harvest statewide; mountain lion sightings increased as total deer harvest increased. Many diet analyses of mountain lions show that deer are the major component in the diet (Robinette et al. 1959,

Anderson 1983, Iriarte et al. 1990). We expected that as deer harvest increased, mountain lion sightings would increase. We, therefore, rejected our null hypothesis that mountain lion sightings were not correlated with deer harvest trends. More observations of mountain lion sign occurred in Harvest Unit 2 than expected based on area. However, because the deer harvest in this unit did not notably increase from 1985 to 1995, we attribute this occurrence to other factors such as land ownership patterns.

Sightings of mountain lions and their sign occurred more in 1995 than in any other year. There is a possibility that this pattern was due to recall bias of the survey recipients. However, we maintain that an observation of a mountain lion in the wild is a truly memorable experience and natural resource professionals would remember at least the year of such an experience.

Sightings of mountain lions showed a negative correlation with human population density per km^2; the number of sightings of mountain lions decreased as human population density per km^2 increased. There were fewer observations of mountain lion sign than expected in areas with 15.4-38.6 people per km^2. These areas are

highly urbanized and contain much human disturbance. Observations of mountain lion sign occurred more than expected in the >38.6 people per km^2 category, which was attributed to the fact that the Wichita Mountains National Wildlife Refuge (an area known to have resident mountain lions) is located within this category of human population. Ten observations of mountain lion sign occurred in the Wichita Mountains National Wildlife Refuge.

More negative responses to the survey questions were observed in the Arkansas Valley of Omernik's (1987) ecoregion map than expected based on area. This area is highly industrialized by private timber corporations, thus creating human disturbance. Based on reactions by mountain lions to human disturbance (Van Dyke et al. 1986), it is reasonable to predict fewer mountain lion sightings in areas characterized by frequent disturbance.

We conclude that the occurrence of mountain lions in Oklahoma is due primarily to human population density and white-tailed deer populations. If we assume that a higher white-tailed deer harvest reflects an increase in the numbers of white-tailed deer, we can also assume that mountain lion abundance will increase with deer harvest.

However, human population in an area also will determine the presence of mountain lions. In each ecoregion where lion sightings occurred more than the expected, the human population densities were small. In areas of mountain lion presence, human disturbance must be kept to a minimal and a prey base (deer) must be adequate. If these conditions are met, we predict that mountain lion abundance in Oklahoma will continue to increase. Additionally, 3 of the 6 states that border Oklahoma contain huntable lion populations (Colorado, New Mexico, and Texas). We reason that mountain lions in Oklahoma have immigrated via travel corridors from adjacent states and are selecting for areas with minimal disturbance and an adequate prey base. We suggest that future studies of mountain lions in Oklahoma be concentrated on the Central Rolling Red Plains ecoregion. Track counts may be useful in determining areas that contain resident mountain lions on a smaller scale.

LITERATURE CITED

Ackerman, B.B. 1982. Cougar predation and ecological energetics in southern Utah. M.S. Thesis, Utah State Univ., Logan. 95pp.

Anderson, A.E. 1983. A critical review of literature on puma (Felis concolor). Colorado Div. Wildl. Spec. Rep. 54. 91pp.

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conserv. Biol. 7:94-108.

Belden, R.C. 1986. Florida panther recovery plan implementation-a 1983 progress report. Pages 159-172 in S.D. Miller and D.D. Everett, eds. Cats of the world: biology, conservation, and management. National Wildlife Federation, Washington, D.C.

----, and B.W. Hagedorn. 1993. Feasibility of translocating panthers into northern Florida. J. Wildl. Manage. 57:388-397.

Berg, R.L. 1981. A mail survey for information of the distribution of mountain lions in the state of Wyoming. M.S. Thesis, Univ. of Wyoming, Laramie. 94pp.

----, L.L. McDonald, and M.D. Stickland. 1983. Distribution of mountain lions in Wyoming as determined by mail survey questionnaire. Wildl. Soc. Bull. 11:265-268.

Byers, C.R., and R.K. Steinhorst. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48-1050-1053.

Cockran, W.G. 1954. Some methods for strengthing the common X^2 tests. Biometrics. 10:417-451.

Groves, C.R. 1988. Distribution of the wolverine in Idaho as determined by mail questionnaire. Northwest Sci. 62:181-185.

Hemker, T.P., F.G. Lindzey, B.B. Ackerman, and A.J. Button. 1984. Population characteristics and movement patterns of cougars in southern Utah. J. Wildl. Manage. 48:1275-1284.

Iriarte, J.A., W.L. Franklin, W.E. Johnson, and K.H. Redford. 1990. Geographic variation of food habits and body size of the America puma. Oecologia. 85:185- 190.

Koehler, G.M., and M.G. Hornocker. 1991. Seasonal resource use among mountain lions, bobcats, and coyotes. J. Mamm. 72:391-396.

McBride, R.T., R.M. McBride, J.L. Cashman, and D.S. Maehr. 1993. Do mountain lions exist in Arkansas? Proc. Annu. Conf. SEAFWA. 47:394-402.

Miller, F.L., and F.D. Reintjes. 1995. Wolf-sightings on the Canadian Arctic Islands. Arctic 48:313-323.

Neter, J., W. Wasserman, and M.H. Kutner. 1990. Applied linerar statistical models. Richard D. Irwin, Inc., Homewood, Ili. 1,181pp.

Neu, C.W., D.R. Byers, and J.M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Assoc. of American Geographers 77:118-125.

Quinn, T. 1995. Using public sighting information to investigate coyote use of urban habitat. J. Wildl. Manage. 59:238-245.

Robinette, W.L., J.S. Gashwiler, and O.W. Morris. 1959. Food habits of the cougar in Utah and Nevada. J. Wildl. Manage. 23:261-273.

Shaw, H.G. 1979. A mountain lion field guide. Ariz. Game and Fish Dep., Spec. Rep. 9. 27pp.

Statistical Analysis System. 1992. SAS Institute, Inc. Cary, NC, 27513.

Steele, R.G., and J.H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. McGraw-Hill, Inc. New York. 633pp.

Stoms, D.M., F.W. Davis, C.B. Cogan, M.O. Painho, J. Scepan, and J.M. Scott. 1993. Geographic analysis of California condor sighting data. Conserv. Biol. 7:148-159.

Tewes, M.E., and D.D. Everett. 1986. Status and distribution of the endangered ocelot and jaguarundi in Texas. Pages 147-158 in S.D. Miller and D.D. Everett, eds. Cats of the world: biology, conservation, and management. National Wildlife Federation, Washington, D.C.

Tinsley, J.B. 1987. The puma: legandary lion of the Americas. Texas Western Press, El Paso. 142pp.

United States Department of Agriculture-Soil Conservation Service. 1981. Land resource regions and major resource areas of the United States. Agricultural handb. 296. Washington, D.C. 82pp.

Van Dyke, F.G., R.H. Brocke, H.G. Shaw, B.B. Ackerman, T.P. Hemker, and F.G. Lindzey. 1986. Reactions of mountain lions to

logging and human activity. J. Wildl. Manage. 50:95-102.

----, and R.H. Brocke. 1987. Sighting and track reports as indices of mountain lion presence. Wildl. Soc. Bull. 15:251-256.

Wikle, T. 1991. Atlas of Oklahoma. OK State Univ., Dept. of Geography. 183pp.

Young, S.P., and E.A. Goldman. 1946. The puma: mysterious American cat. Dover Publications, New York. 358pp.

Zar, J.H. 1984. Biostatistical analysis: second edition. Prentice-Hall, Inc. New Jersey. 718pp.

Table 1. Agencies and total numbers of surveys sent to each agency.

Agency	Total Surveys Sent
Natural Resource Conservation Service	302
Oklahoma Department of Wildlife Conservation	257
U.S. Army Corp of Engineers	122
Oklahoma State University Division of Agricultural Sciences and Natural Resources	95
Oklahoma Department of Tourism and Recreation	50
Samuel R. Noble Foundation	47
Weyerhauser Company	36
U.S. Fish and Wildlife Service	35
U.S. Animal Damage Control	30
The Nature Conservancy	9
U.S. Forest Service	3
Total	**1,013**

Table 2. Mountain lion sightings relative to Major Land Resource Areas[a] in Oklahoma, 1985-1995.

Ecoregion	Total km^2	Proportion of Total km^2	No. of Sightings Observed	Expected No. Of Sightings Observed	Proportion Observed in Each Area	95% Confidence Interval for Sighting Proportion[b]	Ecoregion Preference[c]
Arkansas Valley and Ridges	13525.86	0.075	11	20	0.041	0.00709 - 0.07562	0
Central Rolling Red Plains	42405.10	0.233	86	62	0.323	0.24281 - 0.40381	+
Central Rolling Red Prairies	37542.26	0.207	57	55	0.214	0.14366 - 0.28491	0
Cherokee Prairies	17177.16	0.095	29	25	0.109	0.05538 - 0.16266	0
Cross Timbers	25841.37	0.143	38	38	0.143	0.08263 - 0.20308	0
Grand Prairie	5967.40	0.033	11	9	0.041	0.00709 - 0.07562	0
Ouachita Mts.	10343.73	0.057	12	15	0.045	0.00939 - 0.08083	0
Ozark Highlands	7940.19	0.044	6	12	0.023	0 - 0.04811	0
Southern High Plains	13276.22	0.073	7	19	0.026	0 - 0.05387	-
Western Coastal Plain	7289.05	0.040	9	11	0.034	0.00272 - 0.06495	0

[a]U.S.D.A. 1981.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$)

Table 3. Mountain lion sightings relative to Omernik's[a] ecoregions in Oklahoma, 1985-1995.

Ecoregion	Total km²	Proportion of Total km²	No. of Sightings Observed	Expected No. Of Sightings Observed	Proportion Observed in Each Area	95% Confidence Interval for Sighting Proportion[b]	Ecoregion Preference[c]
Arkansas Valley	6688.50	0.037	3	10	0.011	0 - 0.029	-
Central OK/TX Plains	53137.08	0.293	60	78	0.226	0.157 - 0.294	0
Central Great Plains	63640.23	0.351	119	93	0.447	0.365 - 0.529	+
Central Irregular Plains	19837.61	0.109	38	29	0.143	0.085 - 0.201	0
Ouchita Mts./South Central Plains	11025.33	0.061	13	16	0.049	0.013 - 0.084	0
Ozark Highland	3942.20	0.022	4	6	0.015	0 - 0.035	0
Western High Plains	23037.35	0.127	29	34	0.109	0.058 - 0.160	0

[a]Omernik 1987.

[b]Bonferroni confidence intervals (Neu et al. 1974).

[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$).

Table 4. Mountain lion sightings relative to deer harvest units[a] in Oklahoma, 1985-1995.

Deer Harvest Unit	Total km^2	Proportion of Total km^2	No. of Sightings Observed	Expected No. Of Sightings Observed	Proportion Observed in Each Area	95% Confidence Interval for Sighting Proportion[b]	Ecoregion Preference[c]
1	19204.52	0.106	16	28	0.060	0.019 - 0.101	-
2	19581.51	0.108	45	29	0.169	0.104 - 0.234	0
3	22134.14	0.122	48	32	0.180	0.114 - 0.247	0
4	16346.79	0.090	22	24	0.083	0.035 - 0.131	0
5	9189.46	0.051	20	13	0.075	0.029 - 0.121	0
6	43899.07	0.242	55	64	0.207	0.136 - 0.277	0
7	8566.18	0.047	14	13	0.053	0.014 - 0.091	0
8	12471.51	0.069	17	18	0.064	0.021 - 0.106	0
9	9002.03	0.050	7	13	0.026	0 - 0.054	0
10	13491.40	0.074	14	20	0.053	0.014 - 0.091	0
11	7421.67	0.041	8	11	0.030	0 - 0.060	0

[a]M.G. Shaw, Okla. Dept. Of Wildl. Cons., unpubl. data.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$)

Table 5. Observations of mountain lion sign relative to Major Land Resource Areas[a] in Oklahoma, 1985-1995.

Ecoregion	Total km^2	Proportion of Total km^2	No. of Sightings Observed	Expected No. Of Sightings Observed	Proportion Observed in Each Area	95% Confidence Interval for Sighting Proportion[b]	Ecoregion Preference[c]
Arkansas Valley and Ridges	13525.86	0.099	6	8	0.078	0 - 0.157	0
Central Rolling Red Plains	42405.10	0.311	40	24	0.519	0.373 - 0.666	+
Central Rolling Red Prairies	37542.26	0.275	16	21	0.208	0.089 - 0.327	0
Cherokee Prairies	17177.16	0.126	7	10	0.091	0.007 - 0.175	0
Cross Timbers	25841.37	0.189	8	15	0.104	0.014 - 0.193	0

[a]U.S.D.A. 1981.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$)

Table 6. Observations of mountain lion sign relative to Omernik's[a] ecoregions in Oklahoma, 1985-1995.

Ecoregion	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[b]	MV[c]	Total
Arkansas Valley	0	0	0	0	0	1	0	0	0	0	2	0	3
Central OK/TX Plains	1	1	0	0	3	2	1	0	1	2	6	1	18
Central Great Plains	0	3	3	1	0	3	0	1	3	7	15	3	39
Central Irregular Plains	0	0	0	0	0	2	1	1	0	0	7	0	11
Ouchita Mts./South Central Plains	0	0	0	0	1	0	0	1	0	0	2	0	4
Ozark Highland	0	0	0	0	0	0	0	0	0	0	0	0	0
Western High Plains	0	0	0	0	0	1	1	1	1	1	7	0	12
Total	1	4	3	1	4	9	3	4	5	10	39	4	87

[a]Omernik 1987.
[b]1995 includes values from 1 January - 20 March 1996.
[c]Missing values for date.

Table 7. Observations of mountain lion sign relative to deer harvest units[a] in Oklahoma, 1985-1995.

Deer Harvest Unit	Total km^2	Proportion of Total km^2	No. of Sightings Observed	Expected No. Of Sightings Observed	Proportion Observed in Each Area	95% Confidence Interval for Sighting Proportion[b]	Ecoregion Preference[c]
1	19204.52	0.106	3	9	0.034	0 - 0.090	-
2	19581.51	0.108	22	9	0.253	0.121 - 0.385	+
3	22134.14	0.122	19	11	0.218	0.093 - 0.344	0
4	16346.79	0.090	2	8	0.023	0 - 0.069	-
5	9189.46	0.051	4	4	0.046	0 - 0.110	0
6	43899.07	0.242	21	21	0.241	0.111 - 0.371	0
7	8566.18	0.047	2	4	0.023	0 - 0.069	0
8	12471.51	0.069	7	6	0.080	0 - 0.163	0
9	9002.03	0.050	0	4	0	0 - 0	-
10	13491.40	0.074	4	6	0.046	0 - 0.110	0
11	7421.67	0.041	3	4	0.034	0 - 0.090	0

[a]M.G. Shaw, Okla. Dept. Of Wildl. Cons., unpubl. data.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$)

Table 8. Observations of mountain lion sign relative to human population density per km^2[a] in Oklahoma, 1985-1995.

Cateogory	Total km^2	Proportion of Total km^2	No. of Sightings Observed	Expected No. Of Sightings Observed	Proportion Observed in Each Area	95% Confidence Interval for Sighting Proportion[b]	Category Preference[c]
<3.9	44294.79	0.244	25	21	0.287	0.162 - 0.412	0
3.9-7.3	49378.18	0.272	22	24	0.253	0.133 - 0.373	0
7.7-15.1	44466.37	.0245	17	21	0.195	0.086 - 0.305	0
15.4-38.6	34461.90	0.190	9	17	0.103	0.019 - 0.188	-
>38.6	8707.07	0.048	14	4	0.161	0.059 - 0.262	+

[a]Wikle 1991.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference (P<0.05)

Table 9. Total negative responses to sightings of mountain lions or their sign relative to Major Land Resource Areas[a] in Oklahoma, 1985-1995.

Ecoregion	Total km^2	Proportion of Total km^2	No. of Negative Responses Observed	Expected No. Of Negative Responses	Proportion Observed in Each Area	95% Confidence Interval for Proportion[b]	Ecoregion Preference[c]
Arkansas Valley and Ridges	13525.86	0.075	25	15	0.121	0.058 - 0.183	0
Central Rolling Red Plains	42405.10	0.233	37	48	0.180	0.105 - 0.255	0
Central Rolling Red Prairies	37542.26	0.207	40	43	0.194	0.117 - 0.272	0
Cherokee Prairies	17177.16	0.095	28	20	0.136	0.069 - 0.203	0
Cross Timbers	25841.37	0.143	23	29	0.112	0.050 - 0.173	0
Grand Prairie	5967.40	0.033	14	7	0.068	0.019 - 0.117	0
Ouachita Mts.	10343.73	0.057	5	12	0.024	0 - 0.054	-
Ozark Highlands	7940.19	0.044	15	9	0.073	0.022 - 0.124	0
Southern High Plains	13276.22	0.073	3	15	0.015	0 - 0.038	-
Western Coastal Plain	7289.05	0.040	16	8	0.078	0.025 - 0.130	0

[a]U.S.D.A. 1981.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$)

Table 10. Total negative responses to sightings of mountain lions or their sign relative to Omernik's[a] ecoregions in Oklahoma, 1985-1995.

Ecoregion	Total km^2	Proportion of Total km^2	No. of Negative Responses Observed	Expected No. Of Negative Responses	Proportion Observed in Each Area	95% Confidence Interval for Proportion[b]	Ecoregion Preference[c]
Arkansas Valley	6688.50	0.037	22	8	0.107	0.049 - 0.165	+
Central OK/TX Plains	53137.08	0.293	65	60	0.316	0.229 - 0.403	0
Central Great Plains	63640.23	0.351	72	72	0.350	0.260 - 0.439	0
Central Irregular Plains	19837.61	0.109	28	23	0.134	0.072 - 0.200	0
Ouchita Mts./South Central Plains	11025.33	0.061	4	13	0.019	0 - 0.045	-
Ozark Highland	3942.20	0.022	8	4	0.039	0.003 - 0.075	0
Western High Plains	23037.35	0.127	7	26	0.034	0 - 0.068	-

[a]Omernik 1987.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$).

Table 11. Total negative responses to sightings of mountain lions or their sign relative to deer harvest units[a] in Oklahoma, 1985-1995.

Deer Harvest Unit	Total km^2	Proportion of Total km^2	No. of Negative Responses Observed	Expected No. Of Negative Responses	Proportion Observed in Each Area	95% Confidence Interval for Proportion[b]	Ecoregion Preference[c]
1	19204.52	0.106	10	22	0.049	0.006 - 0.091	-
2	19581.51	0.108	18	22	0.087	0.032 - 0.143	0
3	22134.14	0.122	14	25	0.068	0.018 - 0.118	-
4	16346.79	0.090	14	19	0.068	0.018 - 0.118	0
5	9189.46	0.051	14	10	0.068	0.018 - 0.118	0
6	43899.07	0.242	51	50	0.248	0.162 - 0.333	0
7	8566.18	0.047	16	10	0.078	0.025 - 0.131	0
8	12471.51	0.069	23	14	0.112	0.049 - 0.174	0
9	9002.03	0.050	17	10	0.083	0.028 - 0.137	0
10	13491.40	0.074	22	15	0.107	0.046 - 0.168	0
11	7421.67	0.041	7	8	0.034	0 - 0.070	0

[a]M.G. Shaw, Okla. Dept. of Wildl. Cons., unpubl. data.
[b]Bonferroni confidence intervals (Neu et al. 1974).
[c]+ = positive preference, 0 = no preference, - = negative preference ($P<0.05$)

Fig. 1. Major Land Resource Areas revised from the Natural Resource Conservation Service (U.S.D.A. 1981).

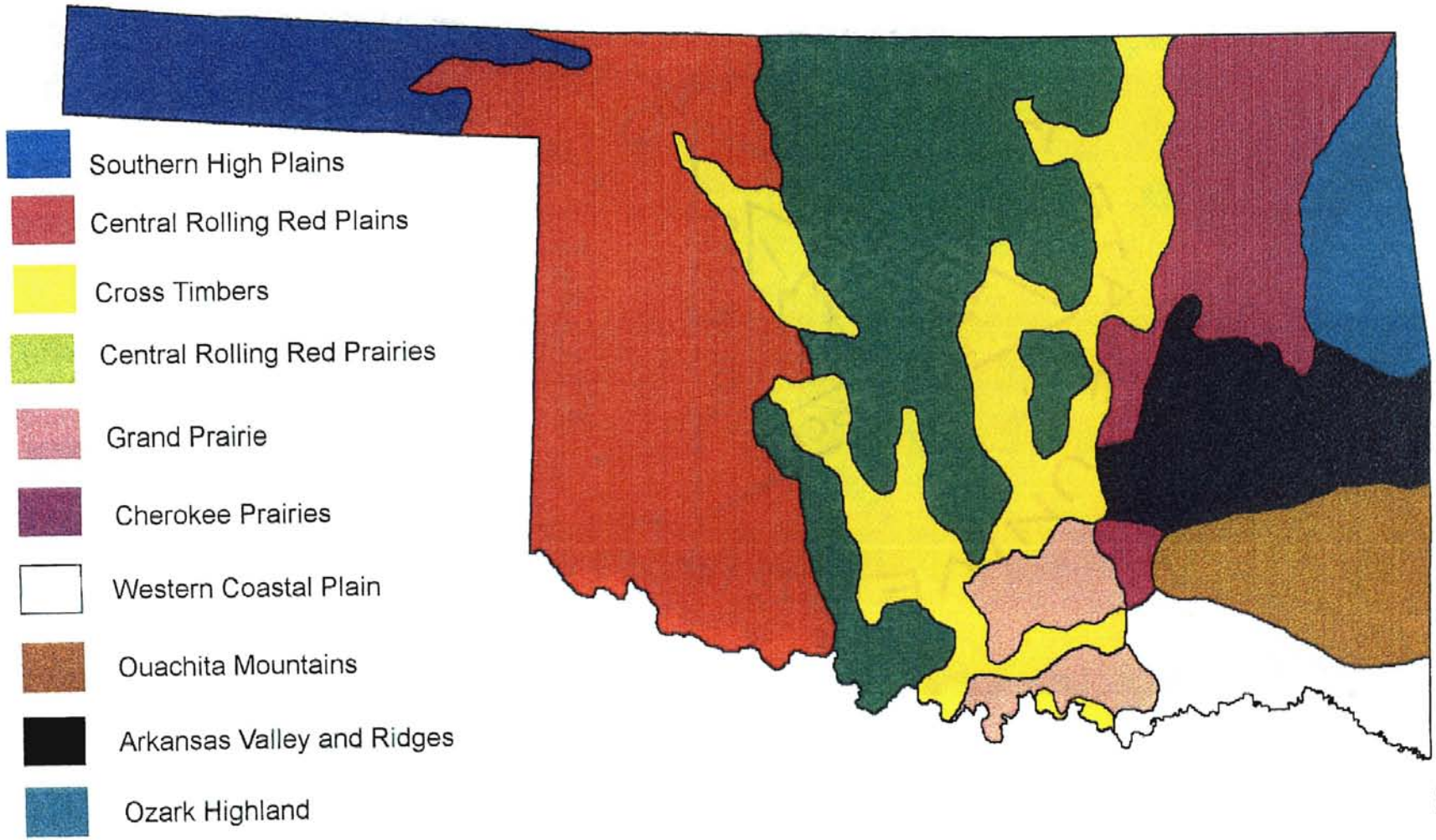


Fig. 2. Ecoregions revised from Omernik's (1987) ecoregions.

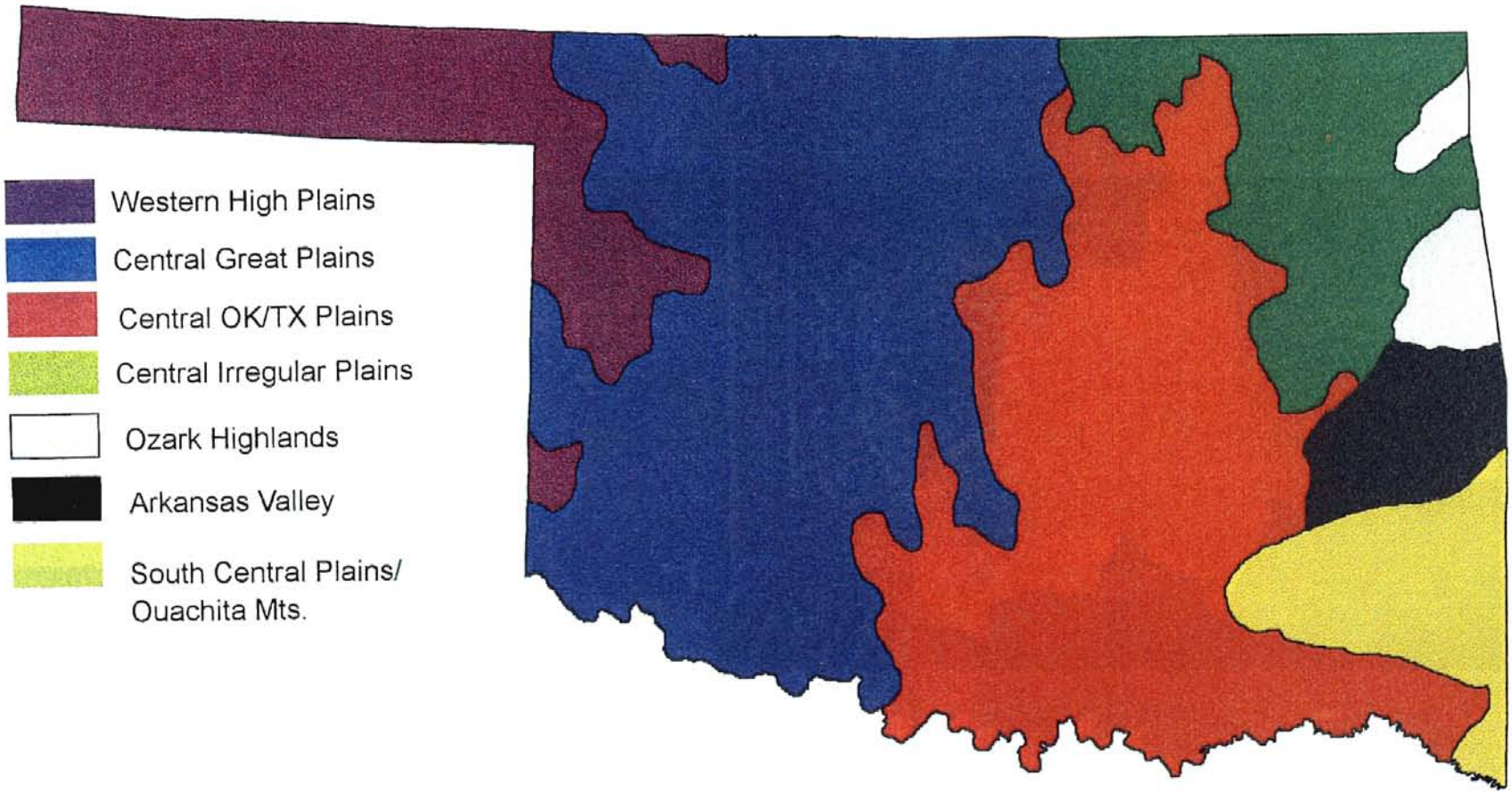


Fig. 3. Deer Harvest Units of Oklahoma (M.G. Shaw, Okla. Dept. of Wildl. Cons., unpubl. data).

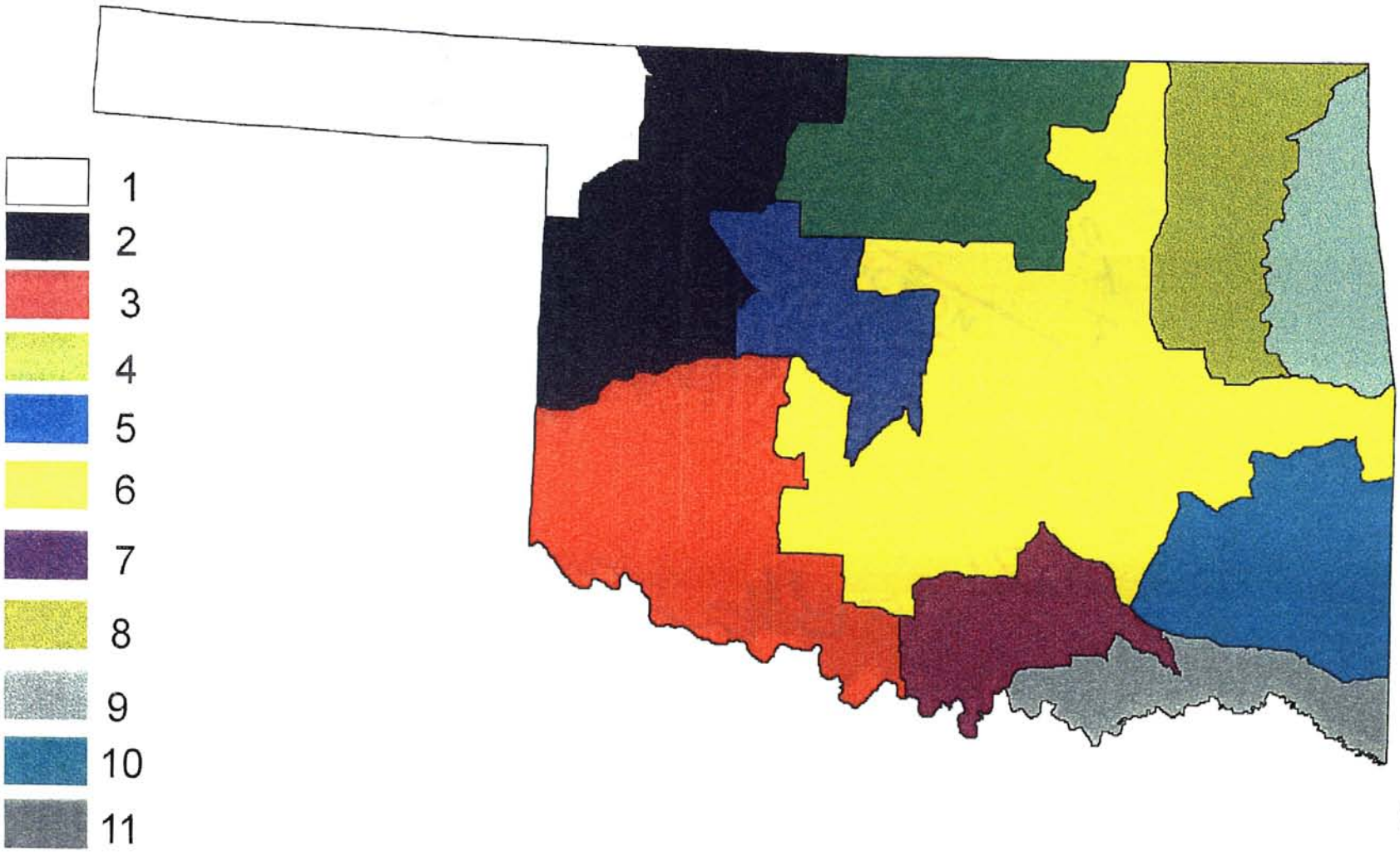


Fig. 4. Generalized topography (meters above sea level) of Oklahoma revised from Wikle (1991).

Fig. 5. Log of the number of mountain lion sightings relative to deer harvest per year in Oklahoma, 1985 - 1995.

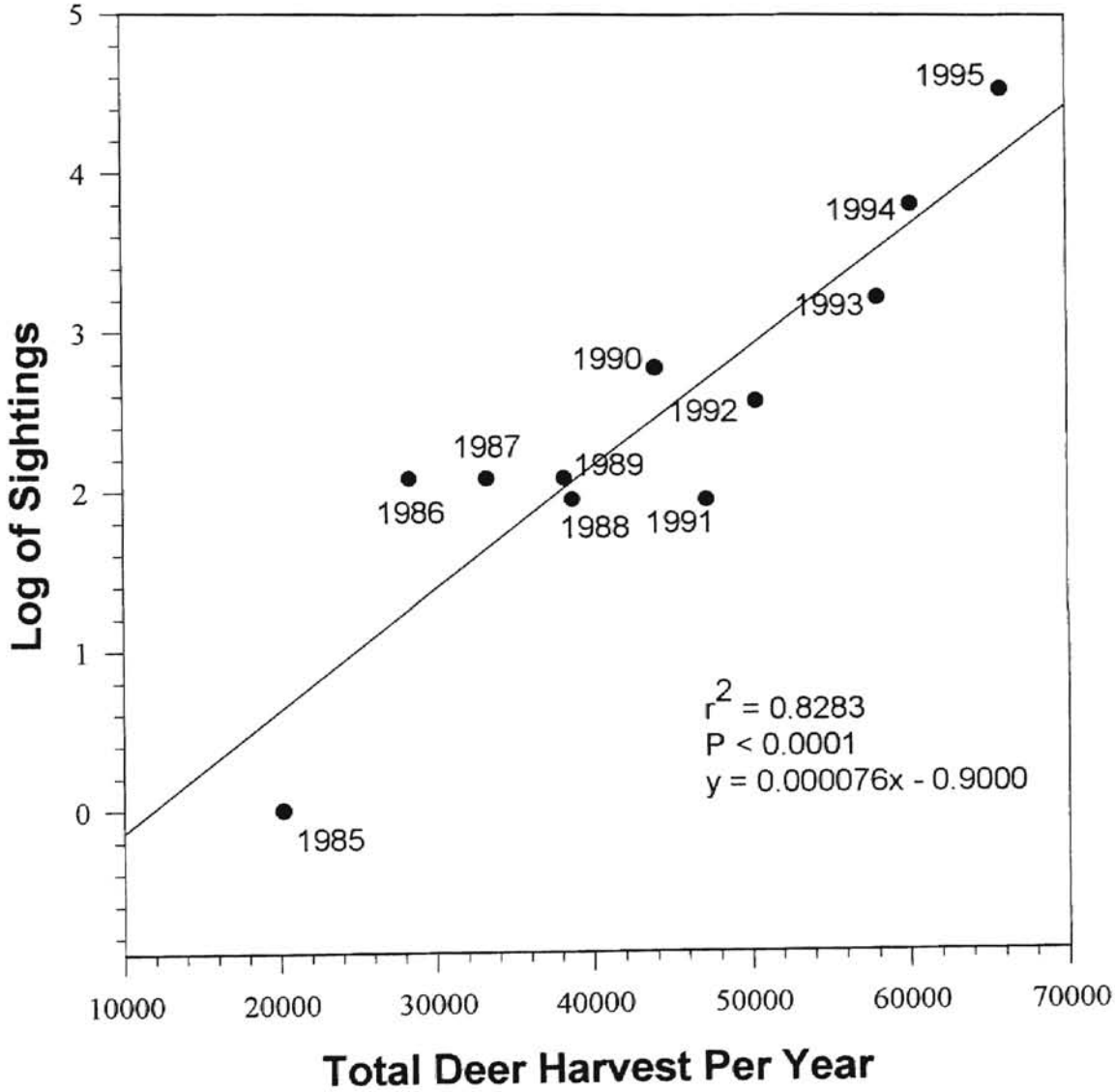


Fig. 6. Total number of mountain lion sightings (n=251) by year in Oklahoma, 1985-1995. 1995 includes values for January, February, and March 1996.

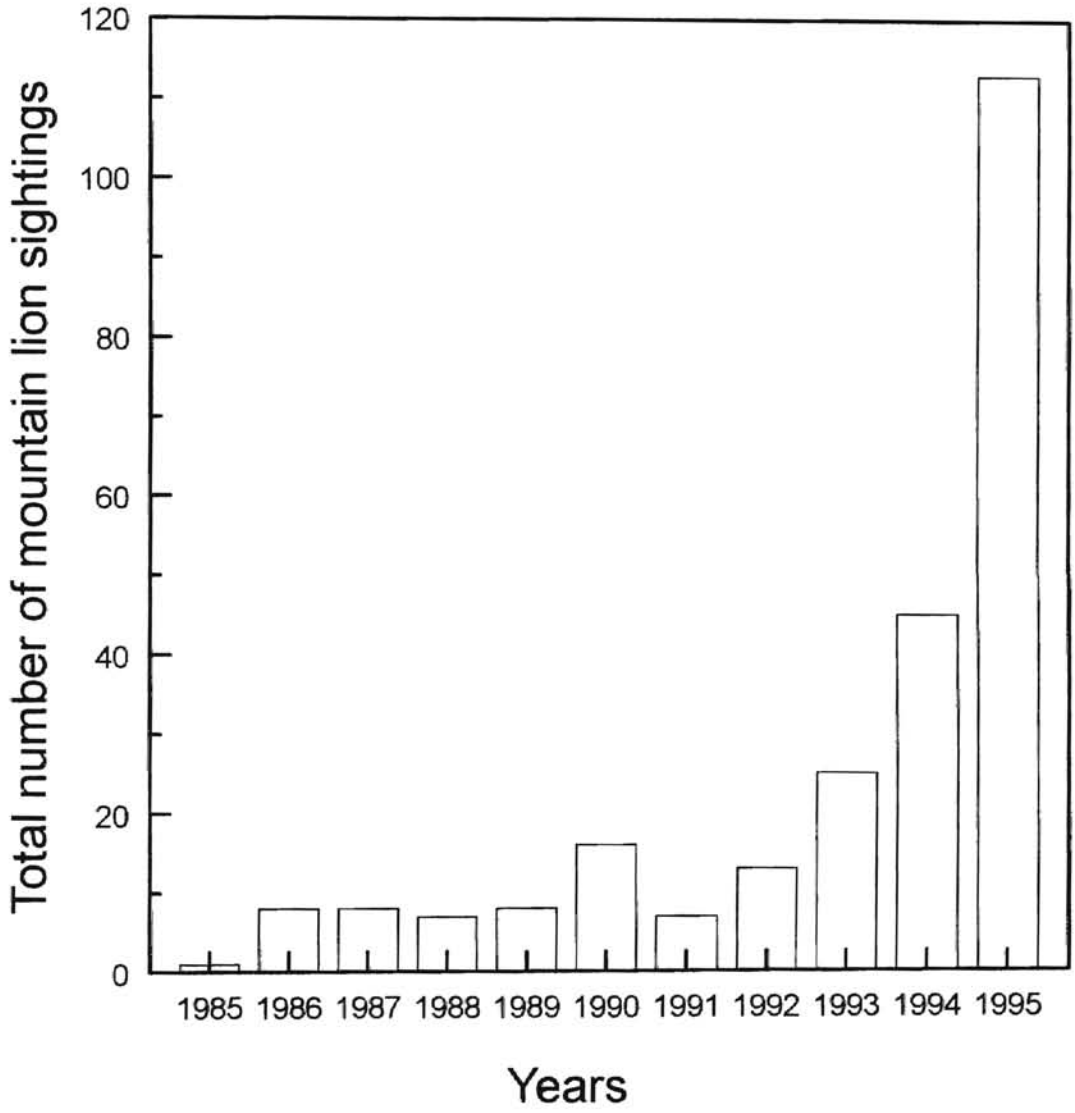


Fig. 7. Mountain lion sightings relative to human population density per km^2 in Oklahoma, 1985-1995.

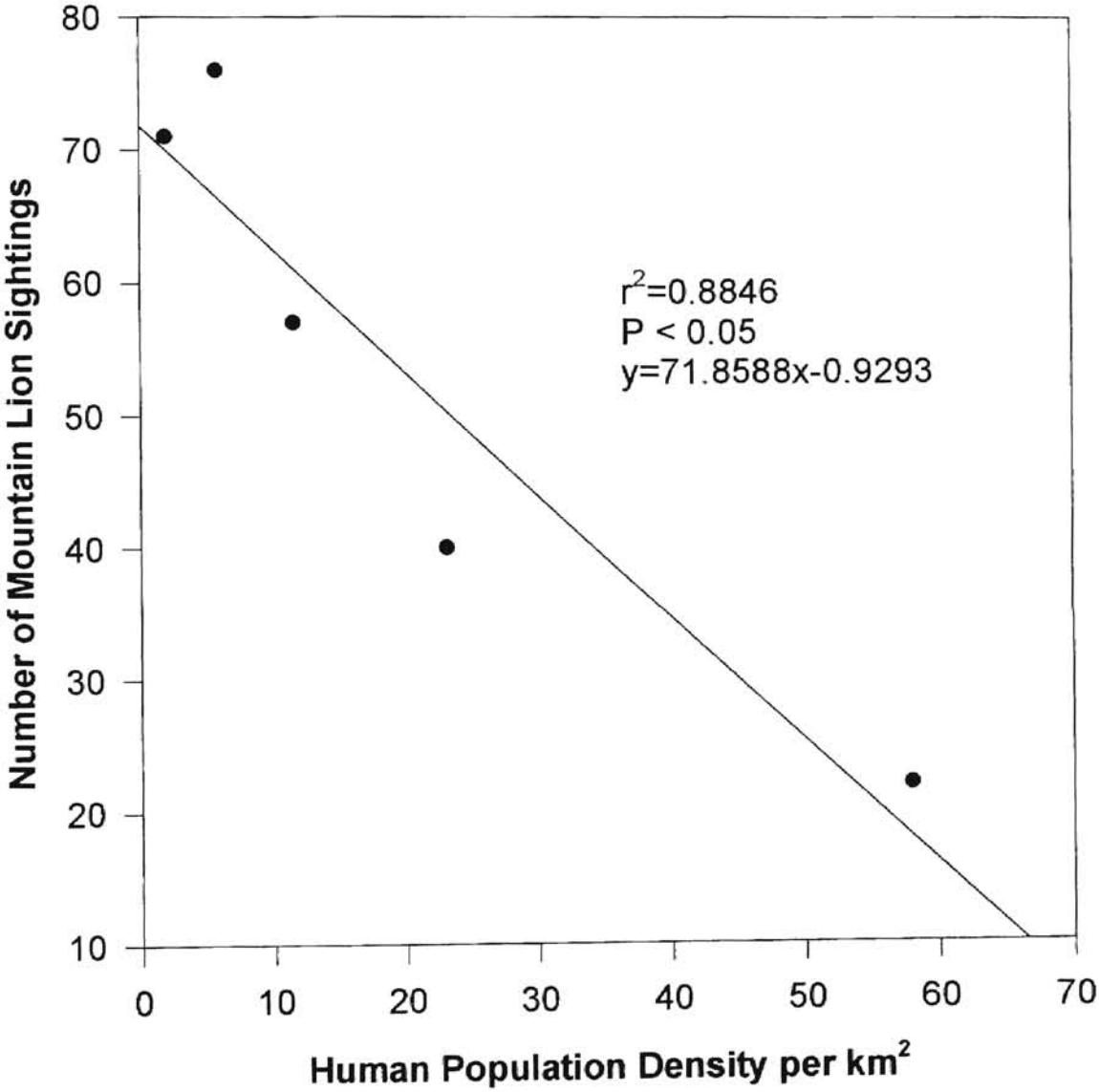
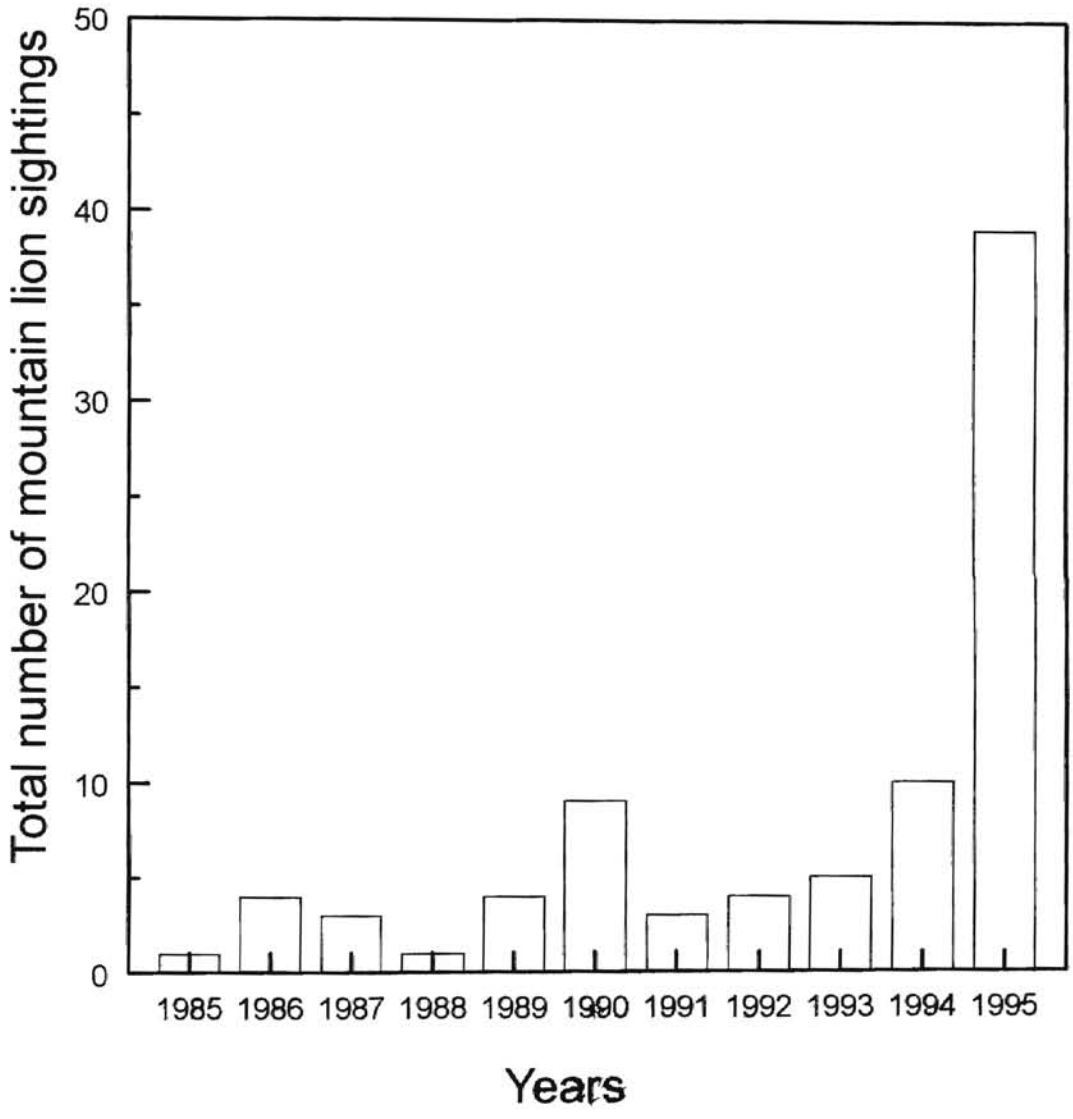


Fig. 8. Total number of observations of mountain lion sign (n=83) by year in Oklahoma, 1985-1995. 1995 includes values for January, February, and March 1996.



Name:_____

MOUNTAIN LION SURVEY QUESTIONNAIRE

1. Have you seen a mountain lion in Oklahoma at some time in the last 10 years (1985-1995)?

☐ NO - If your answer is no, please continue with question 2

☐ YES- If your answer is yes, please give your best account on the following information:

A. On the enclosed map (see back of page 2) please locate each sighting with a dot and a small "S", and then number each "S".

B. Please give the approximate date (year and month/season) of each sighting, a description of the lion(s), and circumstances of the sighting (time of day, weather, habitat, etc.).

S1 **Date:** **Description:**

S2 **Date:** **Description:**

S3 **Date:** **Description:**

2. Can you give an accurate report of a lion sighting in Oklahoma by someone else in the past 10 years?

☐ NO- If your answer is no, please continue with question 3

☐ YES- If your answer is yes, please give your best account on the following information:

A. On the attached map please locate each sighting with a dot and a small "E", and then number each "E".

B. Please give the approximate date (year and month/season) of the sighting, a description of the lion(s), and circumstances of the sighting.

E1 **Date:** **Description:**

E2	Date:	Description:
E3	**Date:**	**Description:**

3. Have you found sign of mountain lions (scat, tracks, kills, etc.) in Oklahoma in the last 10 years?

☐ NO- If your answer is no, please continue with question 4.

☐ YES- If your answer is yes, please give your best account of the following information:

A. On the attached map please indicate with a dot and a small "X" each location where sign was found, and then number each "X".

B. In the space below list each sign location followed by: a) the approximate date when this sign was observed, and b) a description of the sign.

X1	Date:	Description:
X2	**Date:**	**Description:**
X3	**Date:**	**Description:**

4. Can you give an accurate report of mountain lion sign observed by someone else in Oklahoma in the last 10 years?

☐ NO- If your answer is no, please continue with question 5.

☐ YES- If your answer is yes, please give your best account of the following information:

A. On the attached map please indicate with a dot and a small "✔" each location where sign was found, and then number each "✔".
date when this sign was observed, and b) a description of the sign.

B. In the space below (or on the back of this page) list the number of each sign location followed by: a) the approximate date when this sign was observed, and b) a description of the sign.

✔1	Date:	Description:
✔2	Date:	Description:
✔3	Date:	Description:

5. If you answered NO to questions 1 or 2 please go to question number 7, otherwise go to question 6.
6. In what county or counties do you currently work in or have you worked in during the past ten years?_____
7. How do you feel lion sightings in these areas have changed in the past 10 years? Please circle the most appropriate answer.

   \+ increasing - decreasing 0 stable

8. Do you know of another person (or persons) in your area who should be contacted for information on mountain lions? Please provide names and hometown (and addresses if possible). _____
9. Your name:_____

   Address and Phone:_____
10. If you have additional knowledge of mountain lions in Oklahoma, or comments to add to the questions above, please provide this information below or on additional paper:

25 February 1996

Dear Colleague,

The Oklahoma Cooperative Fish and Wildlife Research Unit at Oklahoma State University is conducting a study that we hope will provide needed information on the distribution and status of mountain lions in Oklahoma. A primary component of this study is to survey individuals in the natural resource professions that are most knowledgeable about wildlife and who may have had the opportunity to observe mountain lions or their sign in the wild or may know of someone reliable and knowledgeable who has. Your help in completing the enclosed questionnaire is requested, even if you have not personally seen a lion.

I you or someone you know has seen a mountain lion or mountain ion sign, please complete the enclosed survey and return it in the postage paid envelope. Even if you or someone you know has not witnessed a mountain lion or mountain lion sign, please return the survey so that this information may be recorded. The information that you are asked to provide will be held strictly confidential. Also, please be as accurate as possible when filling out the information concerning locations of mountain lion sightings and sign, as this is a major component of this study.

With an animal as elusive as the mountain lion, a mail survey questionnaire is an effective method for gathering base-line information on its status and distribution. Although this study will not indicate the exact number of mountain lions in Oklahoma, it should provide a measure of relative abundance throughout the state.

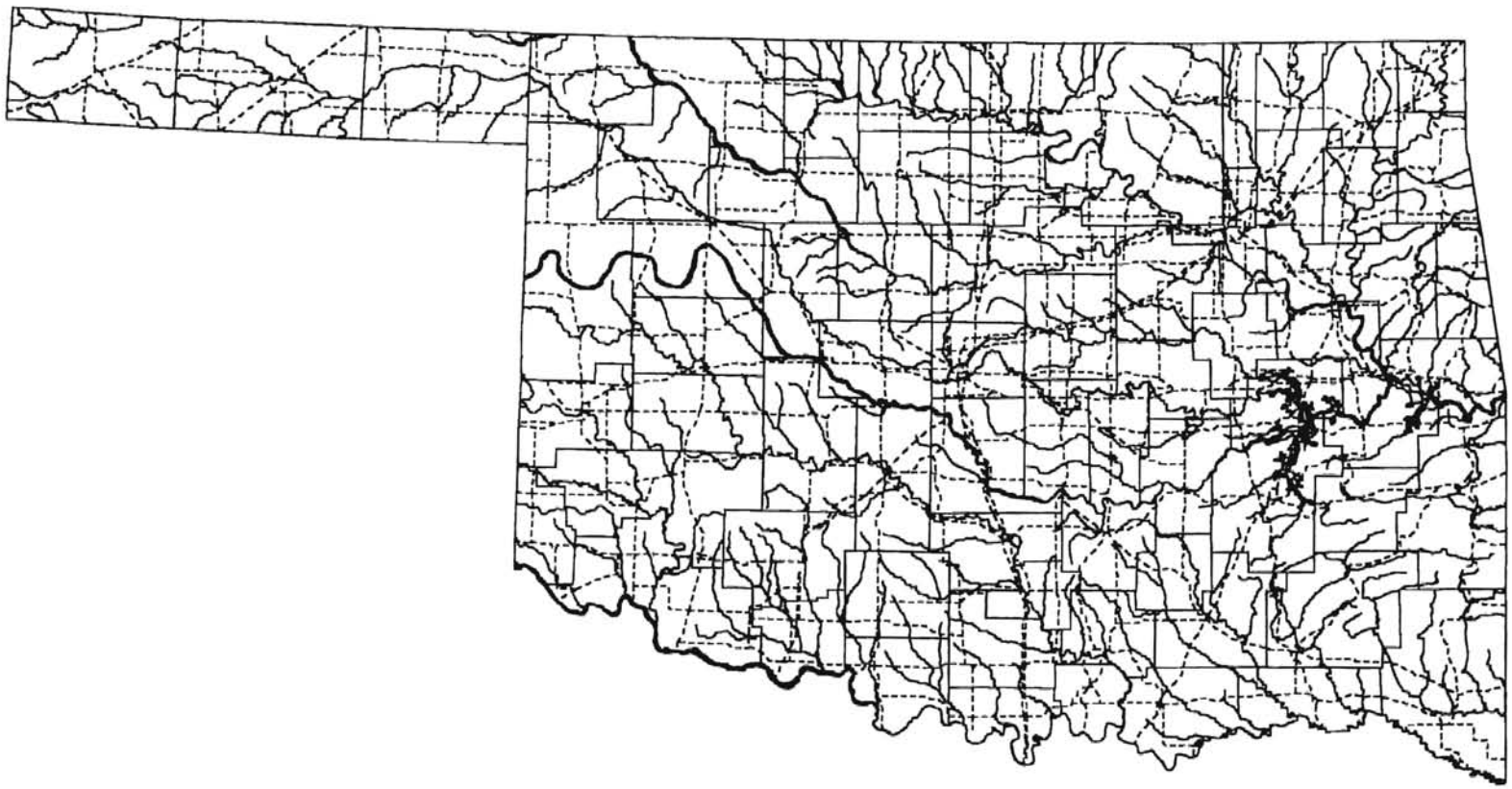
Finally, feel flexible in responding to the survey questions. If you feel the need to expand on a question or to make additional comments, please do so on the back of the survey or on additional paper.

If you have questions or problems in completing this survey, please contact Jason Pike or Dr. James Shaw at the Oklahoma Cooperative Fish and Wildlife Research Unit at Oklahoma State University, (405) 744-6342. Please return the completed survey in the provided postage paid envelope. Your help in this is very much appreciated.

Sincerely,

Michael Shaw
Wildlife Research Supervisor

Appendix C. State map of Oklahoma sent in mail survey.



Appendix C. Institutional Review Board Form

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 11-09-95 **IRB#:** AS-96-024

Proposal Title: STATUS AND DISTRIBUTION OF THE MOUNTAIN LION IN OKLAHOMA

Principal Investigator(s): James Shaw, David Leslie, Jr., Ronald Masters, Jason Pike

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature: _____ Date: December 13, 1995
Chair of Institutional Review Board

VITA

Jason Richard Pike

Candidate for the Degree of

Master of Science

Thesis: A GEOGRAPHIC ANALYSIS OF THE STATUS OF MOUNTAIN LIONS IN OKLAHOMA

Major Field: Wildlife and Fisheries Ecology

Biographical:

Personal Data: Born in Texarkana, Texas on February 18, 1972, the son of Rick and Jo Carole Pike.

Education: Received Bachelor of Science Degree in Biology with an emphasis in Zoology from Southeastern Oklahoma State University, Durant, Oklahoma in May, 1994; completed requirements for the Master of Science Degree at Oklahoma State University, Stillwater, Oklahoma, in May 1997.

Professional Experience: Park Naturalist, Okla. Dept. of Tourism and Recreation, Beavers Bend State Park, May-September 1991; Research Assistant, Hornocker Wildlife Research Institute, Selway-Bitteroot Wilderness, Idaho, June-August 1993; Teaching Assistant, Oklahoma State University, Department of Zoology, August-December 1994; Research Assistant, Oklahoma Cooperative Fish and Wildlife Research Unit, June 1995-May 1997.