Distribution, Abundance, and Habitat Affinities of Oklahoma Muskrats (*Ondatra zibethicus*): New Insight from Trapper Reports

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Distributional records of the muskrat (*Ondatra zibethicus*) are missing for much of Oklahoma. In the spring of 2005, I further investigated the status of Oklahoma muskrats by collecting surveys from Oklahoma fur trappers and United States Department of Agriculture wildlife technicians (government trappers). Surveyed individuals were asked to give county locations of muskrat sightings/collections, as well as habitats in which the sightings or collections occurred. I received a total of 93 completed surveys, which yielded 188 reports of muskrats occurring in 63 counties. Muskrats were most often reported in farm pond habitats and least reported in marsh habitats. Muskrats were reported mostly in areas with favorable combinations of human population density, annual mean precipitation, abundance of major river drainage systems, and percent cover of tallgrass prairie and forested land cover. © 2006 Oklahoma Academy of Science.

INTRODUCTION

The muskrat (*Ondatra zibethicus*) is considered the most valuable and abundant semi-aquatic fur-bearer in North America. Because of the economic importance of the muskrat, and through fur company records, we have distribution records dating back several hundred years. Muskrats in North America range from the Arctic Circle southward to the Gulf of Mexico (Hornhuff 1931, Errington 1951, Wilner et al 1980, Allen and Hoffman 1984, Engeman and Whisson 2003). One could assume that the biogeography of such a widespread and well-known species would be well documented in all areas of the United States; however, verified accounts are missing for much of Oklahoma. Caire et al (1989) provided documentation for 28 of Oklahoma's 77 counties, and stated that abundance is highest in the northeast quarter of the state, declining towards the west and southeast. Braun and Revelez (2005) provided records for two additional counties in north-central and northeastern Oklahoma.

Although biogeographical records of the muskrat are incomplete, the history of Oklahoma's riparian wetland habitats is well understood. Changes in these habitats have undoubtedly influenced the distribution of muskrat populations. According to the Oklahoma Department of Wildlife Conservation and the Advisory Group for Oklahoma's Comprehensive Wildlife Conservation Strategy (2005), over 100 riparian and aquatic vertebrates are considered species of concern. The muskrat is currently absent from this list; however, many of the listed animals share similar habitat requirements and are similarly specialized for a riparian or aquatic existence. It has been suggested that due to pollution, bank-side modifications for agriculture and forestry, enhanced or decreased water flow, recreation, and intensive livestock grazing, riparian habitats have become less suitable for highly specialized animals (Dunstone et al 1998). Regardless of the severity of particular land use effects, it has been estimated that from 67% to 70% of Oklahoma's original wetlands have been drained or filled, and dam construction along with channelizing of streams have further contributed to the

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loss of these habitats (United States Geological Survey 2006, United States Fish and Wildlife Service 2006).

In early 2005, I further investigated the status of Oklahoma muskrats by soliciting fur-trappers and United States Department of Agriculture wildlife technicians (government trappers) for accounts of recent muskrat sightings or collections. These fur-trappers and technicians spend considerable time in muskrat habitats and are regarded as having reliable knowledge of fur-bearing animals. Ideally, collecting this type of information will serve as a resource in estimating current trends, as well as directing future field investigations. The results presented here represent a compilation of anecdotal information based on the accounts of the surveyed participants and do not include voucher specimens.

METHODS

In January and February 2005, I attended two annual fur auctions where trappers offer their season's fur catch to competitively bidding fur-buyers from throughout the midwest. I attended the first event, hosted by the Oklahoma Fur Harvesters Association, in Chandler, OK, on January 29. I attended the second fur auction, hosted by the First Oklahoma Trapper and Predator Callers Association, on February 5 in Okmulgee, OK. On both days, between 7:30 am and 3:30 pm, I distributed and collected questionnaires. On February 14, I attended a technical meeting of the USDA Wildlife Services Oklahoma Division held in Oklahoma City, OK. I was allowed to speak to wildlife technicians in order to explain the purpose of my project. Surveys were handed out and collected after completion.

Trappers were asked to give locations of muskrat sightings or collections, with county of occurrence being the minimum level of detail. Reported county occurrences of muskrats were used to produce a state-wide distribution map to be compared with current specimen-based maps. In addition to county reports, trappers were asked to

report corresponding habitat(s) in which muskrats were observed or collected. The survey included a list of eight habitat types: marsh, stream, lake, river, road-side ditch, farm pond, golf course pond, and other. I sorted each county report and corresponding habitat description(s) into one of Oklahoma's seven major subregions: panhandle, northwest, southwest, north-central, south-central, northeast, and southeast. Oklahoma subregion boundaries were defined so as to maintain uniformity in land area among the subregions, and to represent the state's major physiognomic regions.

The total number of both muskrat reports and habitat reports were calculated for each subregion and presented in graphical form as counts and percentages. Chi square was used to analyze the frequencies of muskrat reports and habitat reports among the seven subregions of Oklahoma. Human population density (log_{10}), annual mean precipitation, abundance of major river drainage systems, percent cover of forested land, and percent cover of tallgrass prairie were compared with respective abundance of muskrat reports among the subregions using Spearman's rank order correlation. I used principle components analysis (PCA) to examine the multivariate relationships among all independent variables and subregions. The seven subregions represent sampling entities and variables are examined in their explanation of variation among the subregions (sampling entities).

RESULTS AND DISCUSSION

A total of 93 completed surveys yielded 188 reports of muskrats occurring in 63 counties, 39 of which do not have specimen based documentation (Fig. 1). Muskrat report abundance did vary across subregions ($X^2 = 40$, $P < 0.0001$), with the highest in the northeast portion of the state, and lowest in the panhandle (Fig. 2). These results are congruent with Caire et al (1989) in that abundance is highest in the northeast, declining to the west and southeast.
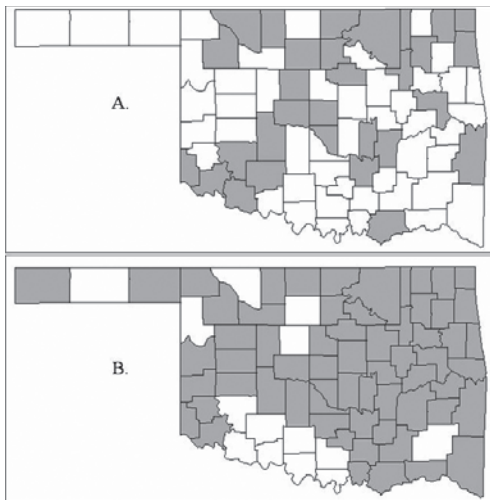
Figure 1. (A) Muskrat distribution (shaded counties) based on Caire et al (1989) and Braun and Revelez (2005). (B) Muskrat distribution based on trapper reports.
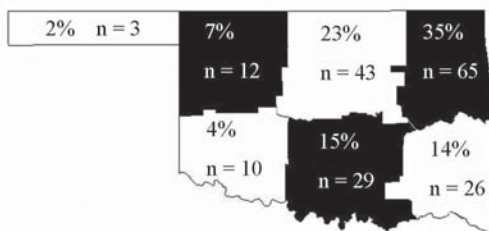

Figure 2. Muskrat reports among Oklahoma sub-regions; percentages of total (%) and counts (n).

Completed surveys yielded a total of 260 habitat reports among the 63 reported counties. Habitat report abundance also varied among subregions ($X^2 = 55$, $P < 0.0001$), following the same trend as muskrat reports. The most frequently reported habitat type was "farm pond," while the lowest was "marsh." Relative percentages (%) and counts (n) of reported habitat types were: farm pond 26% ($n = 66$); stream 19% ($n = 50$); lake 14% ($n = 36$); river 13% ($n = 35$); roadside ditch 11% ($n = 28$); golf course pond 7% ($n = 19$); other 7% ($n = 18$); marsh 3% ($n = 8$). The relative proportions of reported habitat types did not vary among subregions. The "other" habitat category included mine pits in the northeast, and irrigation drainages in the southwestern portion of the state.

Glass (1952) suggested that although Oklahoma muskrats were historically stream dwellers, man-made impoundments now sustain the majority of muskrats, whereas native stream habitats have been hydrologically altered to an unsuitable degree. Without a doubt, farm ponds provide an additional habitat of importance for muskrat populations (Shanks and Arthur 1952). An increase in abundance and distribution of Missouri muskrats has been attributed to the construction of thousands of farm ponds statewide (Schwartz and Schwartz 2001). Although muskrats do occupy farm ponds, trappers agree that these habitats are usually occupied only temporarily. Shanks and Arthur (1952) found that pond dwelling muskrats frequently move and the majority of studied Missouri farm ponds sustained no more than two animals. Due to trampling effects of livestock and elevated turbidity levels, many Oklahoma ponds may be incapable of supporting the herbaceous vegetation necessary for muskrats (Glass 1952). Personal observations and consensus among trappers is that many farm ponds, which offer suitable habitat during spring, summer, and early fall, fail to provide adequate late fall/winter food and cover offered by seasonally persistent plants such as cattails (*Typha* spp.) and bulrush (*Schoenoplectus* spp.).

The relatively low number of marsh habitat reports was unforeseen. The muskrat is known as a marsh animal throughout its range and cattail marshes are considered a staple for muskrat trappers in other regions. Allen and Hoffman (1984) suggested that habitats dominated by cattails are capable of supporting much higher densities of muskrats than habitats of low cattail abundance. Kroll and Meeks (1985) found muskrat harvest numbers were directly correlated with area cover of cattails. A consensus among many seasoned trappers is that a decline in muskrats over the past 40 years has coincided with the disappearance of cattail marshes through urban sprawl, road construction, channelizing streams, draining

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for cultivation, and heavy livestock use.

A strong correlation ($r = 0.96\ P = 0.005$) did exist between muskrat report abundance and human population density (Fig. 3). This suggests that if the number of trappers per capita is equitable across the state, the likelihood of muskrats being reported might vary accordingly. Based on this assumption, muskrats in remote areas are more likely to go unnoticed, while those in more populated regions are more likely to be observed, reported, and possibly reported multiple times by more than one person. However, western Oklahoma marks the periphery of the muskrat's known range and it is documented that most species occur in clumped distributions and have a low abundance nearing the margins of their range (Brown 1995). Given that only an estimated three percent of historic riparian habitats remain in western Oklahoma (Farley et al 2002), actual field work is necessary to verify muskrat abundance and distribution in this region.
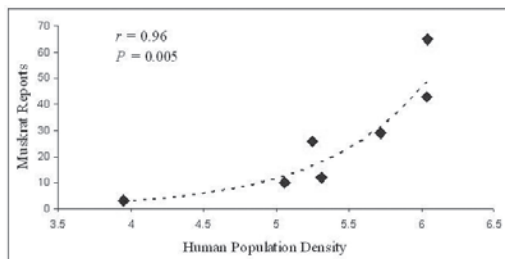

Figure 3. Muskrat report abundance and human population density ($\log_{10}$) with power trend-line.

Correlation analysis also revealed an association ($r = 0.79\ P = 0.04$) between muskrat report abundance and annual mean precipitation (Fig. 4). The southeastern subregion immediately stands apart from other observations where it represents the highest annual mean precipitation, but has a lower abundance of muskrat reports than the adjacent northeastern subregion. This is likely due to a localized region occurring in Pushmataha, LeFlore, and McCurtain Counties, where annual precipitation is over 50 inches.
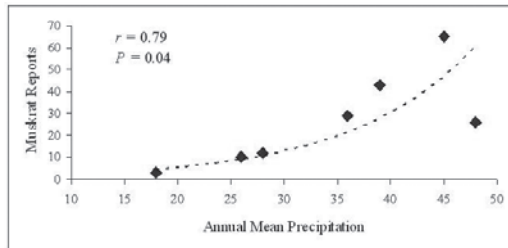
Figure 4. Muskrat report abundance and annual mean precipitation (cm) with power trend-line.

This unique locality acts to skew the correlation between annual mean precipitation and muskrat report abundance. Removing the southeastern subregion greatly increases the correlation ($r = 0.95\ P = 0.004$), indicating that annual mean precipitation is strongly associated with muskrat report abundance across most of Oklahoma.

Obvious implications of annual mean precipitation include the seasonal stability of permanent water sources and availability of dispersal corridors. It is plausible that western Oklahoma's relatively low annual mean precipitation creates temporally narrow dispersal corridors as well as seasonal water-level fluctuations in otherwise suitable habitats. Unstable water level has been suggested as a critical limiting factor for muskrat populations, because it inhibits the establishment of desirable emergent plant communities and influences predation risk (Bellrose and Low 1943, Glass 1952, Sather 1958, Allen and Hoffman 1984, Virgil and Messier 1996, 2000). It is quite possible that anthropogenic landscape alterations have compounded the effects of natural temporal variations in habitats and dispersal corridors, leaving muskrat populations disjointed in the more arid portions of the state. Glass (1952) reported that land use practices have resulted in decreased soil water storage and increased surface runoff, thereby causing once steady flowing streams to exist in an intermittent dry / flood flow regime. Thurber et al (1991) concluded that year-round water depth is a major modifier in the abundance and distribution of muskrats.

Correlation analyses revealed associations for percent forested cover/muskrat report abundance ($r = 0.67$ $P = 0.10$), and percent tallgrass prairie cover/muskrat report abundance ($r = 0.67$ $P = 0.11$). The southeastern subregion is dominated by oak-pine forests and post oak-blackjack oak forests, with remaining land cover consisting of patches of loblolly pine forests, oak-hickory forests, cypress bottom forests, and tall grass prairie (Tyrl et al 2002). Most water sources in the southeast are bordered by wooded plant communities rather than the terrestrial herbaceous communities preferred by muskrats. Brooks and Dodge (1981) suggested that forested cover has a negative effect on the abundance of muskrats. Clay and Clark (1985) described muskrats inhabiting "unusual" forested habitats after being displaced by floods; however, muskrats quickly left these habitats as flood waters receded and preferred habitats became available again. Schooley et al (2006) indicated that pine plantations negatively influenced round-tailed muskrat (*Neofiber alleni*) dispersal due to vegetation structure alone, or due to increased perches for avian predators. It is likely that suitable muskrat habitats and dispersal corridors exist in clumped distributions across the heavily wooded landscapes of southeastern Oklahoma. This dominance of forested habitat might partially explain the decreased abundance of reports in southeastern Oklahoma, and possibly the decrease in muskrat abundance as reported by Caire et al (1989).

The north-central subregion sustains the highest fraction of tallgrass prairie across Oklahoma, and remnant habitat patches are still widespread. Payne et al (2001) noted that muskrats were known to occupy farm ponds in the Tallgrass Prairie Preserve, Osage County. Trappers from Osage, Pawnee, Kay, Grant, Noble, and Payne Counties attested that muskrats are common and many permanent water bodies sustain muskrat populations. One trapper conveyed that a large ranch operation in Osage County has experienced problems with muskrats burrowing into the dams of many newly constructed farm ponds. He estimated that at least 40 of the ranch's ponds contained muskrats. Anecdotal trapper accounts corroborate the statistics in relating favorable year round rainfall, remnant tallgrass prairie habitat patches, and abundance of permanent water bodies to a stable abundance of muskrats in north-central Oklahoma.

Correlation analysis revealed an association between abundance of major river drainage systems and muskrat report abundance ($r = 0.61$ $P = 0.15$). Rivers with seasonally stable water flow and suitable herbaceous vegetation are known to provide hospitable muskrat habitats (Brooks and Dodge 1981, Allen and Hoffman 1984, Brooks 1985). My observations indicate that muskrats in southwest Oklahoma use rivers for periodic dispersal and refuge habitat during periods of drought (manuscript in preparation). It is quite likely that Oklahoma muskrat populations follow dynamic fluctuations similar to those observed in other regions. As local populations reach low densities and marginal habitats suffer high mortality and/or high emigration, river corridors might play a key role in seeking other habitats and re-colonizing formerly occupied vacant habitats. Jackson (2003) suggested that river systems provide vital links for many semi-aquatic species including the muskrat, within the larger landscape. Major river systems might serve as one underlying mechanism influencing the abundance of muskrats and, as the correlation analysis suggests, abundance of muskrat reports. Southeastern Oklahoma's decrease in major river systems, relative to the neighboring northeastern subregion, in combination with the prevalence of forested habitat and lower human population, likely influences the abundance of muskrat reports from that subregion. Farley et al (2002) conveyed that conservation strategies are needed which address habitat requirements of terrestrial plants and animals that require riparian dispersal corridors.

PCA results illustrated the collective

relationships among the variables measured and overall variation among subregions (Fig 5). The first component explained 66% of total variation among Oklahoma subregions. Component 1 loadings were a combination of human population density (0.56), annual mean precipitation (0.56), tallgrass prairie land cover (0.45), forested land cover (0.33), and major river system abundance (0.25). The second principle component accounted for 27% of remaining variation among subregions; loadings were dominated by forested land cover (0.76), tallgrass prairie land cover (⁻0.54), and annual mean precipitation (0.26). Component 1 loadings verify that all variables measured effectively separate the western subregions (panhandle, northwest, and southwest) from the central (north-central and south-central) and eastern subregions (northeast and southeast), and component 2 loadings verify that vegetation structure is almost exclusively responsible for the measured variation between the remaining northern and southern subregions. It is plausible, with an annual mean precipitation shift from xeric to mesic (i.e., surface water is no longer a limiting factor), other environmental factors become overridingly influential on muskrat populations.

Northeast and north-central Oklahoma produced the highest numbers of muskrat reports and were distinguished from other subregions by high human population density, tallgrass prairie land cover, and abundance of major river systems. Southeast and
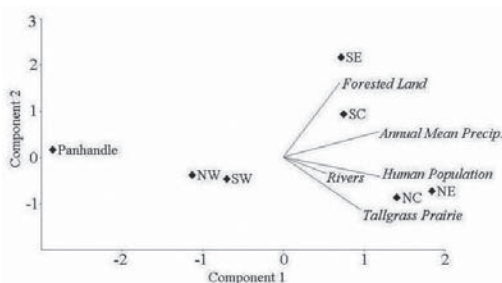

Figure 5. PCA scatterplot. Component 1 = 66% of variation among sub-regions. Component 2 = 27% of remaining variation.

south-central Oklahoma were characterized by lower human population density, a substantial increase in forested land cover, and equally significant decreases in tallgrass prairie land cover and muskrat report abundance. PCA did illustrate an east to west gradient in most of the variables measured much like the east to west gradient in muskrat report abundance. All three western subregions are distinct with relatively low annual mean precipitation, decrease in tallgrass prairie land cover, decrease in forested land cover, lower abundance of major river systems, less dense human population, and low muskrat report abundance. These subregions are dominated by mixed-grass eroded plains and short-grass high-plains physiognomic types. Although muskrats have been verified in western portions, it is uncertain how natural and anthropogenic variations in environmental conditions influence abundance and distribution in the western landscapes.

Results presented here indicate that the likelihood of muskrats being reported in any given locale is largely associated with one human social factor (human population density) and four ecological factors (annual mean precipitation, abundance of major river drainage systems, forested land cover, and tallgrass prairie land cover). These results do provide an overall pattern of muskrat distribution, abundance, and habitat associations as indicated by trapper reports, as well as possible explanations for those reported patterns. Hopefully, these results will facilitate a greater interest for muskrat ecology in Oklahoma. To date, many of the reported muskrat locations have been field checked and verified.

ACKNOWLEDGMENTS

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