SMALL MAMMAL ASSEMBLAGES IN NATURAL PLANT COMMUNITIES OF WISCONSIN

by

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ABSTRACT

Small mammals play important roles in Wisconsin ecosystems; however, considering their importance and ubiquity, we know little about the best way to capture them or how to distinguish between cryptic species. Additionally, we do not have consistent information regarding distributions and habitat requirement of many small mammal species. This study was broken into 4 parts in order to address these knowledge gaps.

When evaluating richness and diversity of small mammal communities it is important to consider the impact that trap efficacy may have on these indices. The objectives of my study were to determine species specific trap efficacy relative to Sherman traps and pitfall traps, assess the impact of trap efficacy on measures of species richness and diversity, and compare mortality rates between trap types, and if pitfall covers reduce trap mortality. In the summers of 2009 and 2010, I trapped throughout Wisconsin in 5 habitats. I used 180 transects (190 m-long) of 20 Sherman live traps spaced every 10 m and 10 pitfall traps spaced every 20 m for 4 consecutive nights. I trapped 3,261 small mammals of 22 species in 34,235 trap nights. Pitfall traps were more effective at capturing shrews and voles, whereas Sherman traps captured more mice (*Peromyscus* spp.) and squirrels. Irrespective of habitat type, both trap types together captured significantly higher species richness and diversity than either trap type independently. Covers significantly reduced mortality for *Peromyscus* spp., but not for voles or shrews and covers reduced overall captures of voles. My results indicate that Sherman and pitfall traps capture different portions of the small mammal community and, regardless of the habitat type, should be used in combination when assessing species richness and diversity.

In Wisconsin, white-footed mice (*Peromyscus leucopus noveboracensis*) and woodland deer mice (*P. maniculatus gracilis*) are difficult to distinguish. Recent climatic trends have facilitated encroachment of *P. leucopus* north into the range of *P. maniculatus*, making unambiguous species identification imperative. Cranial and external measurements have been used previously to differentiate these species. However, since large geographic morphological variation occurs and most previous studies used measurements from deceased specimens, definitive morphological measurements need to be identified that can quickly and effectively classify live Wisconsin *Peromyscus* spp. in the field. I live trapped *Peromyscus* spp. in central and northern Wisconsin during the summer of 2010. I measured ear, tail, hindfoot, and weight from live animals and collected tissue for genetic confirmation. In addition to using mDNA analysis to identify samples to species, I collected measurements from 84 *P. maniculatus* and 293 *P. leucopus* in 6 Wisconsin counties. I used discriminate function analysis (DFA) to develop equations to identify characteristics that best separated mice to species. By using ear length alone, 97.9% of the samples could be correctly classified with most *P. leucopus* <17mm and most *P. maniculatus* ≥ 17mm. By adding weight to the function, I was able to achieve 99.2% classification accuracy and with the addition of tail was able to achieve 99.5% differentiation.

The arctic shrew (*Sorex arcticus*) and American water shrew (*S. palustris*) are wide-spread boreal species. *Sorex arcticus* reaches its southern distribution in Wisconsin and within the Midwest *S. palustris* also reaches its southern range extent in Wisconsin. Although the ranges of both species are generally thought to occur in the Driftless Area in the southwestern portion of Wisconsin, no occurrences have been documented from

the region. Within the past decade and half, the known distribution of these species has changed dramatically. I used museum records and geo-referenced surveys to remap the known distribution of *S. arcticus* and *S. palustris* in Wisconsin. Herein, I report records of *S. arcticus* and *S. palustris* within the Driftless Area and extend the distribution of *S. arcticus* and *S. palustris* south of their former range, including the most southerly extant record of *S. arcticus*. This study emphasizes the continued value of voucher specimens and museum collections.

Determining small mammal species habitat associations and environmental characteristics, important in site occupancy, are central to understanding species biology and community organization. During the summers of 2009 and 2010, I trapped small mammals and measured habitat variables throughout the state of Wisconsin at 180 sites spanning 13 natural habitats. I captured 3,261 individual small mammals of 22 species, allowing for characterization of small mammal communities within natural habitats. I was also able to model occupancy for 12 species using habitat covariates while incorporating imperfect detection. Comparisons among small mammal communities indicated that organization was based on soil moisture, abundance of trees, and climate. Additionally, the most important covariates in predicting small mammal occupancy were basal area, frequency and duration of wet periods, and minimum winter temperature. The ability to detect differences in community similarity and species occupancy, based on climate, is likely a product of the large geographical extent of this study, underscoring the need to assess community structure at multiple scales. Given the importance of climate in structuring these small mammal communities, predicted warming winter temperatures could have considerable impacts on small mammal communities in the region.

Interestingly, occupancy of the meadow jumping mouse was best predicted by the presence of precipitation before a trap check and availability of pitfall traps. These conclusions would have been missed using other analyses that do not account for imperfect detection. Finally, my results indicate that soil moisture, abundance of trees, and climate are important for species occupancy and, at the community level, these variables create regular and predictable community structure across a heterogeneous landscape.

ACKNOWLEDGEMENTS

When I first began this project nearly 3 years ago, I was a naïve undergraduate student looking to spend time in the field. While undoubtedly still naïve in many respects, I could have never imagined the extent to which this undertaking has expanded and the geographical expanse to which it transverses. Although I personally spent thousands of hours studying small mammals and put my own sweat, blood, and with some chagrin, tears into this project, it would not have been possible without the help and encouragement of my friends and colleagues. Here, I would here like to take the time to sincerely thank those that gave their hand and guided me in times of need, ultimately making this project possible.

First and foremost I would like to thank my parents, Mary Bratz and Dick Stephens, who instilled in me a sense of wonder and appreciation for the outdoors. From an early age, they encouraged me to spend time outdoors and ask questions about the natural word. Unknowingly, they had steered me down a road toward becoming a wildlife biologist. In addition to their constant encouragement, throughout my career, they also offered a tremendous amount of backing and logistical support for this project. During 3 summers of field work, they offered their home as a sort of staging grounds for cleaning traps incrusted with mud and small mammal whatnots and clothing soiled by long days of pitfall digging and slugging through swamps. They also offered much needed advice and technical support during some of my most difficult times. Without the help of my parents, this project would not have been possible, and for that, I am ever indebted.

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I would also like to thank my committee members, Dr. Chris Yahnke and Dr. Shelli Dubay for their help throughout my undergraduate and graduate careers. Chris provided Sherman live traps and logistical support for preparing and housing voucher specimens collected in the field. I would like to thank Shelli for her editorial support, constant encouragement, and insightful conversations on both academic and life issues.

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PREFACE

As management of wildlife shifts from single species to biological diversity, species that were previously considered economically unimportant are now gaining attention. Within the last century, 69 native mammalian species are known to occur in Wisconsin. Of these, 5 are thought to be extirpated, 17 are regulated game animals, 19 are protected from harvest, and 28 are unprotected non-game animals. In early management schemes, regulated game animals received the majority of researcher and land manager time and attention. As a result, we know much about the biology, distribution, and habitat needs of game animals. However, the majority of mammalian species in Wisconsin fall under the category of unprotected non-game animals, and most of these, approximately 23, are small mammals (<250g). These animals are critical to healthy ecosystems because they consume vegetation and seeds (Gibson et al. 1990, Howe and Brown 2000), provide prey for avian and mammalian predators (Buskirk and MacDonald 1984, Knick 1990, Swengel and Swengel 1992), disperse seeds and spores (Maser et al. 1978, Vander Wall et al. 1993), prey on other small mammals and insects (Getz et al. 1992, Anderson and Folk 1993), and act as reservoirs for diseases (Levine et al. 1985). Yet, considering the importance and ubiquity of small mammals, we know little about the best way to capture them or how to distinguish between cryptic species. Additionally, we do not have consistent information regarding distributions and habitat requirement of many species.

Whereas techniques such as tracking plates or trail cameras may be used to assess the presence of small mammals, the best way to study them is by direct capture. Because different trap types preferentially capture different species of small mammals, researchers should use more than one trap. Yet, many researchers choose to use only one trap type,

potentially causing spurious results in community ecology studies if a trap is only capturing a portion of a small mammal community.

In the first chapter, I investigated the efficacy of Sherman live and pitfall traps in capturing Wisconsin small mammal species. I also evaluated how trap efficacy affects community metrics of richness and diversity within a variety of habitats. Mortality estimates are necessary in mark recapture studies and thus I determined relative mortality rates for both Sherman traps and pitfall traps and if the addition of covers to pitfall traps reduced pitfall mortality or capture success. In addition, I assessed whether capture ratios of Sherman traps to pitfall traps were the same on nocturnal and diurnal trap checks, if both trap types capture animals of similar weights and gender, and if capture rates differed on nights with rain than on nights without rain.

In Wisconsin, many small mammal species are cryptic and difficult to identify. This creates problems during ecological studies where species are both cryptic and syntopic. When field studies forgo species identification, resolution is lost at the community level. Additionally, conclusions based on lumping cryptic species may be problematic and possibly lead to erroneous conclusions.

In the second chapter, I compared measurements from live white-footed mice (*Peromyscus leucopus noveboracensis*) and deer mice (*Peromyscus maniculatus gracilis*) to determine which field measurements were most useful in grossly distinguishing these cryptic species. I developed discriminant function equations using a combination of measurements to differentiate live *Perosmyscus* spp. in northern Wisconsin. In Appendix A, I also provide field techniques useful for distinguishing masked shrews (*Sorex cinereus*) and pygmy shrews (*Sorex hoyi*).

Basic information on the distribution of many small mammal species is lacking in Wisconsin. In 1961, Hartley Jackson published a compilation of museum records, studies, and data from intensive field work on all Wisconsin mammals from the late 1800s to the mid-1900s (Jackson 1961). His work centered on occurrence, habitat, and life history information. In 2008, Charles Long published an updated version of Jackson's book, but much of his work relied heavily on sampling that occurred from 1960-1990 in central Wisconsin (Long 2008). These books are useful for assessing the historical distribution of small mammal species. However, considering the importance of small mammals, little information has been published in Wisconsin that documents small mammal occurrences on a wide geographic basis in the last few decades. Recently distributions of many small mammal species in the Great Lakes region have changed, ostensibly from climactic change and habitat alteration (Martin et al. 2003, Myers et al. 2009). Still, distributions of other small mammals have been expended based on more thorough sampling throughout the state. In Wisconsin, many of these distributional changes are marked only by anecdotal evidence or by small scale unpublished studies and little work has been published regarding the statewide distribution of small mammals incorporating records from the last few decades (Loren Ayers (WDNR), personal comm.).

In the third chapter, I used historical museum record locations, in conjunction with recent georeferenced small mammal surveys, to map and update the range of the arctic shrew (*Sorex arcticus*) and American water shrew (*S. palustris*) and assess their rank within the state of Wisconsin. Additionally, listed in Appendix B are distributional range maps created for nearly 30 small mammal species using both historical museum records and data collected from my field work.

Recently, interest in explicitly measuring species associations in natural plant communities has become a significant interest in Wisconsin (WDNR 2005). Although elucidating these broad scale macrohabitat associations is important, an understanding of quantitative biotic and abiotic associations within these habitats is also imperative. Understanding what causes small mammal communities to form within in natural plant communities creates baseline data that can be used to assess small mammal communities within anthropogenically altered systems. Moreover, a fundamental understanding of biotic and abiotic characteristics, important to individual species, can be used to help shape management decisions and predict potential impacts of climate change and anthropogenic perturbations. A number of studies have investigated small mammal associations within Wisconsin's native plant communities, but they are often limited to one community type (Kantak 1981, Finnell 2000, Chapman and Ribic 2002, Anthony et al. 2003), use disparate collection techniques (Komarek 1932, Pitts 1983), have limited geographical extent (Schmidt 1931, Hanson 1946, Beck and Vogl 1972, Johnson 1978), or use vague or broad classifications of communities (Evrard 1998). Furthermore, these studies fail to quantify biotic or abiotic factors that may play a role in the presence or abundance of species within natural plant communities. Thus, although these studies help shape our cursory understanding of native Wisconsin small mammal community structure, a large scale geographic and holistic investigation into the qualitative and quantitative habitat characteristics shaping Wisconsin small mammal communities is long overdue.

In the fourth chapter, I present results from extensive small mammal sampling throughout the state of Wisconsin. I established species specific associations to natural

plant communities and compared similarity of small mammal assemblages in natural plant communities. In addition, I also modeled occupancy for 12 small mammal species using biotic and abiotic characteristics collected at the site level. I used results from these models to draw inference on how climate change and anthropogenic influences may affect small mammal species and communities.

Finally, because museum specimens have proven to be of immeasurable importance in documenting the occurrence of small mammals species, tracking population changes over time, answering genetic questions, and making morphological comparisons (Moritz et al. 2008, Woodman and Stephens 2009, Rowe et al. 2011), over 900 voucher specimens were preserved and deposited in accredited museums. Listed in Appendix E are prepared voucher specimens and their final disposition.

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CHAPTER I:

EFFECTS OF TRAP TYPE ON SMALL MAMMAL RICHNESS, DIVERSITY, AND MORTALITY

ABSTRACT

When evaluating richness and diversity of small mammal communities it is important to consider the impact that trap efficacy may have on these indices. The objectives of my study were to determine species specific trap efficacy relative to Sherman traps and pitfall traps, assess the impact of trap efficacy on measures of species richness and diversity, and compare mortality rates between trap types and if pitfall covers reduce trap mortality. In the summers of 2009 and 2010, I trapped throughout Wisconsin in 5 habitats. I used 180 transects (190 m-long) of 20 Sherman live traps spaced every 10 m and 10 pitfall traps spaced every 20 m for 4 consecutive nights. I trapped 3,261 small mammals of 22 species in 34,235 trap nights. Pitfall traps were more effective at capturing shrews and voles, whereas Sherman traps captured more mice (*Peromyscus* spp.) and squirrels. Irrespective of habitat type, both trap types together captured significantly higher species richness and diversity than either trap type independently. Covers significantly reduced mortality for *Peromyscus* spp., but not for voles or shrews and covers reduced overall captures of voles. My results indicate that Sherman and pitfall traps capture different portions of the small mammal community and, regardless of the habitat type, should be used in combination when assessing species richness and diversity.

INTRODUCTION

In ecological studies of small mammals, trapping is often used to capture species in a given area. Indices of richness and diversity are calculated from these captures and used to describe the structure of small mammal community assemblages (Caro 2001, Sullivan and Sullivan 2001, Constantine et al. 2004). Underlying assumptions of these indices are that individuals captured during trapping reflect accurately the number of species and relative abundance of animals that occur in a given area. In order to meet this assumption, a number of trap types are often used (Beacham and Krebs 1980, Kalko and Handley 1993). Traditionally, snap traps were extensively used to capture small mammals and numerous studies have compared snap traps to pitfall traps or live traps such as Sherman traps or Longworth traps (Wiener and Smith 1972, Hansson and Hoffmeyer 1973, Beachman and Krebs 1980, Pendleton and Davison 1982, Mengak and Guynn 1987, Kalko and Handley1993, Woodman et al. 1996). Although effective, snap trapping removes animals from the population and therefore cannot be used in mark-recapture studies or studies that require live animals. Furthermore, removal trapping may have ethical ramifications, especially when rare or sensitive species are involved (Farnsworth and Rosovsky 1993). Consequently, the use of snap traps in ecological studies has declined in recent years with replacement by live traps such as Sherman traps or pitfall traps.

Pitfall traps have been shown to capture more shrews and fossorial mammals, in addition to a younger age class than live traps (Briese and Smith 1974, Beachman and Krebs 1980, Williams and Braun 1983, Bury and Corn 1987, Handley and Kalko 1993, Dizney et al. 2008). A number of studies comparing Sherman traps and pitfall traps have demonstrated species specific trap biases and indicated that pitfall traps are a valuable addition to trapping

protocols (Williams and Braun 1983, Nicolas and Colyn 2006, Umetsu et al. 2006, Dizney et al. 2008). Nevertheless, it is often unclear as to the extent that adding pitfall traps to a trapping protocol will affect richness and diversity calculations. Moreover, most studies that compare Sherman traps to pitfall traps only do so in one habitat type, leading to conclusions that may only apply to one ecotype. Given the prolific use of metrics such as richness and diversity in describing and comparing small mammal communities and studies, the need to understand the effects of trap type on these metrics within a variety of systems is important.

In addition to understanding trap efficacy and how it affects community metrics, it is also important to identify mortality rates associated with trap type. As with snap traps, the use of traps with high mortality rates can be counterproductive in studies that require live animals and their use also raises ethical concerns where sensitive species may be present. In particular, pitfall traps often have extremely high mortality rates, especially for shrews and during wet weather (Briese and Smith 1974, Bury and Corn 1987, Anthony et al. 2005). When using pitfall traps during precipitation events, moisture accumulation poses a considerable challenge to maintaining live animals. To decrease mortality in pitfalls, covers have been employed to reduce moisture accumulation on rainy nights (Bury and Corn 1987, Dizney et al. 2008). However, no published studies have addressed their effectiveness at decreasing mortality. Additionally, it is unclear how covers may affect capture rates. For example, with herpetofauna, cover boards used to monitor populations may actually attract more animals to an area (Monti et al. 2000). If similar trends hold for small mammals, pitfall covers may increase captures.

I trapped small mammals in 5 habitats across a large geographical extent using a combination of Sherman and pitfall traps. The primary objectives of my study were to: (1)

determine the effectiveness of Sherman traps and pitfall traps at capturing small mammal species and how trap efficacy affects community metrics of richness and diversity within a variety of habitats; (2) compare relative mortality rates for both Sherman traps and pitfall traps; (3) determine if the use of pitfall trap covers reduces pitfall mortality or captures; and (4) determine if capture distributions in Sherman traps and pitfall traps were the same on nocturnal and diurnal trap checks, if both trap types captured animals of similar weights and gender, and if capture rates were different on nights with rain than on nights without rain.

METHODS

Study area. — I conducted the study throughout Wisconsin (Fig. 1). Mean summer temperatures statewide range from 16 ºC in the far north to 23 ºC in the far south and mean winter temperatures range from -17 ºC in the far north to -8 ºC in the far south. Mean annual precipitation varies from 81 cm in the north to 71 cm in central and southern Wisconsin (Wisconsin State Climatology Office 2010). As a result of glaciation, Wisconsin has little topographic relief, with elevations ranging from 177 to 595 m. Abiotic factors and differential climatic conditions create 2 major floristic divisions in Wisconsin, with boreal flora in the north and prairie flora in the south (Curtis 1959). All study sites were placed within natural plant communities (Curtis 1959), both in boreal and prairie regions (Fig. 1).

Small mammal surveys. — I trapped small mammals (<250 g) from June– August 2009 and 2010. I used transects of traps because this trap arrangement captures higher species richness than grids of traps (Read et al. 1988, Pearson and Ruggiero 2003). When possible, I oriented transects in an east to west or north to south direction. However, I often placed transects to fit because of the irregular shape and small size of many natural communities,

henceforth referred to as habitats. Transects were 190 m long and marked every 10 m with removable flags. Transects were trapped for 4 consecutive nights and 6 to 9 transects were geographically clustered within an area. Distance between transects ranged from 0.09 km to 30.51 km (average 8.74 km) and individual transects were placed ≥ 10m from the edge of a plant community to avoid edge effect. Sherman live traps (7.6 x 8.9 x 23.9 cm; H.B. Sherman Inc., Tallahassee, Florida) were placed at every flag (*n*=20) and pitfall traps (38 cm deep, 20 cm diameter, 10 L, floral cooler buckets, Syndicate Sales, Inc., Kokomo, Indiana) at every other flag (*n*=10). Due to logistical constrains, pitfall traps were only installed at every other station. I positioned traps within a 1 m radius of the flag and along natural runways such as fallen trees or rocks when possible. Pitfall traps were excavated using a posthole digger and all soil was placed into sandbags and returned to the hole when trapping was complete. Extremely rocky soil and shallow bedrock precluded digging of pitfall traps in 6 dry prairie transects. I baited all traps with peanut butter spread 4 mm thick between sheets of paper towel and cut into 2.5 x 2.5 cm squares. One square was used in each trap and bait was replaced as needed. I checked traps twice daily, approximately 1 to 4 hours after sunrise and 4 hours before sunset to 1 hour after sunset. Following high mortality in pitfall traps during rainy nights in 2009, I placed black corrugated plastic covers (30 cm x 30 cm) approximately 15 cm above every other pitfall trap (*n*=5/transect) using 2 wooden dowels in 2010.

I identified captured animals to species, determined sex and weighed and marked each individual with a slight ear notch. A different combination of ear notches was used each day and these, along with weight and gender, were used to identify recaptured individuals. To identify recaptured shrews, I trimmed the terminal caudal hairs. In 2010, the presence or absence of precipitation during the trapping interval was also recorded (R. Stephens, pers.

obs.). Incidental deaths and voucher specimens were prepared as study skins, skeletons, and tissues and deposited in the UW- Stevens Point Museum of Natural History, Stevens Point, WI; National Museum of Natural History, Washington D.C.; Harvard Museum of Comparative Zoology, Cambridge, MA; and University of Alaska Museum, Fairbanks, AK (See Appendix E). My trapping protocol was approved by the UWSP Animal Care and Use Committee and followed guidelines outlined by the American Society of Mammalogists (Sikes et al. 2011).

Data analysis. — Because peanut butter is a highly odiferous bait and more bait at a station could potentially bring additional animals into an area, before beginning analysis I assessed whether a baited pitfall trap, paired with a Sherman trap, was influencing the capture rates in Sherman traps. Because pitfall traps were never used independently, it was not possible to test whether baited Sherman traps had an impact on capture rates of pitfall traps. For 7 commonly captured species I used a paired sample t-test to compare the number of individuals captured in Sherman traps without a paired pitfall trap to Sherman traps paired with a pitfall trap within a transect. Results of this test indicated that trap pairing significantly increased captures of white-footed mice (*Peromyscus leucopus*) in Sherman traps by approximately 12%, but did not significantly affect captures of other species (Table 1). These results indicated that trap pairing only minimally affected capture rates in Sherman traps and I chose to proceed with further analysis with the caveat that captures in pitfall traps could have been affected by the presence of a Sherman trap.

For species of which I captured ≥ 30 individuals, I used a chi-square goodness-of-fit test to compare the distribution of captures among traps according to trap availability. My expected chi-square values were based on number of trap nights, approximately a 2:1

ratio of Sherman traps to pitfall traps when adjusted for trap nights. Trap nights were adjusted for tripped or disabled traps where: trap nights = (traps * number of trap checks) – (sprung Sherman traps or disabled pitfall traps * 0.5) (Nelson and Clark 1973, Beauvais and Buskirk 1999). One trap night was subtracted for missing or destroyed traps. Because prior exposure to traps is known to change individual capture rates (Getz 1961), I only used first time captures in these analyses, reducing the number of captures used in analyses and making them more conservative in their ability to detect differences. Pitfall traps are often considered a passive trap, capturing animals by haphazard encounter, rather than an animal purposefully entering. However, there has been little documented evidence to support this hypothesis. If pitfall traps are indeed a passive trap, than greater ambient light should decrease captures by making the traps more visible. For species that had ≥ 4 captures in each trap type during morning and evening checks, I assessed whether nocturnal and diurnal capture distributions were similar using a chi-square test of independence. When this test was significant I also used a chi-square goodness of fit test to determine if distributions in trap types were different. Pitfall traps are known to capture smaller animals (Umetsu et al. 2006). Thus, for 7 species with ≥ 12 individuals in each trap type, which included northern the short-tailed shrew (*Blarina brevicauda*), meadow vole (*Microtus pennsylvanicus*), southern red-backed vole (*Myodes gapperi*), *P. leucopus*, woodland deer mouse (*P. maniculatus gracilis*), masked shrew (*Sorex cinereus*), and meadow jumping mouse (*Zapus hudsonius*), I used a Mann-Whitney *U*-test to assess whether Sherman live traps and pitfall traps captured animals of similar weights. Weights of animals trapped in 2009 were not used because weights were infrequently recorded if animals had died in a trap. Additionally, for these same species I

used a chi-square test of independence to determine if both trap types were capturing similar sex ratios. *Sorex cinereus* and *B. brevicauda* were excluded from analysis because sexing these species proved difficult in the field. I also used a chi-square goodness of fit test to analyze whether using pitfall trap covers changed the number of captures within groups of similar genera and same type of locomotion. These included quadrupedal insectivores, represented by shrews (*B. brevicauda* and *Sorex* spp.); quadrupedal rodents, represented by arvicoline rodents (*M. pennsylvanicus*, *M. ochrogaster, M. gapperi*, and *S. cooperi*); scansorial rodents, represented by *Peromyscus* spp.; and bipedal rodents, represented by *Z. hudsonius*.

For transects containing both trap types (n = 74), I calculated the richness (total number of species) and diversity using the Shannon-Wiener diversity index ($H = -\Sigma p_i \log_e p_{i,}$ where p_i = relative abundance of the i^{th} species) for Sherman live traps, pitfall traps, and a combination of both traps using first time captures (Shannon and Weaver 1949). These values were compared within each of the 5 habitat types (barrens, dry forests, dry prairies, wet forests, and wetlands/wet prairies) using a one-way repeated measures ANOVA with Greenhouse-Guisser correction for unequal variance and Bonferroni post hoc tests. Although some data sets were only marginally normally distributed, ANOVAs are reasonably robust to slight deviations in normality (O'Brien and Kaiser 1985).

To determine if animals were differentially captured on nights with precipitation, I compared numbers of captures on rainy and non-rainy nights for groups (shrews, arvicoline rodents, *Peromyscus* spp., and *Z. hudsonius*) captured in 2010 using a chi-square goodness of fit test with expected distribution based on trap nights with and

without rain. I used pairwise chi-square tests to compare mortality rates of groups captured in covered pitfall traps, uncovered pitfall traps, and Sherman live traps on both rainy and non-rainy nights. I used recaptured animals from 2010 with the exception of *Z. hudsonius* which was excluded because too few individuals were taken in Sherman traps. All statistical analyses were performed in PSAW Statistics version 18 (IBM SPSS Statistics, Chicago, Illinois). Statistical significance was assessed at $\alpha = 0.05$.

RESULTS

Trap efficacy. — I captured 1,264 individuals of 18 species in 2009 and 1,997 individuals of 21 species in 2010, totaling 3,261 individuals of 22 species of small mammals (Table 2). Sherman live traps captured 1,924 individuals of 21 species in 22,599 trap nights (8.5% trap success) and pitfall traps accounted for 1,337 individuals of 16 species in 11,636 trap-nights (11.5% trap success). Sherman traps captured 6 unique species (all > 50 g), and pitfall traps had 1 unique capture (Table 2). For 12 species with over 30 captures, pitfall traps were significantly more effective for capturing 8 species. At the extremes pitfall traps were nearly 40 times more likely to capture pygmy shrews (*S. hoyi*) than Sherman traps, whereas thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*) and eastern chipmunks (*Tamias striatus*) were 19 and 7 times more likely, respectfully, to be captured in Sherman traps (Table 2).

Among 4 species that had significantly higher capture rates in pitfall traps, I found that for *B. brevicauda* and *M. gapperi* the capture distributions in pitfall traps and Sherman traps was significantly different for diurnal and nocturnal trap checks (Table 3). Additionally, *M. pennsylvanicus* and *S. cinereus* had capture distributions that were marginally significantly different (Table 3). After adjusting for trap nights, there was no

difference in capture rates between trap types for diurnal and nocturnal captures for *B. brevicauda* ($\chi^2 = 0.06$, $P = 0.806$) and *M. pennsylvanicus* ($\chi^2 = 1.25$, $P = 0.263$), whereas *M. gapperi* was captured more often in Sherman traps during diurnal checks ($\chi^2 = 0.81$, $P = 0.004$). Sorex cinereus still showed a tendency for capture in pitfall traps ($\chi^2 = 43.41$, $P > 0.001$).

Of 7 species analyzed, only *M. gapperi* and *P. leucopus* had significantly different mean weights between trap types (Table 4). Sherman traps caught larger *P. leucopus* than pitfall traps, whereas pitfall traps caught larger *M. gapperi* (Table 4). Of 5 species for which I compared sex ratios between trap types, only *M. pennsylvanicus* ($\chi^2 = 6.49$, $P < 0.011$) and *Peromyscus leucopus* ($\chi^2 = 4.59$, $P < 0.032$) had significantly different sex ratios. For *M. pennsylvanicus*, Sherman traps captured 55.1% females and 44.9% males whereas pitfall traps captured 35.8% females and 64.2% males. For *P. leucopus*, Sherman traps captured 44.7% females and 55.3% males whereas pitfall traps captured 54.8% females and 45.2% males. The addition of covers to pitfall traps significantly lowered captures of arvicoline rodents ($\chi^2 = 9.074$, $P = 0.003$). Although not significant, captures were also lower in covered pitfall traps for *Peromyscus* spp. ($\chi^2 = 1.38$, $P = 0.240$), shrews ($\chi^2 = 0.994$), and *Z. hudsonius* ($P = 0.319$; $\chi^2 = 0.231$, $P = 0.631$).

Community composition. — I observed significantly different richness and Shannon-Wiener diversity values among Sherman traps, pitfall traps, and both trap types combined for all 5 habitat types (Table 5). For all habitat types the richness values from both trap types combined were significantly higher than values derived from either Sherman traps or pitfall traps separately. However, richness values from Sherman trap and pitfall trap captures were not significantly different (Fig. 2). On average, richness calculated from a combination of

pitfall and Sherman traps increased by 63% and 47% from using only Sherman traps or pitfall traps, respectively.

For barrens, dry prairies, forested wetlands, and wet prairies/wetlands, the diversity values from both trap types combined were significantly higher than values derived from Sherman live or pitfall traps individually. In these communities, with the exception of forested wetlands, diversity values for Sherman traps and pitfall traps were not significantly different from each other (Fig. 3). In forested wetlands, pitfall traps had significantly higher diversity values than Sherman traps (Fig. 3). In dry forests, combined trap diversity values were not significantly different from those of pitfall traps, but both were significantly higher than those from using Sherman traps independently (Fig. 3). On average, Shannon-Wiener diversity values calculated from a combination of pitfall traps and Sherman traps was 72% and 32% greater than using only Sherman traps or pitfall traps, respectively.

Rain and Mortality. — In 2010, I accumulated 17,101 combined trap nights, of which 4,564 (27%) had a rain event that occurred while traps were open. Capture rates for arvicoline rodents ($\chi^2 = 4.12$, $P = 0.042$), *Peromyscus* spp. ($\chi^2 = 22.08$, $P < 0.001$), shrews ($\chi^2 = 48.57$, $P < 0.001$), and *Z. hudsonius* ($\chi^2 = 26.67$, $P < 0.001$) occurred significantly more often when traps were open during a rain event. Compared to dry nights, checks with rain had significantly higher mortality for arvicoline rodents and *Peromyscus* spp. in both covered and uncovered pitfall traps, but mortality was not significantly different in Sherman traps (Fig. 4). The addition of covers to pitfall traps did not significantly lower arvicoline mortality on rainy or non-rain checks, but did significantly lower mortality for *Peromyscus* spp. in both instances (Fig. 4). On nights without rain, mortality of both arvicoline rodents and *Peromyscus* spp. was significantly lower in Sherman traps than in

uncovered pitfall traps. In addition, on nights without rain, Sherman traps had significantly lower mortality than covered pitfall traps for arvicoline rodents, but not for *Peromyscus* spp. (Fig. 4). Shrew mortality was largely independent of trap type and rain events (Fig. 4).

DISCUSSION

Trap efficacy. — I found marked differences in frequencies of captured species between Sherman traps and pitfall traps. Sherman traps captured more *Peromyscus* spp. and squirrels, whereas pitfall traps captured more arvicoline rodents, shrews, and *Z. hudsonius*. These results are consistent with other studies, which found that Sherman traps capture larger animals that are more adept at climbing and saltation, whereas pitfall traps capture smaller animals that are less cursorially or scansorially adapted (Williams and Braun 1983, Bury and Corn 1987, Handley and Kalko 1993, Dizney et al. 2008). It is interesting to note that jumping mice, although adept at saltatorial locomotion, were captured almost 5 times more often in pitfall traps than in Sherman live traps. This difference has been noted in other studies (Williams and Braun 1983, Kalko and Handley1993, Evrard 1998); however, Anthony et al. (2005) found no capture tendencies of jumping mice toward pitfall traps. Discrepancies among studies are likely a function of pitfall depth, with deeper pitfalls or drowning pitfall traps capable of capturing larger animals (Buckner 1955, Ribeiro et al. 2011). The difference in sex ratio for *M. pennsylvanicus* and *P. leucopus* between the 2 trap types was unexpected. Differences in sex ratios in *M. pennsylvanicus* may have been a function of trap density. Male meadow voles disperse farther than females, predisposing them to a greater chance of capture in pitfall traps (Blair1940, Baird and Birney 1982). Male *P. leucopus* also disperse farther than females (Krohne et al. 1984); however, differences in sex ratios may be explained by the

capture of pregnant females. Although I did not keep track of pregnant animals, many pregnant *Peromyscus* spp. were too large to escape from pitfall traps. Since most of my trapping was conducted during the breading season, this may have caused a slight shift in sex ratios toward more females in pitfall traps.

Capture ratios were not the same for 4 species between nocturnal and diurnal checks. Nocturnal captures of *B. brevicauda*, *M. pennsylvanicus*, and *M. gapperi* were more likely in pitfall traps than Sherman traps, but for diurnal captures I observed no significant trap bias for *B. brevicauda* and *M. pennsylvanicus*, and a greater capture rate of *M. gapperi* in Sherman traps. Although many species captured in pitfall traps have relatively poor vision (George et al.1986, Boonstra and Pavone 1993), illumination by ambient light may decrease the capture rate in pitfall traps. This further supports the hypothesis that pitfall traps are passive, and capture species by happenstance encounter (Williams and Braun 1983). Baiting pitfall traps is likely still important for drawing animals in (Sealander and James 1958), nonetheless further research is needed to determine exactly how much baiting increases the probability of capture for these species in pitfall traps.

Many studies have documented bias of captures in pitfall traps toward smaller or younger animals (Briese and Smith 1974, Beachman and Krebs 1980; Nicolas and Colyn 2006, Umetsu et al. 2006), yet I found very little evidence that this occurred in my study. *Peromyscus leucopus* was the only species in my study that followed this tendency, whereas pitfall traps actually caught significantly larger *M. gapperi*. All other species showed no significant difference in capture weights between trap types. This may be a function of the relatively deep and narrow dimensions of my pitfall traps that kept most

animals from jumping out. *Peromyscus leucopus*, are known to jump blindly when disturbed (Brown 1964), and this, along with their adept scansorial ability (Williams and Braun 1983), may have allowed larger individuals to escape capture.

I found that the addition of pitfall trap covers reduced captures of arvicoline rodents by nearly 30%. Covers also reduced captures of *Peromyscus* spp., shrews, and *Z. hudsonius*, but not significantly. If pitfall traps are mainly passive in nature and depend on the animal blundering into the trap, the covers themselves or the shadows they cast may alert animals to the presence of the trap and deter them from venturing close enough for capture. Shillito (1963) found that when short-tailed voles (*Microtus agrestis*) were exposed to new objects, these objects where approached slowly and carefully inspected. Investigation of covers could allow arvicoline rodents to discover and avoid the pitfall traps. Many arvicoline rodents, such as meadow voles, occur in open grasslands where the addition of novel objects would be more conspicuous (Grant 1971). Additionally, shadows cast from greater ambient and lunar light, within these habitats, may make traps easier to detect. My pitfall covers were made from black plastic; the use of a clear material may help eliminate this bias if visual cues are deterring vole captures in traps with covers.

Many studies have established species-specific trap biases among trap types and that these biases must be considered when conducting species specific and community trapping (Williams and Braun 1983, Kalko and Handley 1993, Dizney et al. 2008). Nonetheless, understanding the extent to which these biases affect overall community metrics and comparisons among studies is important. Often, small mammal community composition is quantified using values of species richness or indices of diversity (Caro 2001, Sullivan and

Sullivan 2001, Constantine et al. 2004). My study highlights the importance of using more than one trap type when sampling small mammals at the community level, regardless of the habitat sampled. I found that in all 5 habitats, richness values calculated from Sherman traps and pitfall traps were similar, but using both in combination gave a significantly larger value. I also found that diversity calculated from Sherman traps and pitfall traps was similar for 3 habitats, but was significantly greater when using these traps in concert. Consequently, using only one trap type to sample a small-mammal community may yield different results when comparing small mammal communities among habitats or studies, i.e. significant differences in estimates of richness and diversity may be detected simply as an artifact of trap efficacy. It is well documented that pitfall traps capture more shrews; however, I found that pitfall traps also captured more voles and jumping mice. Moreover, these species often predominate small mammal communities (Healy and Brooks 1988, McComb et al. 1993, Anthony et al. 2003). Often pitfall traps are not used in small mammal community studies or are used at extremely low densities. It is likely that studies of small mammal community ecology that sample in habitats similar to the types I trapped in and that do not use pitfall traps, are missing or underrepresenting a significant portion of the community that are rarely captured in Sherman traps. Subsequently, this may lead to conclusions that are incomplete at best and possibly erroneous.

I deployed pitfall traps at half the density of Sherman traps, yet I was still able to detect significant differences when calculating these community metrics. The ability of pitfall traps to capture more than one animal during a trap check may be one reason that pitfall traps are viewed as more efficient than Sherman traps (Williams and Braun 1983). This is important when considering the extra effort of setting pitfall traps, which can be substantial in

areas with heavy or rocky soil, and coupled with limitations in time and labor, may ultimately limit equal trap effort between these 2 trap types. Understanding species specific trap bias and how it relates to calculations of community composition can be used to determine the optimal trap ratio.

Results from my study concur with others that animals are more likely to be captured on nights with rain (Gentry et al. 1966, Bury and Corn 1987, Umetsu et al. 2006). For mark-recapture studies, consideration of increased capture rates should be tempered by the realization that mortality also increases from hypothermia or drowning during rainy nights (Strombgren 2006). I found that shrew mortality was universally high, regardless of trap type or whether a rain event occurred. This mortality is likely a consequence of their high metabolic requirements (Morrison et al. 1957), and may be reduced by increasing food availability and the frequency of trap checks (Buckner 1957, Hawes 1977, Strombgren 2006). Provisioning pitfall traps with meal worms or some other type of high protein food source may have helped reduce mortality. I found no difference in mortality rates between rainy and non-rainy nights for Sherman trap captures of either arvicoline rodents or *Peromyscus* spp., indicating that this type of trap may be especially useful in mark recapture studies. For uncovered pitfall traps, I observed an increase in mortality on rainy nights by 43% for arvicoline rodents and 48% for *Peromyscus* spp. Pitfall trap covers were not effective at significantly reducing arvicoline rodent mortality on rainy nights, but covers did significantly reduce mortality of *Peromyscus* spp. by 44%. Covers also significantly reduced *Peromyscus* spp. mortality on trap checks without rain by 8%. Discrepancy in cover efficacy among groups was likely caused by differences in life history traits and ability to thermoregulate, where *Peromyscus* spp. are better able to cope with unfavorable conditions (Morrison and

Ryser 1959). Condensation or small amounts of precipitation often caused complete saturation of the pelage in arvicoline rodents and frequently caused death. For these instances, placing a sponge, leaf litter, or nesting material in the bottom of pitfall traps may help animals stay dry and further increase the utility of pitfall traps in mark recapture studies. Flooding, especially in wet communities, was also a serious problem and having an absorbent material in the bottom of the pitfall trap would be insufficient to prevent drowning (Strombgren 2006). Placing Styrofoam, or other buoyant material, in the pitfall may act as a 'life raft' and help reduce mortality when flooding occurs (Dick Bautz, personal communication). It is important to note that covered pitfall traps were not effective at significantly reducing mortality of species most commonly captured in pitfall traps.

One of the goals of small mammal community studies is to accurately determine the number of species and their relative abundance in an area. To quantify these, estimates of richness and diversity are often used. However, use of different trap types may confound estimates and comparisons within and among studies. My results indicate that Sherman traps and pitfall traps complement each other in the species that they capture and must be used together to sample effectively small mammal community assemblages, regardless of the habitat. Although it is often impossible to know the true value of species richness and diversity, capturing more species at a location gives estimates that are closer to true species richness and likely diversity. Furthermore, it may not be necessary to have an equal number of Sherman traps and pitfall traps to increase richness and diversity index measures. The use of transects of Sherman traps, with interspersed 10 L pitfall traps, may be a way to optimize captures, yet reduce the labor involved with installation of pitfalls.

For some species, Sherman traps and pitfall traps captured different sex ratios and body mass estimates of rodent species. This may be a function of trap type or trap density and should be taken into consideration when choosing a trap to study the demographics of small mammals. Pitfall covers were effective at reducing mortality of *Peromyscus* spp. during rain events, but not for species most commonly captured in pitfall traps. Pitfall covers may also reduce captures for arvicoline rodents. More research is needed to fully assess the utility of pitfall covers.

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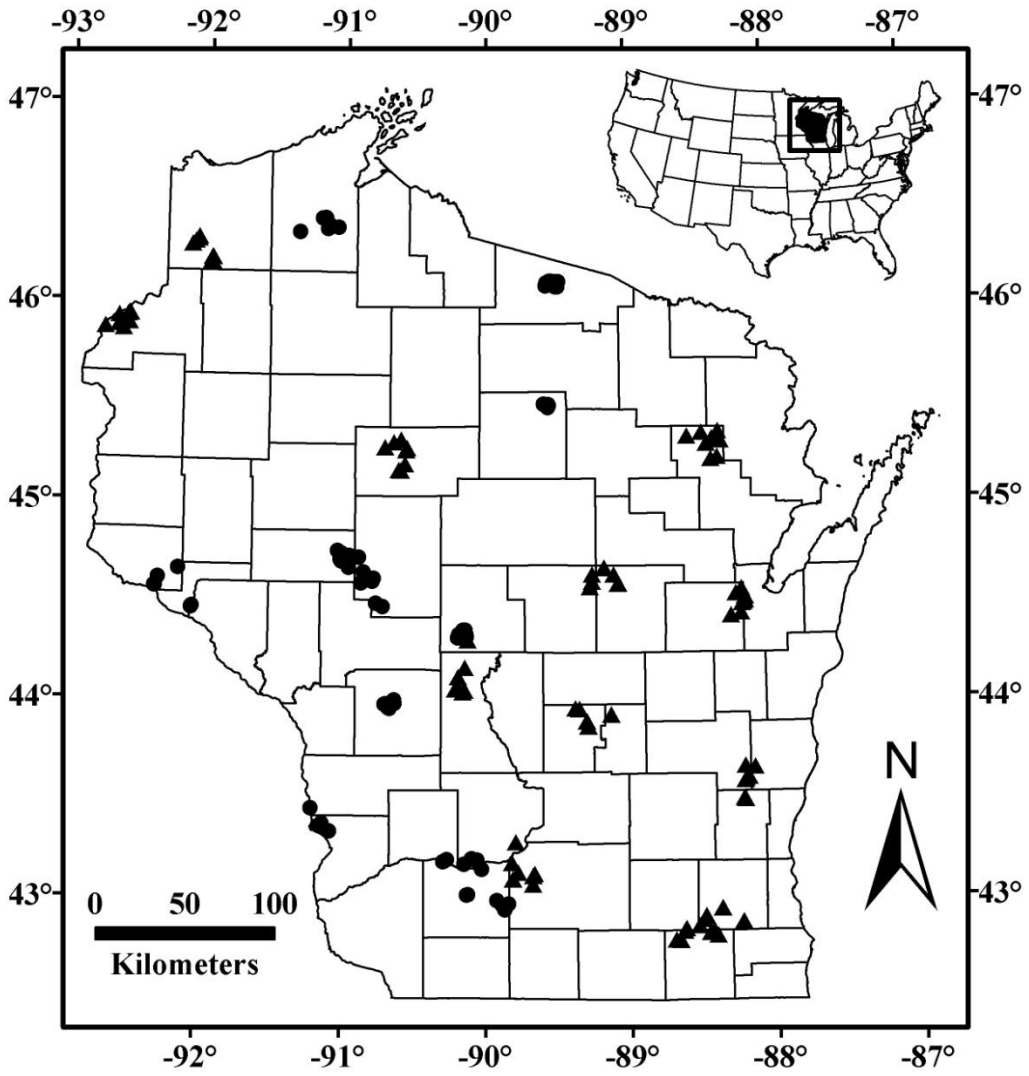


Figure 1. Map of Wisconsin depicting locations of small mammal trapping transects for 2009 (circle) and 2010 (triangle).

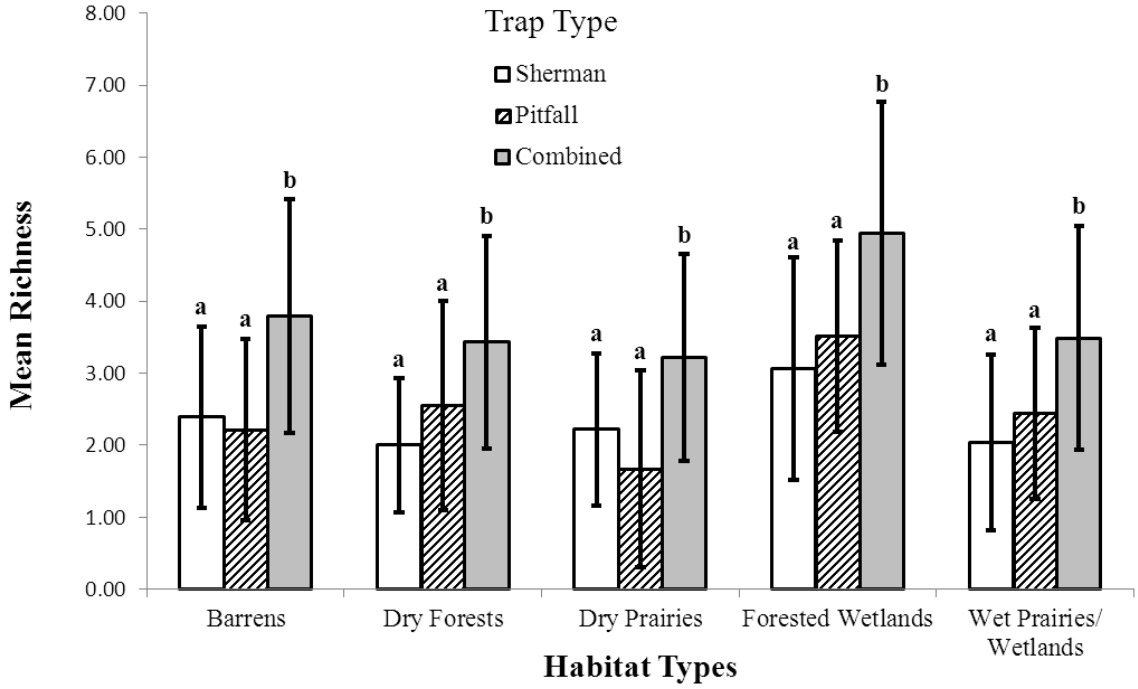


Figure 2. Mean (±SD) species richness of small mammals captured by Sherman traps, pitfall traps, and a combination of both trap types in 5 Wisconsin habitats. Within each habitat, trap types sharing a common letter were not significantly different ($P \leq 0.05$) as indicated by Bonferroni-corrected post hoc tests.

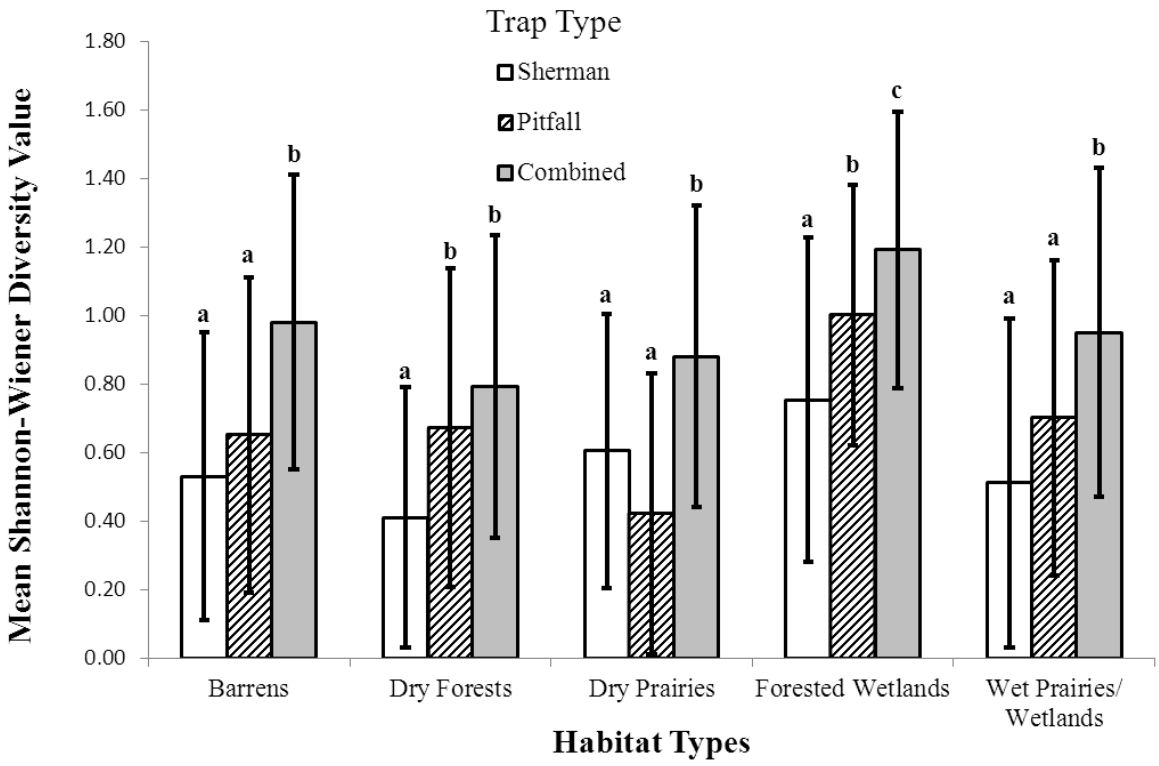


Figure 3. Mean (±SD) Shannon-Wiener diversity index values of small mammals captured by Sherman traps, pitfall traps, and a combination of both trap types in 5 Wisconsin habitats. Within each habitat, trap types sharing a common letter were not significantly different ($P \leq 0.05$) as indicated by Bonferroni-corrected post hoc tests.

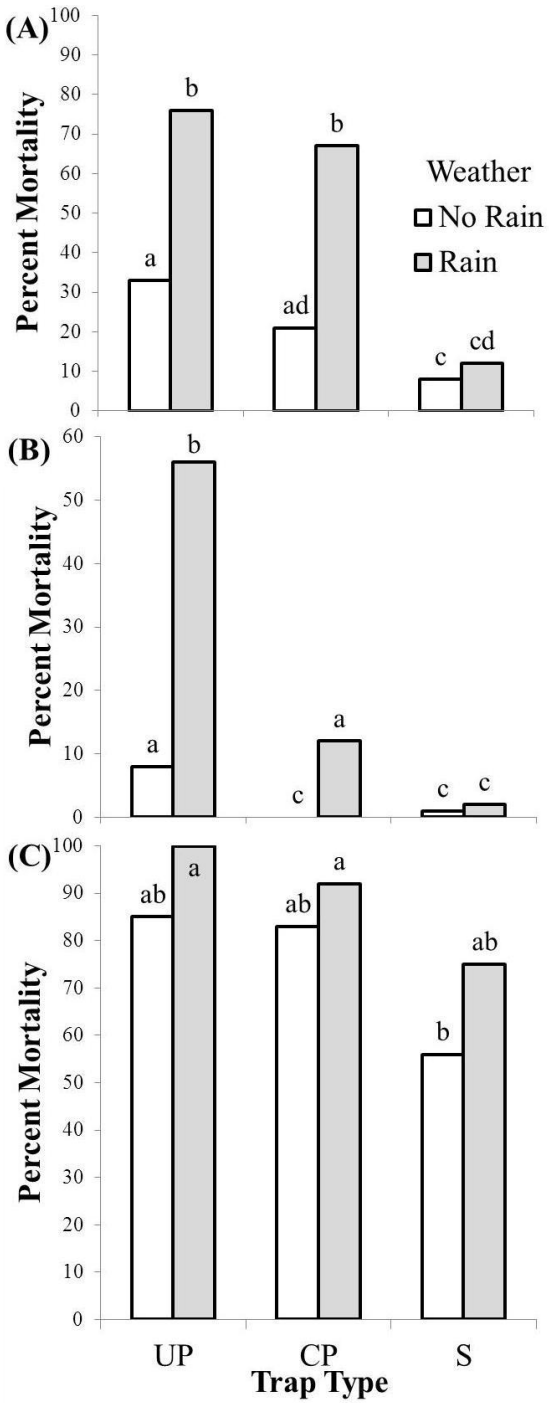


Figure 4. Arvicoline rodents (A), *Peromyscus* spp. (B), and shrew (C) mortality for uncovered pitfall traps (UP), covered pitfall traps (CP), and Sherman traps (S) following periods with and without rain. Trap types sharing a common letter were not significantly different ($P \leq 0.05$) as indicated by a chi-square test of independence.

Table 1. Results of a paired sample t-test comparing individuals captured in Sherman traps paired with a pitfall trap (Paired) and individuals captured in Sherman traps without pitfall traps (Un-paired).

Species	Paired	Un-paired	df	t -value	*P* -value
Blarina brevicauda	1.21	1.59	33	-1.888	0.068
Microtus pennsylvanicus	1.89	1.39	55	1.412	0.163
Myodes gapperi	3.94	4.35	48	-1.117	0.269
Peromyscus leucopus	7.50	6.68	119	2.330	0.021
Peromyscus maniculatus gracilis	2.92	3.88	23	-1.786	0.087
Ictidomys tridecemlineatus	2.18	1.82	21	0.879	0.389
Tamias striatus	1.46	1.50	27	-0.138	0.892

Table 2. Number of individual small mammals captured in 2009-2010 and associated catch per 100 trap nights (CPU), adjusted for tripped or disabled traps. Differences in probability of capture are the multiplicative increase in capture in one trap type versus another (Sherman trap advantage is bold-faced, pitfall trap advantage is not). All differences in probability were significant at $P<0.05$ as indicated by chi-square goodness of fit test.

	Number of Individuals Captured		Sherman Live Trap		Pitfall Trap		Differences in probability of capture
Species	2009	2010	Captures	CPU	Captures	CPU	
Peromyscus leucopus	**436**	**757**	**1004**	**4.443**	**189**	**1.624**	**2.74**
Myodes gapperi	91	359	262	1.159	188	1.616	1.4
Sorex cinereus	179	267	28	0.124	418	3.592	29.0
Microtus pennsylvanicus	167	173	166	0.735	174	1.495	2.0
Blarina brevicauda	167	59	96	0.425	130	1.117	2.6
Peromyscus maniculatus gracilis*	**26**	**96**	**104**	**0.460**	**18**	**0.155**	**3.0**
Zapus hudsonius	32	53	24	0.106	61	0.524	4.9
Sorex arcticus	31	50	11	0.049	70	0.602	12.3
Ictidomys tridecemlineatus	**47**	**25**	**70**	**0.310**	**2**	**0.017**	**18.0**
Tamias striatus	**12**	**49**	**57**	**0.252**	**4**	**0.034**	**7.3**
Sorex hoyi	13	30	2	0.009	41	0.352	39.8
Synaptomys cooperi	11	28	7	0.031	32	0.275	8.9
Glaucomys volans	8	18	26	0.115	0	0.000	
*Peromyscus maniculatus bairdii**	20	5	24	0.106	1	0.009	
Microtus ochrogaster	15	1	15	0.066	1	0.009	
Mustela ermine	2	14	16	0.071	0	0.000	

Table 2. Continued.

Species	Number of Individuals Captured		Sherman Live Trap		Pitfall Trap		Differences in probability of capture
	2009	2010	Captures	CPU	Captures	CPU	
Condylura cristata	3	4	1	0.004	6	0.052	
Tamiasciurus hudsonicus	2	4	6	0.027	0	0.000	
Glaucomys sabrinus	2	0	2	0.009	0	0.000	
Sorex palustris	0	2	1	0.004	1	0.009	
Mustela frenata	0	1	1	0.004	0	0.000	
Reithrodontomys megalotis	0	1	0	0.000	1	0.009	
Sylvilagus floridanus	0	1	1	0.004	0	0.000	

* The woodland form of the deer mouse (*Peromyscus maniculatus gracilis*) and the prairie form (*P. m. bairdii*) are listed separately because of marked difference in morphology and habitat preferences.

Table 3. Number of individuals with ≥ 4 captures in each trap type during nocturnal and diurnal checks in Wisconsin during the summers of 2009 and 2010.

	Nocturnal Captures		Diurnal Captures		Chi-square test	
Species	Sherman	Pitfall	Sherman	Pitfall	Chi-square	*P*
Blarina brevicauda	87	126	9	4	4.04	0.044
Microtus pennsylvanicus	128	148	38	26	3.51	0.060
Myodes gapperi	206	176	56	12	19.17	<0.001
Sorex cinereus	22	376	6	42	3.54	0.060

Table 4. Mean weight of small mammal species captured in Sherman traps and pitfall traps. An asterisk (*) indicates species with a significant difference in weight ($P \leq 0.05$, Mann-Whitney U test).

	Sherman			Pitfall			Mann-Whitney test	
Species	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD	U	*P*
Blarina brevicauda	21	18.16	2.79	36	18.63	3.30	342.0	0.549
Microtus pennsylvanicus	77	27.5	11.05	95	30.71	12.51	3111.0	0.092
Myodes gapperi	208	18.43	5.33	148	19.81	6.30	13509.0	0.049
Peromyscus leucopus	620	21.13	5.51	133	18.64	6.74	40332.0	<0.001
Peromyscus maniculatus gracilis	80	17.78	4.12	96	17.31	3.98	628.0	0.906
Sorex cinereus	16	3.78	0.55	200	3.91	2.00	1540.5	0.803
Zapus hudsonius	14	16.29	2.67	39	16.39	3.57	263.5	0.847

Table 5. Results of one way repeated measures analysis of variance for richness and Shannon-Wiener diversity of small mammal captures among 3 trap types (Sherman traps, pitfall traps, and a combination of both trap types) within habitats of Wisconsin. An asterisk (*) indicates $P \leq 0.05$.)

		Richness			Shannon-Wiener Diversity		
Habitat	*n*	*d.f.*	*F*	*P*	*d.f.*	*F*	*P*
Barrens	28	1.56, 42.13	22.14	<0.001*	1.43, 38.51	14.79	<0.001*
Dry Forest	40	1.31, 51.26	24.66	<0.001*	1.40, 54.75	13.03	<0.001*
Dry Prairie	18	1.32, 22.48	16.56	<0.001*	1.43, 24.39	14.19	<0.001*
Forested Wetlands	49	1.50, 71.75	51.90	<0.001*	1.23, 58.79	30.85	<0.001*
Wet Prairie/Wetlands	39	1.67, 63.59	33.02	<0.001*	1.44, 54.88	19.72	<0.001*

CHAPTER II:

FIELD IDENTIFICATION OF *PEROMYSCUS LEUCOPUS NOVEBORACENSIS* AND *P. MANICULATUS GRACILIS* IN WISCONSIN FROM EXTERNAL MEASUREMENTS

ABSTRACT

In Wisconsin, white-footed mice (*Peromyscus leucopus noveboracensis*) and woodland deer mice (*P. maniculatus gracilis*) are difficult to distinguish. Recent climatic trends have facilitated encroachment of *P. leucopus* north into the range of *P. maniculatus,* making unambiguous species identification imperative. Cranial and external measurements have been used previously to differentiate these species. However, since large geographic morphological variation occurs and most previous studies used measurements from deceased specimens, definitive morphological measurements need to be identified that can quickly and effectively classify live Wisconsin *Peromyscus* spp. in the field. I live trapped *Peromyscus* spp. in central and northern Wisconsin during the summer of 2010. I measured ear, tail, hindfoot, and weight from live animals and collected tissue for genetic confirmation. In addition to using mDNA analysis to identify samples to species, I collected measurements from 84 *P. maniculatus* and 293 *P. leucopus* in 6 Wisconsin counties. I used discriminate function analysis (DFA) to develop equations to identify characteristics that best separated mice to species. By using ear length alone, 97.9% of the samples could be correctly classified with most *P. leucopus* <17mm and most *P. maniculatus* ≥ 17mm. By adding weight to

the function, I was able to achieve 99.2% classification accuracy and with the addition of tail was able to achieve 99.5% differentiation.

INTRODUCTION

The woodland form of the deer mouse (*Peromyscus maniculatus gracilis*) and white-footed mouse (*P. leucopus noveboracensis*) are sympatric in the Great Lakes and Appalachian regions of the United States. Ecologically, these species can occupy similar habitats, have similar niche requirements, and closely resemble each other in morphological appearance (Wolf 1985, Long 1996). A number of external characteristics such as pelage color, degree of caudal hair pencilation, and bicoloration of the tail can assist identification of *P. maniculatus* and *P. leucopus* (Choate 1973, Long and Long 1993, Finnell 2000). However, subjectivity and intraspecific variation makes these characteristics unreliable for definitive identification (Feldhamer et al. 1983, Rich et al. 1996). To circumvent these shortcomings, a number of studies have attempted to define morphological characteristics to differentiate between *P. maniculatus* and *P. leucopus* (Stromberg 1979, Feldhamer et al.1983, Kamler et al.1998, Reed et al. 2004). These studies often use external measurements taken from dead animals (Feldhamer et al. 1983, Sternburg, and Feldhamer 1997, Reed et al. 2004), and therefore may not reflect accurately measurements from live animals (Bruseo et al. 1999). Cranial characteristics alone, or in conjunction with external measurements, have also been used (Rich et al. 1996, Long and Long 1993, Sternburg, and Feldhamer 1997, Reed et al. 2004), but these require the sacrifice of animals (Lindquist et al. 2003). Additionally, given geographic morphological variation of *P. maniculatus* and *P. leucopus* (Palas 1992, Tolliver et al. 1987, Sternburg, and Feldhamer 1997), studies using morphological characteristics often

only apply to small geographical regions or are only applicable to one subspecies (Bruseo et al. 1999).

Electrophoresis of salivary amylase has proved effective for unequivocal distinction of *P. maniculatus* from *P. leucopus* (Aquadro and Patton 1980, Bruseo et al. 1999); however, insufficient salivary sequestration or degradation can severely reduce its utility (Sternburg and Feldhamer 1997, Lindquist et al. 2003). Differentiation using molecular markers also gives unambiguous distinction among *Peromyscus* species. Nevertheless, both these procedures require specialized equipment and must be performed in a lab, which can be expensive for large sample sizes (Sternburg and Feldhamer 1997, Reed et al. 2004). Furthermore, these procedures are time consuming and are not practical for field studies which may require rapid species determination, i.e. in removal studies in which one species is removed and the other retained (Bruseo et al. 1999).

Currently, *P. leucopus* is expanding its range northward in Wisconsin and Michigan, ostensibly due in part to recent climatic changes (Long 1996, Myers et al. 2009). Moreover, *P. leucopus* may be replacing *P. maniculatus* within habitats formerly occupied only by *P. maniculatus* (Long 1996). Range extensions of *P. leucopus* and concomitant declines of *P. maniculatus* have been noted in Michigan (Myers et al. 2009) and anecdotally in Wisconsin (Long 1996). Where the species are sympatric, the need to understand this trend is crucial and much information is lost when researchers forgo species identification during ecological studies because of researcher uncertainty in identification (Evrard 1998, Chapman and Ribic 2002, Kaminski et al. 2007). To my knowledge, there has only been one study conducted on morphological characteristics of

P. maniculatus gracilis and *P. leucopus noveboracensis* in Wisconsin (Long and Long 2003). The results are difficult to use in the field since external measurements were taken from dead animals and cranial characteristics were extensively used (Long and Long 2003). Additionally, relatively few animals were used and genetic testing was not used to confirm species identification, creating a situation where metrics used to identify species *a priori* were also used in the analysis. The objective of my study was to determine external measurements that could be taken in the field to distinguish live *P. maniculatus gracilis* and *P. leucopus noveboracensis* in Wisconsin, irrespective of demographics.

METHODS

Field methods - As part of a larger study of ecological communities and trap efficacy for Wisconsin small mammals, *P. maniculatus gracilis* and *P. leucopus noveboracensis* were live trapped throughout northern Wisconsin in the summer of 2010. I used 190 m transects of 20 Sherman live traps and 10 pitfall traps placed in natural plant communities. Natural communities ranged from wetland to upland forest within Burnett, Douglas, Oconto, Portage, Taylor, and Waupaca Counties. I trapped each transect for 4 consecutive days and checked traps in the morning and evening.

I only included first capture live *Peromyscus* for the purpose of this study. I performed all measurements of tail length (sacrum to caudal tip, excluding hairs), right hindfoot length (calcaneus to longest claw), and right ear length (basal notch to tip, excluding hairs) using a flexible clear plastic ruler to the nearest mm. Weight was taken using a pull scale to the nearest gram (weight of animal in clear plastic bag, tared for bag weight). Total length was not taken because of the variability of this measurement on

live animals. I also collected tissue samples using a small ear biopsy taken during the marking process. Tissues were placed in individually marked vials filled with 70% ethanol. My trapping and tissue sampling protocol was approved by the University of Wisconsin Stevens Point Institutional Animal Care and Use Committee and followed guidelines outlined by the American Society of Mammalogists (Sikes et al. 2011).

Lab methods – DNA was extracted from ear tissue samples using QIAamp® DNA Mini Kit TissueProtocol (QIAGEN Inc., Valencia, CA) within a research molecular laboratory setting. Manufacturer's recommendations were followed except that samples were incubated overnight at 56°C in buffered ATL and proteinase K. A polymerase chain reaction (PCR) was used to amplify a 358 base pair product from mitochondrial *cytochrome b* with primers BM1 and BM2 (Boakye et al. 1999, Lee et al. 2002, Meece et al. 2005) using the HotStarTaq Master mix kit (QIAGEN) according to manufacturer recommendations. The PCR product then underwent restriction fragment length polymorphism (RFLP) analysis using restriction enzyme *Hae*III. *Hae*III cut amplified PCR products from *P. leucopus* into fragments but did not cut *P. maniculatus* products. Digested PCR products were sized by gel electrophoresis on 2.0% LE agarose gel stained with ethidium bromide and identified to species.

Analysis – I used a two-tailed student's t-test to determine if measurements differed between males and females for both *P. maniculatus* and *P. leucopus*. I found no indication of sexual dimorphism for any measurements of either species, as noted by other authors (Long and Long 1993, Kamler et al. 1998), and subsequently grouped sexes for analyses. I also chose to pool juveniles, sub-adults, and adults in order to better characterize measurements useful for distinguishing all cohorts of a population. I used a

two-tailed student's t-test to compare univariate measurements between species and used correlation matrices to test for collinearity of variables. I visually inspected univariate measurements for normality using histograms and used Box's M statistic to test for homogeneity of variance-covariance matrices using alpha = 0.05 (McGarigal et al. 2000). I used discriminant function analysis (DFA) to develop equations useful in distinguishing between the two species. I used leave-one-out classification for validation, in which each case is independently left out and is classified by the functions derived from all other cases. All statistical analyses were performed in PSAW Statistics version 18 (IBM SPSS Statistics, Chicago, Illinois).

RESULTS

I collected live animal measurements and tissue from 381 individuals. Based on RFLP of the *cytochrome b*, 84 individuals were identified as *P. maniculatus*, 293 as *P. leucopus*, and 4 as unknowns. *Peromyscus maniculatus* and *P. leucopus*, respectively, were captured in the following Wisconsin counties: Burnett (14, 68), Douglas (2, 2), Oconto (36, 120), Portage (0, 15), Taylor (31, 22), and Waupaca (0, 62). All external measurements were significantly different between *P. maniculatus gracilis* and *P. leucopus noveboracensis*, with *P. maniculatus* having a longer tail, ear, and hindfoot, but lighter in overall weight than *P. leucopus* (Table 1). I noted a high degree of intraspecific variation for both species and no single univariate measurement unambiguously differentiated between the species (Table 1). Hindfoot length had the highest degree of overlap with both species having a range from 18 to 22mm. Ear length proved to be the most useful univariate measurement for differentiating the species, with most *P. leucopus* having ear lengths <17 mm and most *P. maniculatus* having ear lengths ≥17mm. The

exceptions were 1 *P. leucopus* with an ear equal to 17mm and 7 *P. maniculatus* with ears equal to16mm. Six of these 7 *P. maniculatus* had weights ≤ 13g and 1 was only 7g, suggesting that nearly all of these animals were juveniles (Dice and Bradley 1942). When DFA was performed on ear length alone, I was able to achieve 97.9% classification accuracy and 97.7% cross-validation accuracy (eigenvalue of 2.81, canonical correlation of 0.86, Wilk's λ was 0.262, and $P < 0.001$). This function misclassified the aforementioned 1 *P. leucopus* and 7 *P. maniculatus*.

I developed three additional discriminant functions for differentiating between *P. leucopus* with *P. maniculatus*. Based on residual assessment, all measurements were relatively normally distributed. None of the variables were highly correlated with most pairwise comparisons <0.42. Tail and ear had the highest correlation of 0.61. The Box's M statistic indicated that homogeneity of variance-covariance matrices were not met for either function 3 or 4 (Box's M = 16.614, $P = 0.001$; Box's M = 28.019, $P < 0.001$, respectively); however, this test is extremely sensitive and based on my large sample size was likely not an issue (Tabachnick and Fidell 1989). Homogeneity of variance-covariance was met for function 2 (Box's M =7.474, $P= 0.06$).

I did not use hindfoot length in any function given its high rate of intraspecific variation and interspecific overlap. Function 2 used ear length and tail length, function 3 used ear length and weight, and function 4 used ear length, tail length, and weight (Table 2). Ear length was the best predictor in all functions as indicated by the standardized canonical discriminant function coefficients (Table 2). Function 2 was significant with an eigenvalue of 2.84, canonical correlation of 0.86, Wilk's λ of 0.261, and $P < 0.001$. This function achieved no additional classification accuracy above that achieved by ear

length alone. Function 3 had an eigenvalue of 3.69, canonical correlation of 0.89, Wilk's λ of 0.213, and P <0.001. I was able to raise classification accuracy to 99.2% and 99.2% cross-validation accuracy. Cross validation showed that 2 *P. leucopus* and 1 *P. maniculatus* were misclassified. Function 4 was statistically significant with an eigenvalue of 4.43, canonical correlation of 0.90, Wilk's λ of 0.184, and P <0.001. This function achieved a classification accuracy of 99.7% and 99.5% cross validation accuracy. Cross validation showed that 2 *P. leucopus* were classified incorrectly and all *P. maniculatus* were correctly classified. The standardized and unstandardized discriminant function coefficients for all functions can be found in Table 2.

DISCUSSION

Although all univariate measurements were statistically different between *P. maniculatus gracilis* and *P. leucopus noveboracensis*, none explicitly distinguished between them. Range of hindfoot length was identical in both species and tail length and weight overlapped substantially. Finnell (2000) noted the same trends in *Peromyscus* spp. from northern Wisconsin and Upper Michigan, with considerable overlap, but significant differences in tail length, hindfoot length, and ear length. Of these 3 measures, hindfoot showed the greatest overlap (Finnell 2000). Despite overlap of ear length, I found that it alone could distinguish 97.9% of *Peromyscus* samples and was the most useful univariate measurement in identifying the species, as also found by Long and Long (2003). Ear length was better at distinguishing *P. leucopus*, but misclassified several young *P. maniculatus*. Nevertheless, it is interesting to note that ears from young *P. maniculatus*, even those of 7g, were well developed, demonstrating that this measurement may be useful on animals shortly after weaning. Dice and Bradley (1942) noted that in *P.*

maniculatus, growth of the ear began to plateau even before weaning occurred. Thus, using ear alone may be useful for grossly separating *P. leucopus* from *P. maniculatus*; animals with ears <16mm belonging to *P. leucopus*, animals with an ear >16mm likely belonging to *P. maniculatus*, and animals with an ear length of 16mm possibly belonging to either species. While Long and Long (1993) commented that the ear length is often "slightly made in error," I feel that well-trained persons can accurately measure ear length on live mice. Nonetheless, I caution against use of measurements from naïve field technicians as evidence from Lindquist et al. (2003) suggests that inexperience can lead to greater variation for this measurement.

Many DFA functions exclude juvenile animals from analysis (Feldhamer et al. 1983, Long and Long 1993, Kamler et al. 1998); however, I concur with others (Rich et al. 1996, Bruseo et al. 1999, Lindquist et al. 2003) that creating a function for the entire population is much more practical for field applications. Therefore, I created 3 additional functions to discriminate between *P. leucopus* and *P. maniculatus* using both sexes and all age classes. Moreover, some females were pregnant or lactating at the time that measurements were taken. Thus, I feel that my sample reflects actual *Peromyscus* spp. population demographics encountered in northern Wisconsin during the summer months.

Function 2, using ear length and tail length, gave no additional classification accuracy above that of using ear alone. Mice are often captured with tails damaged from the trap or naturally docked, further limiting use of this function for distinguishing individuals with damaged tails. Function 3 used ear length and weight and differentiated 99.2% of individuals. Adding weight to the function helped separate young *P. maniculatus* with ear lengths of 16mm, which ear length alone could not discern.

Function 4 used tail length, ear length, and weight and had 99.5% cross validation accuracy. Bruseo et al. (1999) found that these measurements appeared in their best DFA models for distinguishing between these species. Long and Long (1993) also found ear and tail to be the most useful external measurements, although weights were not available. Based on the slight increase in classification accuracy (0.3%) by adding tail length to the function, it is likely that ear length and weight produce an adequate degree of classification accuracy. Equations derived from the unstandardized coefficient from Table 2 can be used to distinguish animals captured and measured in the field.

With documentation that *P. maniculatus gracilis* is declining in the Great Lakes region (Long 2009, Myer et al. 2009), it is imperative that field researchers distinguish this species from *P. leucopus noveboracensis*. Because research budgets are often small and genetic testing for large samples is cost prohibitive, I believe that external measurements from live animals offer a satisfactory alternative for identification of live *P. maniculatus gracilis* and *P. leucopus noveboracensis* in northern Wisconsin, provided an experienced researcher is executing them. Even if electrophoresis of salivary amylase or genetic testing will be used to ultimately confirm identification, the few minutes required to take external measurements will provide a substantial failsafe in the event that tissue samples are lost or fail to produce unequivocal identification.

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Table 1. Mean, standard deviation, range, and results of a t-test comparing univariate external measurements of live *Peromyscus leucopus* and *P. maniculatus* from central and northern Wisconsin, 2010.

	P. maniculatus (*n* = 84)*			*P. leucopus* (*n* = 293)*			*t*	*df*	*P*-Value
	$\overline{X}$	SD	range	$\overline{X}$	SD	range			
Tail	87.1	6.8	66 - 103	74.8	5.8	56 - 92	-16.35	373	<0.001
Hindfoot	20.6	0.7	18 - 22	20.3	0.8	18 - 22	-2.74	375	0.006
Ear	17.9	1.0	16 - 20	14.4	0.8	12 - 17	-32.47	375	<0.001
Weight	17.4	3.9	7 - 27	19.8	4.7	9 - 33	4.70	375	<0.001

**Peromyscus leucopus* and *P. maniculatus* had sample sizes 292 and 83, respectively, for the tail measurement because of bobbed tails.

Table 2. Standardized and unstandardized coefficients calculated from discriminant function analyses of external measurements of live *Peromyscus leucopus* and *P. maniculatus* from central and northern Wisconsin, 2010. Equations based on unstandardized coefficients; *P. leucopus* < 0 < *P. maniculatus* †.

Variables	Standardized Coefficient	Unstandardized Coefficient*
Function 1		
Ear	1.000	1.177
Constant		-20.008
Function 2		
Ear	0.933	1.099
Tail	0.151	0.250
Constant		-20.902
Function 3		
Ear	1.076	1.267
Weight	-0.529	-0.117
Constant		-19.572
Function 4		
Ear	0.883	1.040
Tail	0.543	0.090
Weight	-0.775	-0.172
Constant		-22.333

*Cutoffs for unstandardized coefficients of functions 1-4 were standardized to 0 by subtracting 2.110, 2.255, 2.553, and 2.819 to constants, respectively.

† Equation for function 2 = -20.902 + (1.099)(ear length) + 0.250(tail length)

Equation for function 3 = -19.572 + (1.267)(ear length) – 0.117(weight)

Equation for function 4 = -22.333 + (1.040)(ear length) + (0.090)(tail length) – (0.172)(weight)

CHAPTER III:

REVISED DISTRIBUTION OF THE ARCTIC SHREW (*SOREX ARCTICUS*) AND AMERICAN WATER SHREW (*SOREX PALUSTRIS*) IN WISCONSIN

ABSTRACT

The arctic shrew (*Sorex arcticus*) and American water shrew (*S. palustris*) are wide-spread boreal species. *Sorex arcticus* reaches its southern distribution in Wisconsin and within the Midwest *S. palustris* also reaches its southern range extent in Wisconsin. Although the ranges of both species are generally thought to occur in the Driftless Area in the southwestern portion of Wisconsin, no occurrences have been documented from the region. Within the past decade and half, the known distribution of these species has changed dramatically. I used museum records and geo-referenced surveys to remap the known distribution of *S. arcticus* and *S. palustris* in Wisconsin. Herein, I report records of *S. arcticus* and *S. palustris* in the Driftless Area and extend the distribution of *S. arcticus* and *S. palustris* south of their former range, including the most southerly extant record of *S. arcticus*. This study emphasizes the continued value of voucher specimens and museum collections.

INTRODUCTION

A thorough understanding of a species distribution is imperative, not only for studying temporal biogeography, but also for answering ecological, evolutionary, taxonomic, and policy questions. However, identifying the distributional limits of a species may be difficult because of rarity, mis-identification, and inability to capture or observe individuals. The arctic shrew (*Sorex arcticus*) and American water shrew (*Sorex*

palustris) are 2 species that exemplify many of these problems. Both *S. arcticus* and *S. palustris* reach their southern distributional limits in Wisconsin, yet little work has been devoted to determining their distribution in the Midwest.

The arctic shrew (*Sorex arcticus*) ranges extensively throughout Canada, from the southern Yukon Territory to Quebec, with the putative subspecies *S. a. maritimensis* from New Brunswick and Nova Scotia recently elevated to full species designation (*Sorex maritimensis*) (Stewart et al. 2002). *Sorex arcticus* reaches its southern boundary in the United States in Montana, South Dakota, Michigan, and Wisconsin (Kirkland and Schmidt 1996, Perry et al. 2004). Within Wisconsin, *S. arcticus* occurs throughout the northern portion of the state and as far south as Dane and Dodge Counties (Clough 1960, Nelson 1934), with one specimen recently collected in Waukesha County (Anthony et al. 2003). *Sorex arcticus* primarily occurs at low densities, but may be common in mesic to wetland habitats (Clough 1963, Buckner 1966) and is rarely found in xeric sites (Wrigley et al. 1979), but see Salt (2005).

The American water shrew (*Sorex palustris*) ranges throughout much of Canada, from the southern Yukon Territory to Newfoundland and Nova Scotia (Beneski and Stinson 1987). Within the United States, *S. palustris* is found in southern Alaska and reaches its southern distribution in the West in higher elevations in New Mexico, centrally in Minnesota and Wisconsin, and occurs throughout the Appalachian Mountains to Tennessee (Beneski and Stinson 1987). In Wisconsin, *S. palustris* inhabits the northern portion of the state and ranges as far south as Portage County, with anecdotal accounts in Buena Vista Marsh (C. Long; personal communication). *Sorex palustris* is

generally considered rare and occurs near open water and in wetland habitats (Bailey 1929, Hopper 1942, Conaway 1952, Nagorsen and Peterson1981).

Although *S. arcticus* has been documented in the Minnesota Driftless Area (Jannett and Huber 1994) and fossil records of *S. arcticus* and *S. palustris* have been found in the Driftless Area in Wisconsin (Foley 1984), both species are heretofore unknown in published distribution maps from the Wisconsin portion of the Driftless Area (see Fig. 1) (Jackson 1961, Omernik et al. 2000, Long 2008). The status of both species in Wisconsin has changed dramatically during the past decade, with both species ranked in 2002 as S2 (imperiled in WI because of rarity) by the Wisconsin Department of Natural Resources (WDNR) (Anthony et al. 2003, R. Staffen pers. comm.). Since 2002, periodic rank adjustments have ensued and in 2011 *S. arcticus* was designated to a S4 rank (apparently secure in Wisconsin) and *S. palustris* as S3 rank (rare or uncommon in Wisconsin) (R. Staffen pers. comm.). Despite modifications to the Wisconsin status of these species, data have not been published to substantiate these changes. I used historical museum record locations, in conjunction with recent geo-refernced small mammal surveys, to map and update the range of *S. arcticus* and *S. palustris* and assess their ranks within the state of Wisconsin.

METHODS

Information on the distribution of both species was collected from 2 sources, historical museum records and results of small mammal surveys.

Historical records – Geo-referenced museum records of *S. arcticus* and *S. palustris* were acquired from the WDNR (J. Rosenberg, unpublished data). Museum records were obtained by searching accredited museums in MaNIS (Mammal Networked

Information System). Additionally, records from other regional museums with electronic databases, but that were not in MaNIS were also searched. All records were mapped within a geographic information system (GIS). Museum records were searched through April 2012; however, voucher specimens collected during recent surveys were mapped separately (explained below). For the purpose of mapping, redundant locations were deleted, and only the oldest specimen was retained to represent a unique locality. Specimen specific location data ranged from coordinates to features such as lakes or townships. Because of the imprecise nature of many locations, a buffer was added to account for this inaccuracy, with the exception of latitude longitude coordinates. A buffer of 0.4 km was added to addresses, road junctions, rivers, and roads, whereas a buffer of 3.2 km was added to all other locations. Locations described using the public land survey system (PLSS) were mapped to the smallest subdivision and were not buffered. Imprecise location data, such as those with only county designation were excluded. For the purpose of mapping localities in this study, polygons created from the buffers were changed to centroids.

Small mammal surveys - Surveys were conducted from 1998 to 2011, with the majority of sites trapped between 2009 and 2011. Surveys varied in methodology and geographical extent and a brief description of each is provided. From May to September of 1998 and 1999, Chapman (1999) trapped along streamsides' in the southwestern portion of Wisconsin using four 270m transects of 23 large Sherman live traps (7.6 x 8.9 x 23.9 cm; H.B. Sherman Inc., Tallahassee, Florida), 47 small Sherman live traps (5.1 x 6.4 x 16.5 cm; H.B. Sherman Inc., Tallahassee, Florida), and 16 pitfall traps. In 2005, as part of a larger project investigating peatlands in central and northern Wisconsin, small

mammals were trapped biweekly from May 24 to October 5, 2005 using 300m transects of 16 museum special snap traps and 16 pitfall traps (38 cm deep, 20 cm diameter, 10 L, floral cooler buckets, Syndicate Sales, Inc., Kokomo, Indiana) (L. Ayers, unpublished data). Two transects were placed 180 m to 1,050 m apart, one grading from deciduous upland into non-forested peatlands and the other extending from non-forested peatland into forested peatland (L. Ayers, unpublished data). As part of a larger study investigating ecological communities and trap efficacy of Wisconsin small mammals, I trapped throughout the state of Wisconsin during the summers of 2009 and 2010. Sites were trapped for 4 consecutive days using 190 m transects of 20 large Sherman live traps and 10 pitfall traps (38 cm deep, 20 cm diameter, 10 L, floral cooler buckets, Syndicate Sales, Inc., Kokomo, Indiana) placed in homogeneous natural plant communities ranging from wetlands to uplands. From late May through June 2011, I also surveyed small mammals within the Driftless Area and at the intersection of Wood, Marathon, and Portage Counties (Stephens 2011a, b). Survey methods were identical to those used in 2009 and 2010 with the exception that 10 small Sherman live traps were added to each transect. Additionally, I describe a location in Trempealeau County where a specimen of *S. arcticus* was collected by L. Ayers and P. Beringer in 2003. For mapping purposes, survey locations were plotted as the center of transects (Fig. 1).

RESULTS

Museum records and surveys – Museum specimens of Wisconsin *S. arcticus* and *S. palustris* were represented in 11 and 12 institutions, respectively (Table 1). Collection dates ranged from 1906 to 2008 for *S. arcticus* and from 1907 to 1998 for *S. palustris*. A total of 69 and 38 historical sites were represented by voucher specimens of *S. arcticus*

(Fig. 2) and *S. palustris* (Fig. 3), respectively (see Appendix 1). I found records of 330 historical museum voucher specimens of *S. arcticus* and 70 historical museum voucher specimens of *Sorex palustris* (Table 1). During the 4 surveys, 276 locations were trapped (Fig. 1). These survey efforts yielded 66 and 8 locations containing ≥1 *S. arcticus* and *S. palustris*, respectively (see Appendix 2). In total, 265 *S. arcticus* individuals and 10 *S. palustris* individuals were captured during survey efforts (see Appendix 2).

Sorex arcticus – My trapping revealed that *S. arcticus* is more widespread and abundant in southeastern Wisconsin than indicated by the one specimen (UWZM 33,791) collected in Waukesha County by Anthony et al. (2003) (Fig. 2). In addition to collecting 3 specimens from this site, I also collected 3 specimens from Kettle Moraine Low Prairie SNA, a location that had previously yielded no *S. arcticus* (Anthony et al. 2003). One specimen was also collected in Walworth County, representing the most southerly extant record of *S. arcticus* (UWSP 9,441). Within this portion of the state, all specimens were taken in calcareous fen or wet mesic prairie remnants.

When I mapped historical museum records, I discovered that one specimen collected in 1975 (UWSP 3,873), previously overlooked in other published range maps, was captured within the Driftless Area in Jackson County (Fig. 2). Survey efforts by Stephens (2011a) in the east central portion of the Driftless Area yielded 4 locations of *S. arcticus* in Monroe, Jackson, and Trempealeau Counties (Fig. 2). An additional specimen was captured in Trempealeau County in August 2003 by L. Ayers and P. Beringer; however, the specimen was destroyed when a freezer failed (Appendix 2). With the exception of 1 individual, all *S. arcticus* were captured in wet meadows dominated by sedges (*Carex* spp.) and blue joint grass (*Calamagrostis canadensis*). One

specimen was captured in a dry clear-cut forest; however, this site was < 100m from a flooded wetland. Eight specimens were also taken from a tamarack (*Larix laricina*) bog in Buffalo County in the north central region of the Driftless Area (L. Ayers, unpublished data). Despite considerable trapping effort by Stephens (2011a) and Chapman (1999), in the southwestern portion of Wisconsin, including stream sides and wetlands, no specimens of *S. arcticus* were taken (Fig. 1).

Sorex palustris – Survey efforts by Stephens (2011) yielded one *S. palustris* (UWSP 9,473) from Marquette County in a wet meadow of sedges (*Carex* spp.), blue joint grass (*Calamagrostis canadensis*), and various hydrophilic forbs (Fig. 3). This extends the distribution approximately 50 km south of the anecdotal records in southern Portage County and 75 km south of documented voucher specimens within the same longitudinal state plane of Wisconsin. It also represents the most southerly record in the Midwestern United States. Survey efforts by Stephens (2011a) produced two specimens from the Driftless Area in Jackson County, an area heretofore unknown to contain the species. The northerly Jackson County record (UWSP 9,742) was captured in a wet meadow of *Carex* spp. and *C. canadensis,* < 10 m from a small stream and the southerly record (UAF 113,845) was captured near a forested seep in a monoculture of orange jewelweed (*Impatiens capensis*).

DISCUSSION

Sorex arcticus – In the last 15 years, small mammal trapping has more clearly defined the distribution of *S. arcticus* in Wisconsin. I documented new localities within its known distribution, as well as expanded the known distribution to the southeast and southwest. Although little is known about the vagility of *S. arcticus* (Kirkland and

Schmidt 1996), given its close association to wetland communities it is unlikely that this distributional change was caused by immigration. Rather, the discovery in these areas likely has more to do with its difficulty of capture with common live traps. Pitfall traps are over 12 times more effective at capturing *S. arcticus* than Sherman traps (see Chapter 1), explaining why Anthony et al. (2003) may have had low capture success. Anthony et al. (2003) used only 5 pitfall traps per site, compared to 50 box live traps. Furthermore, the saturated nature of wetland sites coupled with seasonal ebb and flow dynamics from precipitation events can compound trapping difficulty (Jannett and Huber 1994). Thus, despite being a wetland specialist in Wisconsin, *S. arcticus* is more widespread and common than was once thought (Jackson 1961, Long 2008). However, more effort is still needed to fully determine its distributional limits in Wisconsin, particularly in southern Monroe and northern Vernon Counties. Indeed, the extralimital record of *S. arcticus* in Minnesota resides within this general latitudinal zone (Jannett and Huber 1994). Additionally, *S. arcticus* may plausibly range farther south into Walworth County and perhaps northeastern Illinois.

Reducing the state status of *S. arcticus* to S4 rank seems logical in light of the number of new localities and specimens captured during the last decade. However, some evidence suggests that encroachment of the exotic reed canary grass (*Phalaris arundinacea*), may negatively affect *S. arcticus* populations (McMillan and Cook 2008). In central Wisconsin, I found *S. arcticus* in habitats dominated by *P. arundinacea* and at comparable abundances to those found in surrounding natural sedge meadows (Stephens 2011b). Although more research is needed to fully address the effects of *P. arundinacea*

on *S. arcticus*, these preliminary findings indicate it may have little effect in some areas of Wisconsin.

Sorex palustris − Recent survey work has extended the distribution of *S. palustris* both south and west into areas heretofore unknown, yet this species is known from only 74 museum records in Wisconsin. *Sorex palustris* generally occurs at low densities and is notoriously difficult to capture, even in areas where known populations exist (Conaway 1952), possibly explaining why relatively few records have been recorded in Wisconsin. Given that this species is also a wetland specialist, recent known range expansions are likely from its rarity and difficulty in capture, causing them to be missed in previous surveys. Further survey work is needed to elucidate whether these captures are from relictual populations representing extralimital occurrences or if the distribution is contiguous with other recorded sites. Although *S. palustris* is generally considered a cold climate boreal species, many of the river valleys in the Driftless area can be considerably cooler than the surrounding uplands (Van Arsdel 1954) and this species may occur much farther south within the Driftless Area, than I documented.

In the Great Lakes region, recent climatic warming has precipitated distributional changes of many species (Myers et al. 2009); nonetheless, although *S. arcticus* and *S. palustris* are boreal species, their ranges do not seem to have contracted. Paradoxically, their known distributions have been expanded south. Further delineation of the distributions of these species will help create baseline data to track changes in response to climate change. Trapping efforts can help determine niche requirements and environmental characteristics bounding the distribution of *S. arcticus* and *S. palustris*. Additionally, coupled with genetic testing, specimens collected from the Driftless Area

may help clarify distributional changes following glaciation events and determine whether these records have persisted since Pleistocene glaciation or are recent invaders (Jannett and Huber 2004).

Finally, this study underscores the need for continued survey efforts and the collection of voucher specimens housed in accredited museums. Collecting and preparing voucher specimens allows for unequivocal identification, which can be important when dealing with species that are easily misidentified. Even when live traps are used, shrews often quickly expire, making euthanasia unnecessary. Moreover, specimens stored in museums act as permanent records that can make determining a species distribution or tracking changes over time much easier. Without these records, regardless of whether they come from small or regional museums, distributional data from small or localized unpublished trapping studies are difficult to acquire. Museums act as libraries to bring these disparate sources together into one cohesive clearinghouse in which archived museum specimens may be accessed. Because of the importance of museum voucher specimens, agencies funding small mammal survey work should budget specimen preparation and cataloging into their expenses. Admittedly, I likely overlooked localities with species occurrences in this study; however, without publication or preparation of vouchers deposited in museums, these records likely will never make it into the scientific world, and thus, lend little help in understanding our natural world.

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Table 1. Museums with vouchers of *Sorex arcticus* and *S. palustris* from Wisconsin, April, 2012. This list does not include voucher specimens that were collected by the surveys described herein.

Museum	Acronym	*S. arcticus*	*S. palustris*
American Museum of Natural History, New York, NY	AMNH	1	
The Field Museum of Natural History, Chicago, IL	FMNH	7	8
University of Illinois, Museum of Natural History, Champaign, IL	UIMNH	5	5
University of Kansas Museum of Natural History, Lawrence, KS	KU	1	
Milwaukee Public Museum, Milwaukee, WI	MPM	1	2
National Museum of Natural History, Washington D.C.	NMNH	14	6
Royal Ontario Museum, Toronto, Canada	ROM		3
Richter Museum of Natural History, Green Bay, WI	RMNH	2	1
University of Wisconsin, Stevens Point, Stevens Point, WI	UWSP	174	27
University of Wisconsin Zoological Museum, Madison, WI	UWZM	122	14
John Wesley Powell-Dale Birkenholz Natural History Collections, Normal, IL	ISU	1	
Cornell University, Vertebrate Collections, Ithaca, New York	CUMV	1	
University of California, Berkeley, Museum of Vertebrate Zoology, Berkley, CA	MVZ	1	2
University of Colorado Museum, Boulder, CO	UCM		1
Louisiana State University Museum of Natural Science, Baton Rouge, LA	LSUMZ		1
Total	15	330	70

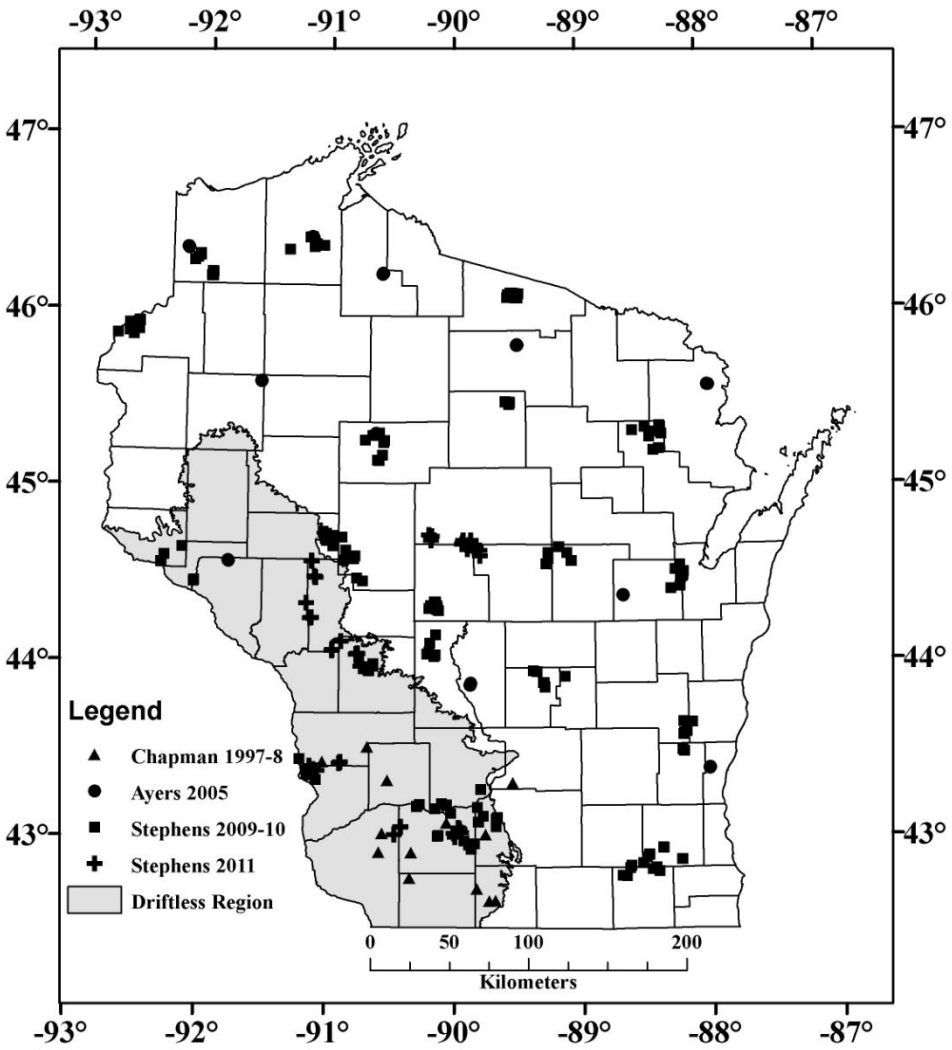


Figure 1. Locations where small mammal field surveys were located and the extent of the Driftless Area in Wisconsin. Different shapes represent surveys described in the text.

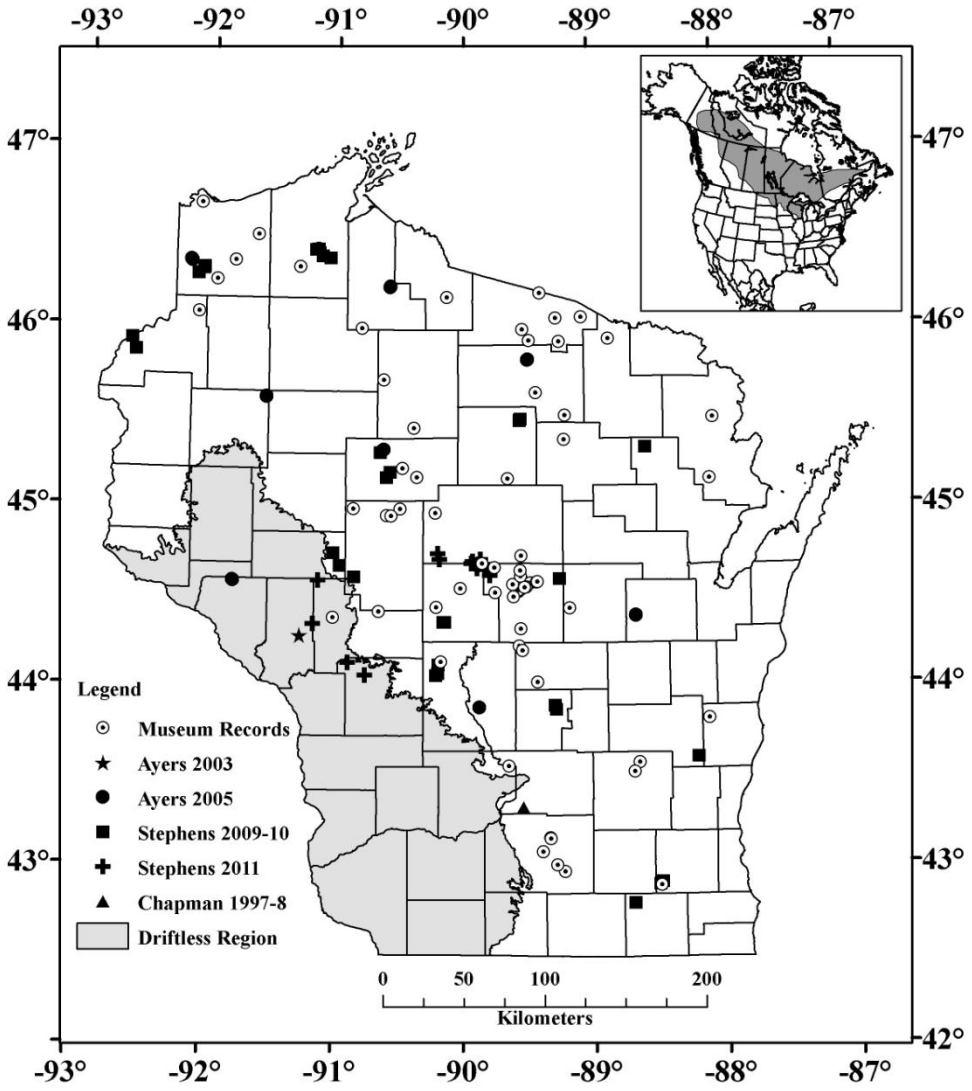


Figure 2. Range of *S. arcticus* in North America [modified from Kirkland and Schmidt (1996)], extent of the Driftless Area in Wisconsin, distribution of *S. arcticus* in Wisconsin based on previous museum records (double circle) and geo-referenced small mammal surveys where *S. arcticus* was captured (various shapes). Museum where historical record is held and location of surveys can be found in Appendix 1 and 2, respectively.

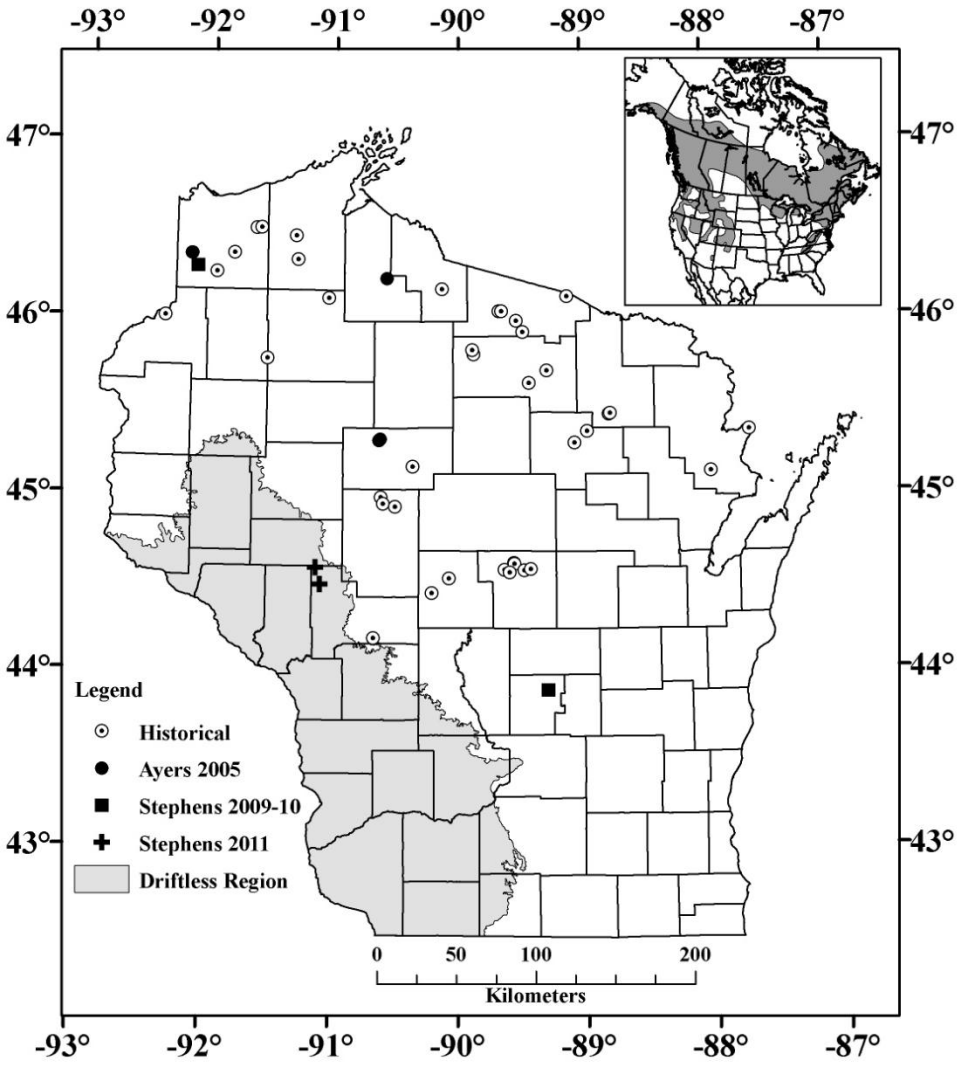


Figure 3. Range of *S. palustris* in North America [modified from Beneski and Stinson (1987)], extent of the Driftless Area in Wisconsin, distribution of *S. palustris* in Wisconsin based on prevous museum records (double circle), and geo-referenced small mammal surveys where *S. palustris* was captured (various shapes). Museum where historical record is held and location of survey can be found in Appendix 1 and 2, respectively.

APPENDIX 1

A list of museum specimens representing unique capture localities for *Sorex arcticus* (1906 to 2008) and *S. palustris* (1907 to 1998). AMNH = American Museum of Natural History; FMNH = The Field Museum of Natural History; HTJ = Published in Mammals of Wisconsin (1961) by H. H. T. Jackson, but no specimen available; ISU = John Wesley Powell-Dale Birkenholz Natural History Collections, Illinois State University; MPM = Milwaukee Public Museum; MVZ = University of California, Berkeley, Museum of Vertebrate Zoology; NMNH = National Museum of Natural History; RMNH = Richter Museum of Natural History; ROM = Royal Ontario Museum; UIMNH = University of Illinois, Museum of Natural History; UWSP = University of Wisconsin Stevens Point; UWZM = University of Wisconsin Zoological Museum; UWZS = University of Wisconsin Zoological Museum, osteological specimen.

Sorex arcticus county locality, catalog numbers.− Ashland, FMNH 47195; Bayfield, UWSP 5687; Clark, AMNH 91014, MVZ 81010, NMNH 229035, UWSP 5802; Dane, NMNH 251134, UIMNH 57104, UWZM 15258, 15262, 22950; Dodge, UWZM 21428, NMNH 274696; Douglas, FMNH 16328, MPM 4135, UIMNH 9883, UWZS 36297, Forest, UWZS 33587; Iron, NMNH 233279; Jackson, UWSP 3873, UWZS 33780; Juneau, UWSP 3874; Langlade, UWSP 827; Lincoln, UWSP 712; Marathon, UWSP 1755, 5004; Marinette, RMNH 808, UWSP 4261; Oneida, FMNH 18919, UWZM 4283; Portage, UWSP 58, 60, 825, 826, 958, 1035, 1228, 1239, 1348, 1461, 797, 2554, 2589, 2713, 2893, 2972, 3523, 3787, 5472; Price, HTJ, RMNH 1155; Sauk, UWZS 34716; Sheboygan, UWSP 3711; Taylor, UWSP 1768, 2693; Vilas, FMNH 16329, 18347, ISU 178, NMNH 226975, 229027, UWZM 13142; Waukesha, UWZS 33791; Waupaca,

UWZS 36657; Waushara, UWSP 59, 3540, 3832; Wood, UWSP 666, 7995, UWZS 33212.

Sorex palustris county locality, catalog numbers.− Bayfield, NMNH 236586, UWSP 5791; Burnett, NMNH 232044; Clark, NMNH 229061, Clark, UWSP 4683, 5105; Douglas FMNH 16332, MPM 4137, UIMNH 9886, 9889; UWSP 3624, 5164; Iron NMNH 233287; Jackson, UWZS 33785; Langlade, ROM 3601310003, UWZM, 14225; Marinette, UWSP 2552, 2896; Oneida, UWSP 5048; UWZM 4285, UWZS 34554, 34581; Portage, UWSP 321, 701, 2564, 2591, 3012, 4934, 1234; Sawyer, UWZM 21431 ; Taylor, UWSP 2694; Vilas, FMNH 16331, 18348, NMNH 229060, UWZM 21430, 21432; Wood, UWZM 22868, UWZS 35231.

APPENDIX 2

Location, date captured, number captured, and voucher specimen deposition of *Sorex arcticus* and *S. palustris* captured during field surveys. Surveys represent those described in the text, A = L. Ayers (2005), AB = L. Ayers and P. Beringer (2003), C = E. Chapman (1999), S1 = R. Stephens (2009-2010), S2 = R. Stephens (2011). Voucher specimens collected from these surveys were deposited in University of Wisconsin- Stevens Point, Stevens Point, WI (UWSP), National Museum of Natural History, Washington D.C. (NMNH), and University of Alaska Museum, Fairbanks, AK (UAM).

	Species	Surv.	County	Latitude	Longitude	Date of Survey	Capt.	Voucher specimens collected
1	*S. arcticus*	A	Adams	-89.87419	43.88558	May 24−Oct. 5 2005	3	
2	*S. arcticus*	A	Ashland	-90.57976	46.22053	May 24−Oct. 5 2005	2	
3	*S. arcticus*	A	Ashland	-90.57695	46.22496	May 24−Oct. 5 2005	12	
4	*S. arcticus*	A	Barron	-91.55353	45.60694	May 24−Oct. 5 2005	3	
5	*S. arcticus*	A	Barron	-91.55567	45.60977	May 24−Oct. 5 2005	12	
6	*S. arcticus*	A	Bayfield	-91.14931	46.42682	May 24−Oct. 5 2005	16	
7	*S. arcticus*	A	Bayfield	-91.15513	46.43035	May 24−Oct. 5 2005	27	
8	*S. arcticus*	S1	Bayfield	-91.15561	46.42904	19−22 June 2009	4	NMNH:570943;UWSP:9458
9	*S. arcticus*	S1	Bayfield	-91.17526	46.42647	19−22 June 2009	3	UWSP:10019,9925,10033
10	*S. arcticus*	S1	Bayfield	-91.12324	46.39026	19−22 June 2009	2	NMNH:570941;UWSP:10009,10030
11	*S. arcticus*	S1	Bayfield	-91.06123	46.37957	19−22 June 2009	2	UWSP:10031,10032
12	*S. arcticus*	A	Buffalo	-91.79724	44.58577	May 24−Oct. 5 2005	7	UWSP:10189,10201
13	*S. arcticus*	A	Buffalo	-91.79504	44.58346	May 24−Oct. 5 2005	1	
14	*S. arcticus*	S1	Burnett	-92.60021	45.85836	21−24 July 2010	1	UWSP:9801
15	*S. arcticus*	S1	Burnett	-92.63270	45.92488	21−24 July 2010	7	NMNH:600009;UWSP,9447,9449,9778,9454

		Species	Surv.	County	Latitude	Longitude	Date of Survey	Capt.	Voucher specimens collected
16	*S. arcticus*	S1		Clark	-90.85293	44.60935	11−14 August 2009	1	UWSP:9711
17	*S. arcticus*	C		Columbia	T10N R8E, S22, SW, NW*		May- Sept. 2008	1	
18	*S. arcticus*	A		Douglas	-92.17379	46.36365	May 24−Oct. 5 2005	2	
19	*S. arcticus*	A		Douglas	-92.16739	46.35885	May 24−Oct. 5 2005	18	
20	*S. arcticus*	S1		Douglas	-92.11564	46.29008	26−29 July 2009	2	UWSP:9455
21	*S. arcticus*	S1		Douglas	-92.07027	46.31632	26−29 July 2009	1	UWSP:9438
22	*S. arcticus*	S1		Douglas	-92.07016	46.32636	26−29 July 2009	1	UWSP:9810
23	*S. arcticus*	S1		Eau Claire	-91.01696	44.74287	6−9 August 2009	7	NMNH:570964;UWSP:9706,9707,9708,10061,9709
24	*S. arcticus*	S1		Eau Claire	-90.96465	44.67268	6−9 August 2009	1	UWSP:10063
25	*S. arcticus*	S1		Fond du Lac	-88.19359	43.60587	12−15 July 2010	4	NMNH:600001;UWSP:9440,9448,
26	*S. arcticus*	S2		Jackson	-91.13271	44.58764	8−11 June 2011	13	UWSP:9736,9737,9739,9741,10098,10184
27	*S. arcticus*	S1		Juneau	-90.19221	44.12261	24−27 August 2010	5	NMNH:600008;UWSP:9452,9453
28	*S. arcticus*	S1		Juneau	-90.19564	44.07332	24−27 August 2010	1	UWSP:9451
29	*S. arcticus*	S1		Juneau	-90.21285	44.06222	24−27 August 2010	1	UWSP:10096
30	*S. arcticus*	S1		Lincoln	-89.54956	45.48894	7−13 June 2009	5	UWSP:10133,10134,9480,9691,9692
31	*S. arcticus*	S1		Lincoln	-89.55624	45.48155	7−13 June 2009	2	UWSP:9479,9459
32	*S. arcticus*	S1		Lincoln	-89.55532	45.47874	7−13 June 2009	1	UWSP:10143
33	*S. arcticus*	S2		Marathon	-89.86460	44.70778	23−26 June 2011	3	UWSP:10097
34	*S. arcticus*	S2		Marathon	-89.93708	44.68570	23−26 June 2011	4	UAF:113789;UWSP:10192,10193
35	*S. arcticus*	S2		Marathon	-89.92785	44.69755	23−26 June 2011	7	UWSP:10095,10093,10187,10188,10194
36	*S. arcticus*	S2		Marathon	-89.87825	44.68103	28 June−1 July	1	
37	*S. arcticus*	S2		Marathon	-89.89267	44.65731	29 June−1 July	5	UAF:113801,113777
38	*S. arcticus*	S2		Marathon	-90.19773	44.73904	30 June−1 July	3	UAF:113836;UWSP:9767,9768
39	*S. arcticus*	S1		Marquette	-89.28232	43.87288	7−11 June 2010	1	UWSP:9446
40	*S. arcticus*	S1		Marquette	-89.29058	43.89735	7−11 June 2010	1	UWSP:9445
41	*S. arcticus*	S2		Monroe	-90.76296	44.06315	13−16 June 2011	5	UAF:113837,113839;UWSP:9743,9746

	Species	Surv.	County	Latitude	Longitude	Date of Survey	Capt.	Voucher specimens collected
42	*S. arcticus*	S2	Monroe	-90.89451	44.13148	13−16 June 2011	1	UWSP:9745
43	*S. arcticus*	S1	Oconto	-88.56912	45.32982	5−8 August 2010	1	UWSP:9531
44	*S. arcticus*	A	Oneida	-89.48915	45.81991	May 24−Oct. 5 2005	3	
45	*S. arcticus*	A	Oneida	-89.49048	45.81740	May 24−Oct. 5 2005	3	
46	*S. arcticus*	A	Outagamie	-88.65735	44.39250	May 24−Oct. 5 2005	2	
47	*S. arcticus*	A	Outagamie	-88.65803	44.39405	May 24−Oct. 5 2005	1	
48	*S. arcticus*	S1	Portage	-89.25190	44.60075	10−13 August 2010	2	UWSP:9457,9456
49	*S. arcticus*	S2	Portage	-89.79385	44.61900	23−26 June 2011	4	UWSP:10112,10191
50	*S. arcticus*	S2	Portage	-89.79453	44.65152	23−26 June 2011	6	UAF:113803;UWSP:10094
51	*S. arcticus*	S2	Portage	-89.82704	44.67361	23−26 June 2011	1	
52	*S. arcticus*	A	Taylor	-90.62477	45.31660	May 24−Oct. 5 2005	1	
53	*S. arcticus*	A	Taylor	-90.63265	45.31164	May 24−Oct. 5 2005	3	UWSP:10195
54	*S. arcticus*	S1	Taylor	-90.60181	45.16137	19−22 August 2010	7	UWSP:9754,10186
55	*S. arcticus*	S1	Taylor	-90.57224	45.19151	19−22 August 2010	5	UWSP:9760,9823,
56	*S. arcticus*	S1	Taylor	-90.65137	45.30157	19−22 August 2010	4	UWSP:9450,9983,9764
57	*S. arcticus*	AB	Trempealeau	91.27081	44.28094	Aug-03	1	
58	*S. arcticus*	S2	Trempealeau	-91.17011	44.34731	8−11 June 2011	8	UAF:113835,113802;UWSP:9735,9738,10185
59	*S. arcticus*	S1	Walworth	-88.69267	42.79605	16−20 June 2010	1	UWSP:9441
60	*S. arcticus*	S1	Waukesha	-88.48303	42.91403	16−20 June 2010	3	UWSP:9439,9444,9443
61	*S. arcticus*	S1	Waukesha	-88.50125	42.89885	16−20 June 2010	3	NMNH:570997;UWSP:9442
62	*S. arcticus*	A	Wood	-89.89034	44.67526	May 24−Oct. 5 2005	1	UWSP:10198
63	*S. arcticus*	A	Wood	-89.87714	44.67509	May 24−Oct. 5 2005	2	UWSP:10196,10197
64	*S. arcticus*	S1	Wood	-90.15562	44.35949	27−30 July 2009	2	NMNH:570975;UWSP:9700
65	*S. arcticus*	S1	Wood	-90.14360	44.35925	27−30 July 2009	1	UAF:113782
66	*S. arcticus*	S2	Wood	-90.18410	44.70882	31 June−1 July	1	UWSP:10111

	Species	Surv.	County	Latitude	Longitude	Date of Survey	Capt.	Voucher specimens collected
1	*S. palustris*	A	Ashland	-90.57695	46.22496	May 24−Oct. 5 2005	1	
2	*S. palustris*	A	Douglas	-92.11564	46.29008	26−29 July 2009	1	NMNH:60003
3	*S. palustris*	A	Douglas	-92.16739	46.35885	May 24−Oct. 5 2005	3	
4	*S. palustris*	S2	Jackson	-91.13271	44.58765	8-11 June 2011	1	UAF:113,845
5	*S. palustris*	S2	Jackson	-91.09779	44.49378	8-11 June 2012	1	UWSP:9742
6	*S. palustris*	A	Marquette	-89.29058	43.89735	7−11 June 2010	1	UWSP:9473
7	*S. palustris*	A	Taylor	-90.62477	45.31660	May 24−Oct. 5 2005	1	
8	*S. palustris*	A	Taylor	-90.63265	45.31164	May 24−Oct. 5 2005	1	

* Location of *S. arcticus* captured by Chapman (1999) was described using the public land survey system (PLSS).

CHAPTER IV

SMALL MAMMAL ASSEMBLAGES AND HABITAT ASSOCIATIONS IN NATURAL PLANT COMMUNITIES OF WISCONSIN

ABSTRACT

Determining small mammal species habitat associations and environmental characteristics, important in site occupancy, are central to understanding species biology and community organization. During the summers of 2009 and 2010, I trapped small mammals and measured habitat variables throughout the state of Wisconsin at 180 sites spanning 13 natural habitats. I captured 3,261 individual small mammals of 22 species, allowing for characterization of small mammal communities within natural habitats. I was also able to model occupancy for 12 species using habitat covariates while incorporating imperfect detection. Comparisons among small mammal communities indicated that organization was based on soil moisture, abundance of trees, and climate. Additionally, the most important covariates in predicting small mammal occupancy were basal area, frequency and duration of wet periods, and minimum winter temperature. The ability to detect differences in community similarity and species occupancy, based on climate, is likely a product of the large geographical extent of this study, underscoring the need to assess community structure at multiple scales. Given the importance of climate in structuring these small mammal communities, predicted warming winter temperatures could have considerable impacts on small mammal communities in the region. Interestingly, occupancy of the meadow jumping mouse was best predicted by the

presence of precipitation before a trap check and availability of pitfall traps. These conclusions would have been missed using other analyses that do not account for imperfect detection. Finally, my results indicate that soil moisture, abundance of trees, and climate are important for species occupancy and, at the community level, these variables create regular and predictable community structure across a heterogeneous landscape.

INTRODUCTION

Environmental characteristics important for small mammal species occupancy and species' associations to natural plant communities have been examined within North American forests (McShea et al. 2003, Coppeto et al. 2006, Zwolak 2009), grasslands (Grant and Birney 1979, Grant et al. 1982, Foster and Gaines 1991), and wetlands (Francl et al. 2004) in detail. However, small mammal communities in the Great Lakes region have received remarkably little attention. These types of studies are not only important for understanding the basic biology of a species, but also for determining how small mammal community assemblages form. In Wisconsin, 27 of 69 native mammal species are small (< 250 g) and non-volant, often constituting the majority of mammalian taxa found in a given ecosystem. Although small, they can have profound impacts on local floral and faunal communities. Specifically, small mammals play crucial roles in ecosystems as consumers of vegetation and seeds (Gibson et al. 1990, Howe and Brown 2000), a prey base for avian and mammalian predators (Buskirk and MacDonald 1984, Knick 1990, Swengel and Swengel 1992), dispersers of seeds and spores (Maser et al. 1978, Vander Wall 1993), predators of other small mammals and insects (Getz et al. 1992, Anderson and Folk 1993), and reservoirs for diseases (Levine et al. 1985).

Over the last few decades, the ranges of many small mammal species have shifted in the Great lakes region, presumably from climate change (Myers et al. 2009). Many southern species have moved northward and displaced boreal species, leading to potential changes in small mammal community composition (Long 1996, Myers et al. 2009). Considering the importance of small mammals, these distributional changes could have significant impacts on local ecosystems. However, in order to address the impacts of these distributional changes, it is first necessary to understand how small mammals are distributed across the landscape and determine what underlying environmental characteristics drive occupancy within an area.

Much of the Great Lakes region has been scoured by glaciation, leaving a landscape with unique landforms and drainage patterns (Curtis 1959). During the last 10,000 years, plants have colonized this region based on local geology, hydrology, soil, and climate (Curtis 1959). Across this heterogeneous landscape, natural disturbances such as fire, flooding, drought, grazing, and wind act in concert with abiotic conditions to create discrete floral assemblages, called natural plant communities (Curtis 1959). Although natural plant communities are qualitatively designated, they form under a relatively narrow set of conditions and embody an amalgam of abiotic and biotic characteristics. Thus, associations of small mammal species to natural plant communities can be useful in determining influences on the formation of small mammal communities. However, because natural plant communities encompass a wide range of environmental characteristics from local geology to floral composition, distinguishing the most important components involved in determining occupancy by small mammal species can be difficult. Therefore, it is also important to identify individual biotic and abiotic

environmental characteristics that are important in predicting site occupancy by a particular species. This understanding helps create baseline data for how small mammal communities structure under natural settings. It can also be used to determine how species are distributed across the landscape and for assessing impacts from disruption of these attributes. In particular, identifying important environmental characteristics involved in species occupancy can help assess potential impacts of anthropogenic disturbances such as silvicultural practices, fire suppression, or development and to evaluate the impacts of climate change on small mammal communities.

Most studies that investigate abiotic and biotic characteristics that influence the distribution and occupancy of small mammal species do so for a single ecosystem type, i.e. forests or grasslands (Finnell 2000, Anthony et al. 2003), at a local scale (Evrard 1998), or for a single species. Although these studies are imperative for building our understanding of small mammal communities in the Great Lakes region, their restricted focus limits how far their results can be extrapolated to other locations or management practices. In order to determine small mammal associations to natural plant communities and identify environmental variables that may influence their distribution within the Great Lakes region, I trapped throughout Wisconsin in a variety of natural plant communities ranging from prairies to northern forests. Traditionally, logistic regression has been used to analyze relationships among biotic and abiotic variables and the presence or absence of a species. However, this analytical technique assumes that when a species is not detected, it does not occur at a site. In many cases, non-detection of a species does not mean that a species is not present (MacKenzie et al. 2002). To avoid this limitation, I used occupancy modeling to account for imperfect detection of a species

(MacKenzie et al. 2002). Specifically, the objectives of my study were to determine: 1) small mammal species' associations in Wisconsin natural plant communities, 2) the similarity/differences between those small mammal community assemblages, and 3) environmental characteristics that best predict the occupancy of a given small mammal species.

METHODS

Study area — Wisconsin comprises nearly 17,000 km^2, extending from approximately 47.1 to 42.5 latitude and 92.9 to 86.8 longitude. It is marked by cold winters (mean January temperature from 1950 to 2006 was -9.5ºC) and warm summers (mean July temperature from 1950 to 2006 was 21.1 ºC), with a general gradation of cooler temperatures in the northwest to warmer temperatures in the southeast and temperatures moderated by lake Michigan in eastern Wisconsin (Serbin and Kucharik 2009). Across Wisconsin, total annual precipitation averages 808 mm (± 165 mm) (Serbin and Kucharik 2009). Wisconsin is relatively flat, with elevations ranging from 177 to 595 m and most of the state has been shaped by Pleistocene glaciations, with the exception of the Driftless Area in the southwestern portion of the state (Curtis 1959). Soils of the Driftless Area are largely formed by weathering of the parent material and accumulation of windblown loess, whereas glacial deposits of till, loess soils, and lacustrine soils left by glacial lakes comprise the majority of the soils (Curtis 1959).

Abiotic factors, primarily temperature, create 2 major distinct floristic divisions in Wisconsin, a northerly zone consisting of boreal flora and a southerly region consisting of prairie flora (Curtis 1959). A band between these two zones, called the tension zone, contains a mix of both boreal and prairie flora (Fig. 1). At a gross scale, boreal and

prairie divisions contain relatively homogeneous vegetation. However, because of variability in local soil nutrient levels, pH, moisture availability, and microclimates the local assemblages of plants vary by species and abundance creating unique combinations called natural plant communities (Curtis 1959). Primary northern natural communities include boreal forest, dry to wet northern forest, pine barrens, open bog, alder thicket, and northern sedge meadow (Curtis 1959). Southern natural communities include oak barrens, oak opening, mesic to wet-mesic southern forest, shrub carr, southern sedge meadow, and dry to wet prairie (Curtis 1959).

Extensive logging in the late 1800s, conversion of prairie to farmland, and the ditching and draining of wetlands have drastically reduced or disturbed the acreage of natural plant communities within Wisconsin (Frelich 1995, Samson and Knopf 1994, Leach and Givnish 1999, Detenbeck et al. 1999). Nevertheless, many remnants of these communities have persisted and sampling these areas offers a glimpse of what pre-settlement small mammal communities may have resembled. I conducted the study throughout the state of Wisconsin and used sites that had little anthropogenic perturbation or encroachment of invasive species (Fig. 1). These included old growth forests, wetlands, prairie remnants, and savanna remnants; however, to a lesser extent, I also used regenerating forest stands and prairie restorations. State Natural Areas (SNA) were used extensively during the study (http://dnr.wi.gov/org/land/er/sna/), with property ownership including state, county, federal, reservation, and private landowners.

Site selection —I used a stratified clustered sampling approach to establish study sites, in which I selected areas throughout the state that reflected natural communities historically found within the area using Curtis (1959). Within regional areas, I selected 6

to 9 representative natural community sites inside an 80 km driving distance. Although natural plant communities represent a continuum, I identified communities as described by Curtis (1959) and Epstein et al. (2008). I grouped these natural plant communities based on vegetation and moisture content into 13 aggregated groups (see Appendix 1), henceforth referred to as natural communities. Digital photographs of each transect are available from the author by request.

Small mammal sampling — Transects of 190 m were established in natural communities and marked at 10 m intervals. I attempted to align transects in a cardinal direction when possible; however, because of the irregular shape and small size of many natural communities, transects were often placed to fit. Transects were located an average of 8.7 km apart to sample independent populations of small mammals and natural communities. Transects were also placed ≥ 10 m from the edge of a community to avoid edge effects. In an attempt to mitigate for the increasing trap success as the season progressed due to increased population sizes from spring to fall (Merritt et al. 2001), in 2009 I started the field season in the northern portion of the state and worked south and in 2010 I started in the south and advanced north.

On each transect I placed Sherman live traps (7.6 x 8.9 x 23.9 cm; H.B. Sherman Inc., Tallahassee, Florida) at every 10m interval (n=20) and pitfall traps (38 cm deep, 20 cm diameter, 10 L, floral cooler buckets, Syndicate Sales, Inc., Kokomo, Indiana) at every other interval (n=10). Shallow bedrock and the presence of sensitive species precluded digging of pitfall traps in 6 dry prairie communities. All traps were baited with peanut butter spread 4 mm thick between sheets of paper towel and cut into 2.5 x 2.5 cm squares. I checked traps twice daily and identified captured animals to species. Animals were sexed, weighed, and

marked with a slight ear notch. Different ear marks were used each day and these, along with weight and gender, were used to identify recaptures. Shrews were marked by trimming the terminal caudal hairs. White-footed mice (*Peromyscus leucopus*) and woodland deer mice (*P. maniculatus gracilis*) trapped in 2009 were identified using field notes and measurements taken from live animals (see Chapter II). In 2010, I identified these species using genetic techniques. For the purpose of this study *P. m. gracilis* and prairie deer mice (*P. m. bairdii*), were treated as separate taxonomic entities because of marked morphological differences and their disparate habitat associations (Jackson 1961). My trapping protocol was approved by the UWSP Animal Care and Use Committee and followed guidelines outlined by the American Society of Mammalogists (Sikes et al. 2011).

I adjusted trap nights for tripped or disabled traps where: trap nights = (traps * number of trap checks) – (sprung Sherman traps or disabled pitfall traps * 0.5) – (1 for missing or destroyed traps) (Beauvais and Buskirk 1999; Nelson and Clark 1973). I calculated trap effort by combining Sherman and pitfall trap nights (approximately a 2:1 ratio) for each transect. I used this trap effort to calculate the catch per unit effort (catch per 100 trap nights) for each species within each natural community.

Habitat and detection covariates — I collected quantitative biotic and abiotic data (henceforth referred to as habitat covariates) that I hypothesized may affect site occupancy by species at each transect. I estimated total canopy closure using a sighting tube with an internal crosshair (Ganey and Block 1994). I used the tube to establish presence or absence of overhead foliage at every interval (n = 20) and calculated the total closure as the percentage of intervals containing overhead foliage (James 1971, Ganey and Block 1994). I estimated herbaceous cover at 5% increments using a 1m x 1m frame at every

other interval. All 10 intervals were averaged to calculate the percentage for the entire transect. I estimated leaf litter depth at every other trap site by pushing a ruler into the litter until the A horizon of the soil was reached; intervals were averaged for each transect. I used the line intercept method to estimate percent cover of coarse woody debris (>3 cm diameter), low shrub (<2 m) and high shrub (>2 m and <10 m) (Ringvall and Ståhl 1999). I pulled a tape the full length of each transect and measured attributes that directly crossed its vertical plane. Sums of each attribute were divided by transect total length. I used a 10-factor prism to tally hardwood, softwood trees, and snags ≥ 2.54 cm. Counts were taken at interval 1, 5, 10, 15, and 20. I calculated average transect basal area (m^2/ha) by pooling counts, multiplying by 10, and dividing by 5.

Because soil moisture may be strongly dependent on season and local weather, taking percent soil moisture at a given time may be misleading. Thus, I used a metric that accounted for the frequency and duration of wet periods. To classify edaphic moisture I used the natural drainage condition of a soil (drclasswttest) from the Soil Survey Geographic Database (SSURGO) downloaded at USDA/NRCS website (http://soils.usda.gov/survey/geography). Classification ranged from 1 to 7, with 1 - very poorly drained and 7 - excessively drained. Using a geographic information system (GIS; ArcGIS v9.3, ESRI, Redlands, California, USA) I overlaid transect locations with soil polygons and their corresponding class; values were taken from the center point of each transect. I used daily climate observations between 2000 and 2010 from the cooperative observer station network to calculate maximum and minimum temperature for summer (June, July, and August) and winter (December, January, and February). Data were obtained from the National Climatic data Center Web site (http://www.ncdc.noaa.gov/oa/ncdc.html/) and gridded values were produced with

approximately 4 km resolution following methods outlined by Serbin and Kucharik (2009) (S. Serbin, unpublished data).

The probability of species detection (*p*) may vary for reasons such as weather, time, or trap effort (Getz 1961a, MacKenzie et al. 2002), therefore, I identified covariates (detection covariates) that I hypothesized could cause heterogeneity in *p*. I acquired maximum temperature, minimum temperature, and precipitation recorded prior to the morning or afternoon check from the National Oceanic and Atmospheric Administration website (http://www.weather.gov/). These data were taken from local weather stations approximately 15 to 50 km from a transect. Time of year may also affect detectability of a species (Moore and Swihart 2005), and I calculated Julian day of trapping starting with the first day trapping commenced. Additionally, because most species showed marked trap biases (see Chapter 1), and availability of traps influences trap effort, I included number of trap nights of Sherman and pitfall traps as a possible detection covariate. Trap type was used as a detection covariate based on which trap was more efficient at capturing a given species (see Chapter 1).

I assessed univariate correlation among habitat covariates and among detection covariates using a Pearson's correlation matrix. When univariate correlations were ≥ 0.70, I removed the least biologically significant covariate or the one that was hardest to measure (Burnham and Anderson 2002).

Community similarity analysis — I used Morisita's Index of Similarity (Krebs 1999) to compare small mammal community structure among natural plant communities ($n = 13$). The Morisita Index measures similarity of communities based on counts of individuals and is nearly independent of sample size and community diversity (Wolda

1981). Similarity is calculated from sample communities *j* and *k*, and is defined as the ratio between the probability that a single individual drawn from sample *j* and one from *k* will belong to the same small mammal species, and the probability that 2 individuals drawn from either *j* or *k* will belong to the same small mammal species. Morisita's index varies from a value of 0 (no similarity between plant communities) to around 1 (complete similarity between communities).

Occupancy modeling analysis— For species that were captured at > 20 transects, I constructed encounter histories at each transect; a species received a 1 for each check it was captured and a 0 when it was not captured. For species that were primarily nocturnal (diurnal captures ≤ 11% of total), I constructed encounter histories based solely on morning checks ($n = 4$). For species that had ≥ 20% of total captures during morning checks, I built encounter histories using both morning and afternoon checks ($n = 7$).

Since most small mammals are detected imperfectly, non-detection at a transect does not imply that a species is not present. Thus, using naïve estimates of species occupancy, or total number of transects with detections divided by the total number of transects, may lead to estimates that are biased low. For species that were captured at > 20 transects, I used a single-season occupancy modeling framework in Program PRESENCE (version 4.3; Hines 2009), which estimates site occupancy (ψ) as a function of detection probability (p); where ψ is the expected probability that a transect is occupied by a given species and p is the probability of a species being detected when present at a transect (MacKenzie et al. 2006). Although small mammals were collected during 2 summers, a given transect was not resampled and survey sites within and

between years were independent, therefore using a single–season analysis does not violate model assumptions.

I created a set of 12 to 20 candidate models for predicting species ψ as a function of habitat covariates and sampling covariates (Table 1). To prevent overparameterizing models, which could lead to specious results from over-fitting, I only considered models with 2 to 6 parameters (including the intercept of ψ and *p*). In order to focus on habitat covariates that were likely most influential in determining occupancy, I used univariate t-tests comparing means of habitat covariates at sites with detections to those without. Significance ($p < 0.05$) was considered indicative of importance, although the magnitude of this importance in relation to other variables was unclear. Additionally, because univariate tests fail to assess interactions among variables, I still included some covariates that were not significant at the univariate level when previous studies indicated that these variables were important for occupancy of a species. Thus, I created models that incorporated a combination of habitat and detection covariates based on this univariate analysis, biology deduced from published literature, and field observations. In addition, each species had a model where ψ and *p* were held constant and at least one model consisting entirely of detection covariates. Models were compared using Akaike's Information Criteria (AIC), with correction for small sample size (Burnham and Anderson 2002). I ranked models using their AIC_c to determine the most parsimonious model. The model with the lowest AIC_c ($\Delta AIC_c = 0$) was considered the "best" model and was used to draw primary conclusions; however, models within 2 AIC_c units of the best model were also considered (Burnham and Anderson 2002). I calculated Akaike weights (w_i) to assess a given model's empirical support compared across models.

RESULTS

During the summers of 2009 and 2010, I sampled 180 sites in 31 types of plant communities across Wisconsin (Fig. 1, see Appendix 1). Each aggregated natural community type (n = 13) averaged 13.2 transects (range 4 to 25); however, 8 transects were not assigned to a natural community because vegetation composition and structure was too dissimilar to be classified within the 13 groups and lacked sufficient replication to be classified as an additional group (see Appendix 1). I captured 1,264 unique individuals of 18 species in 2009 and 1,997 unique individuals of 20 species in 2010. With a total effort of 22,599 Sherman trap-nights and 11,636 pitfall trap-nights, I captured 3,261 individuals comprising 22 species of small mammals in 2 years of trapping in Wisconsin natural communities (Table 2). On average, species occurred in 6.1 natural communities. White-footed mice (*Peromyscus leucopus*), masked shrews (*Sorex cinereus*), northern short-tailed shrews (*Blarina brevicauda*), and meadow jumping mice (*Zapus hudsonius*) were ubiquitous across natural community types (Table 2). However, based on catch per 100 trap nights (CPUE) *P. leucopus* was most abundant in forest communities and *S. cinereus* in wetland communities (Table 2). *Blarina brevicauda* and *Z. hudsonius* were distributed relatively homogenously across habitats, with the former having the highest CPUE in northern forests (Table 2). Meadow voles (*Microtus pennsylvanicus*) occurred in all but 2 natural communities and eastern chipmunks (*Tamias striatus*) and pygmy shrews (*Sorex hoyi*) occurred in all but 3 natural communities (Table 2). Highest CPUE of *M. pennsylvanicus* was recorded in open and moist communities, whereas *T. striatus* was captured more in forested communities (Table 2). *Sorex hoyi* showed no clear capture trend (Table 2). A number of frequently

captured species were narrowly distributed among natural communities. The arctic shrew (*Sorex arcticus*) occurred exclusively in 5 wetland communities, whereas the thirteen-lined ground squirrel (*Ictidomys tridecemlineatus*) and the prairie deer mouse (*P. maniculatus bairdii*) were found almost exclusively in dry open communities, 4 and 3 communities respectively (Table 1). The prairie vole (*Microtus ochrogaster*) was found in 3 southern communities with more open structure and the short-tailed weasel (*Mustela erminea*) was captured exclusively in 4 wetland communities (Table 1).

Community similarity — Results of Morisita's Index of Similarity, comparing small mammal communities within natural communities, ranged from a value of 0.181 to 0.997, indicating that small mammal assemblages vary greatly among natural plant communities (Fig. 2). Similarity of small mammal assemblages appeared to correspond primarily to moisture regimes, presence of trees, and to a lesser extent a latitudinal gradient. The assembledges of small mammals in moist communities of wet prairies, sedge meadows, and shrub wetlands were most dissimilar to the majority of other plant communities (Fig. 2). Forested communities tended to have very similar small mammal communities, but northern forests were more similar to other northern forests than to southern forests and southern forested communities were more similar to other southern forest communities than northern forest communities (Fig. 2).

Analysis of covariates — Maximum and minimum winter and summer temperature were highly correlated ($0.732 < r < 0.942$). I chose to retain minimum winter temperature because it is showing the largest response to climate change (Kucharik et al. 2010), and thus may have the most impact on species. Total canopy closure, canopy closure of hardwoods, and canopy closure of softwoods were highly

correlated with their respective class of basal area ($0.889 < r < 0.930$). Because of the ephemeral nature of canopy closure, I chose to only retain basal area values. Hardwood basal area and softwood basal area were correlated to total basal area, $r = 0.661$ and $r = 0.767$, respectively, and I chose to eliminate total basal area as a habitat covariate. For all species, univariate t-tests revealed that basal area of snags was not significantly different for occupied and unoccupied sites and was eliminated from further analysis. For detection covariates, minimum and maximum temperature were moderately correlated ($r = 0.678$) and only maximum temperature was retained. This left a total of 9 occupancy covariates and 5 detection covariates for building occupancy models (Table 1).

Occupancy modeling— Twelve species had sufficient captures to model site occupancy as a function of habitat and detection covariates (see Appendix 2). Although top models were created for *B. brevicauda, S. hoyi*, the southern bog lemming (*Synaptomys cooperi*), and *T. striatus*, no models had weights (ω_i) over 37%, indicating they may not be well supported. All other species had models weights of 49-99% (see Appendix 2). Detection covariates occurred in top models for 10 of the 12 species. Trap nights occurred in top models for 7 species. Inclusion of pitfall trap nights increased detection of all 4 shrew species and *Z. hudsonius*, whereas increased Sherman trap nights reduced detection of *I. tridecemlineatus* and *P. leucopus* (Table 3). Day of trapping increased detection of the southern red-backed vole (*Myodes gapperi*), *P. maniculatus gracilis*, and *T. striatus* and was also included in supported models of *Z. hudsonius* and *S. cooperi* (Table 3).

All species had habitat covariates in their top models with the exception of *Z. hudsonius*, which was best predicted by rainfall and increasing number of pitfall trap

nights (Table 3). Attributes associated with forest structure, included in analysis, were basal area, high shrub cover, and coarse woody debris. Basal area (+ or -) was the best predictor of species occupancy and occurred in the top model for 8 species. Occupancy of *B. brevicauda*, *P. leucopus*, and *T. striatus* responded positively to increased hardwood basal area and *S. cooperi* and *M. gapperi* responded positively to increased softwood basal area (Table 3). Occupancy of *P. maniculatus gracilis* was positively associated with both hardwood and softwood basal area (Table 3). Conversely, *I. tridecemlineatus* and *M. pennsylvanicus* responded negatively to basal area (Table 3). Coarse woody debris was positively associated with occupancy of *M. gapperi* and *T. striatus* and was also included in a supported model for *P. maniculatus gracilis* (see Appendix 2). Occupancy by *B. brevicauda* responded positively to high shrub cover (Table 3).

Soil moisture, described as a function of frequency and duration of wet periods, occurred in top models for 4 species and was in supported models for 2 additional species (see Appendix 2). Occupancy of 3 species (*S. arcticus, S. cinereus*, and *M. pennsylvanicus*) were associated with soils that are frequently flooded and poorly drained, whereas occupancy of *I. tridecemlineatus* was associated with more well-drained soil conditions (Table 3). Minimum winter temperature occurred in top models for *M. gapperi, P. maniculatus*, and *S. cooperi* (Table 3). Additionally, it occurred in supported models for both *S. arcticus* and *S. hoyi* (see Appendix 2). These species showed a negative association to temperature, also interpreted as increased occupancy as minimum winter temperature decreases.

Herbaceous and low vegetation characteristics considered in models included percent herbaceous cover, leaf litter, and low shrubs. Herbaceous cover was positively

associated with occupancy of *S. arcticus*, *S. cinereus*, and *M. pennsylvanicus* (Table 3). Leaf litter depth was positively associated with occupancy of *S. arcticus* and negatively with *S. hoyi* (Table 3). Three species (*S. cinereus*, *S. hoyi*, and *S. cooperi*) responded positively, in terms of occupancy, to low shrubs.

DISCUSSION

Our understanding of community associations of small mammals within the Great Lakes region have been gleaned largely from studies conducted in other regions of the United States (Grant and Birney 1979, Bellows et al. 2001). Although the species composition in these systems may be similar, many regions have fundamentally different underlying geography or climatic conditions than those found within the Great Lakes region. Thus, proximal cause of a species' occurrence may vary, depending on the region, and extrapolation to other regions may lead to conclusions that are misguided or completely erroneous. Furthermore, conclusions of species occupancy and association based on studies that sample 1 or a few communities may not reflect accurately how a species is distributed over a larger geographic scale. My study focused on small mammals occurring in Wisconsin and addressed species' associations and occupancy within natural plant communities on a statewide scale.

Community associations— Most small mammal species were not evenly distributed among natural communities. Species distributions and similarity among small mammal communities could be explained best by moisture availability, presence of trees, and latitude. The combination of moisture and trees had the greatest effect on community similarity. A study conducted in Ontario, Canada also noted similar structuring of communities based on moisture availability and forested or open

communities (Nagorsen and Peterson 1981). Latitude also had an effect on community similarity and this can be explained by the large geographic extent of this study, with many small mammal species reaching their southern or northern distributional limits in central and southeastern Wisconsin (Jackson 1961, Appendix E). However, latitude itself is not the proximal cause of range limitations. Instead, factors such as climate and biota are likely driving distributions. Moreover, temperature can be a better predictor of a species' distribution than biotic variables such as floral community composition (Rubidge et al. 2011).

Detection covariates— Including Julian day as a detection covariate increased detection of 5 small mammal species. This is intuitive given that most species have several litters each summer and an increased abundance would lead to improved probability of capture. The fact that it did not occur in models for all species may indicate relatively stable populations of these species or that those species have detection rates related to other variables. The concept that increasing Sherman trap effort would reduce probability of detection seems contradictory, yet was consistent for both species containing Sherman trap effort within their top model. Furthermore, in a study of small mammals in Indiana, Urban and Swihart (2011) found that increased Sherman trap effort reduced the detection probability of *T. striatus*, the most abundant species in their study. Yet, for the 3 shrew species that had pitfall trap effort as a detection covariate in my study, detection probability of those species increased. This inconsistency is likely an artifact of differential capture mechanics of the 2 trap types. Sherman traps can only capture 1 individual per check. In many of the communities I trapped in, *P. leucopus* was the most abundant small mammal species and often saturated available Sherman traps.

This may have led to a negative detection probability where increased captures of a species are correlated with decreased trap availability which, when adjusted for tripped or disabled traps, leads to decreased trap effort. Alternatively, pitfall traps can continue to capture individuals, even after the first individual is captured (Williams and Braun 1983). However, pitfall traps are prone to flooding and disengaging in wetlands, reducing the number of trap nights. Thus, I believe that pitfall trap nights should be used as a detection covariate in occupancy modeling for species that are susceptible to capture in pitfall traps. However, I caution against using Sherman trap effort as a detection covariate in studies that have a standardized trapping protocol where all sites have the same number of traps. Inclusion of Sherman trap effort, as a detection covariate, may lead to adding a parameter that is adding little meaningful biological information. Nonetheless, using Sherman trap effort as a detection covariate in occupancy modeling may be useful in studies that have an unstandardized protocol; i.e. when different trap types are used or when numbers of traps may vary by site (Moore and Swihart 2005, Urban and Swihart 2009).

Occupancy covariates—At the species level, results of incorporating habitat covariates into occupancy models closely paralleled findings gleaned from community similarity analysis. Basal area, a proxy for forest, was the overall best predictor of species occupancy as indicated by its prevalence in most top models. It was also a much better predictor of species occupancy, as indicated by occurrence in top models, compared to other forest associated characteristics such as percent cover of CWD and high shrub. Although CWD is often found to be crucial for predicting abundance of many species, I found it to be relatively unimportant for predicting species occupancy. This may be a function of abundance versus occupancy, where abundance may be driven

by availability of CWD, but occupancy is not. Basal area of hardwoods occurred in the majority of occupancy models that had basal area in them. Basal area is indicative of more vertical structural complexity and grossly separated forested species such as *P. leucopus* from grassland species like *M. pennsylvanicus*. Manson et al. (1999) found that captures of *M. pennsylvanicus* were better predicted by distance to forest edge than vegetation cover itself, whereas captures of *P. leucopus* were best predicted by structural complexity. Although I captured *P. leucopus* in all habitat types, the highest CPUE was noted within forested communities and the lowest in open habitats. Some studies have found the abundance of *P. leucopus* to be uncorrelated with environmental characteristics and considered it a generalist species (Dueser and Shuggart 1979, Bellows et al. 2001); however, this is likely a function of sampling in relatively homogeneous systems, i.e. only in forested communities. *Peromyscus leucopus* is omnivorous and semi-arboreal, often nesting off the ground (Lackey et al. 1985). Vertical heterogeneity likely increases the availability of both resources.

Frequency and duration of wet periods were also important for small mammal species occupancy. Mesic soils were important for occupancy of *S. arcticus*, *S. cinereus*, and *M. pennsylvanicus*, whereas *I. tridecemlineatus* was associated with more xeric soils. Communities with high soil moisture are known to be highly productive for shrew species (Wrigley et al. 1979). Mesic conditions often have high abundances of invertebrate foods, which are important for insectivorous mammals such as shrews (Getz 1961b). *Microtus pennsylvanicus* is known to occupy areas that have standing water, as long as sufficient herbaceous cover is available for nests and feeding sites (Getz 1961b). This species feeds on herbaceous material such as graminoids, which are often found in

greater abundance in mesic soils (Getz 1961c). *Ictidomys tridecemlineatus* is a semi-fossorial sciurid and it is logical that this species is associated with well drained xeric soils which would not flood easily (Whitaker 1972, Streubel and Fitzgerald 1978).

Minimum winter temperature also appeared in supported models for 5 small mammal species including *M. gapperi*, *P. maniculatus gracilis*, *S. cooperi*, *S. arcticus*, and *S. hoyi*. All these species reach their southern distribution within the Great Lakes region in Wisconsin (See Appendix E). Climate can be an important predictor of species' occurrence and distribution (Rubidge et al. 2011), and given that winter temperatures are rising in Wisconsin (Kucharik et al. 2010), increased winter temperatures could have serious effects on these species. Indeed, climatic change has already caused reduced relative abundance of *M. gapperi* and *P. maniculatus gracilis* in Michigan small mammal communities (Myers et al. 2009). Since both these species comprise a considerable portion of northern forest ecosystems (Myers et al. 2009), if winter warming trends continue, it is likely to have profound impacts on small mammal community composition. The distribution of *Sorex arcticus* in Wisconsin has recently been expanded based on more thorough sampling effort (see Chapter 3). However, given that temperature is an important predictor for occupancy, this species could be negatively impacted by warming winters. Although *S. cooperi* is not found in southern Wisconsin, its distribution extends as far south as Arkansas making it hard to predict how warming winter temperatures may impact this species in Wisconsin (Linzey 1983).

Despite the large geographic breadth and heterogeneity of communities sampled, the 3 species that showed little affinity to any natural community (*B. brevicauda*, *S. hoyi*, and *Z. hudsonius*) also had occupancy models that were not well supported using habitat

covariates. Other studies have also found *B. brevicauda* to be a habitat generalist (Wrigley et al. 1972, Manson et al.1999). The slight increase in CPUE of *B. brevicauda* in northern forests was likely caused by extraordinary captures of this species during June 2009 in Vilas County. During this time, *B. brevicauda* accounted for 76% of 168 unique captures across a wide range of habitats. Unusually high abundances of this species have been documented in other regions (David and Edwards 1955). These data indicate occupancy and abundance of *B. brevicauda* are not intrinsically linked to any of the natural community types or environmental characteristics I measured. Instead, occupancy may be linked to other factors that influence survival, such as high snowfall and increased use and protection from the subnivean zone or from availability of large invertebrate prey (David and Edwards 1955, Getz 1961c). Although uncommon, *S. hoyi* was noted as a generalist species, with captures in 10 of 13 communities and also had occupancy models with low model weights. The generalist nature of this species has also been noted in Ontario, Canada and Virginia, U.S. (Negorsen and Peterson 1981, Bellows et al. 2001).

It is also interesting to note that occupancy of *Z. hudsonius* was best explained by pitfall trap nights and whether it rained before a trap check. Although previous studies of this species indicate its preference for open grassland sites with moist soil (Hamilton 1935, Whitaker 1972b), results of this study show that *Z. hudsonius* is essentially ubiquitous across natural communities, occurring in wetlands to dry grasslands and from open communities to well forested regions. These findings are consistent with others that also found *Z. hudsonius* to be ubiquitous across a wide range of habitats (Quimbly 1951, Iverson et al. 1967, Urban and Swihart 2009). Quimbly (1951) noted that captures of *Z. hudsonius* were nearly always

greater on nights with precipitation. Likewise, I found that probability of detection increased with increased precipitation. My research suggests that *Z. hudsonius* is 5 times more likely to be caught in a pitfall trap than a Sherman (see Chapter 1). Without occupancy modeling, and the inclusion of detection covariates, this would have been overlooked using analytical techniques such as logistic regression. These findings have implications for instances when *Z. hudsonius* is not captured during studies that do not use pitfall trap and have clear weather.

Species' associations to natural plant communities mirror inference gained from occupancy modeling based on biotic and abiotic environmental characteristics. Within natural plant communities of Wisconsin, occupancy of individual small mammal species is dependent on specific abiotic and biotic characteristics, creating regular and predictable community structure across a heterogeneous landscape. Overall, small mammal communities in Wisconsin form primarily from a combination of soil moisture, presence or absence of trees, and climate. Although these factors may be grossly responsible for species occupancy and ultimately the formation of small mammal communities, it is also likely that interspecific interactions play a role in how small mammal communities structure (Morris and 1972, Anthony et al. 1981). Additionally, factors related to occupancy may not be the same factors responsible for regulating species abundance (Urban and Swihart 2011). Indeed, these may also be dependent on interspecific and intraspecific interactions. Examination of these factors may help determine how species are distributed at the local level.

Although other studies have found moisture gradients and structural heterogeneity to be important in organizing small mammal communities (Nagorsen and Peterson 1981, Bellows et al. 2001), the use of localized study areas likely overlooks associations and community structure caused by climate. Overlooking climate may lead to underestimating its

importance in determining species' occupancy and distribution. Based on my results from occupancy modeling, warming winter trends may have considerable impacts on many of the small mammal species in Wisconsin. Given the abundance of these species across the landscape, impacts on local floral and faunal communities could be profound.

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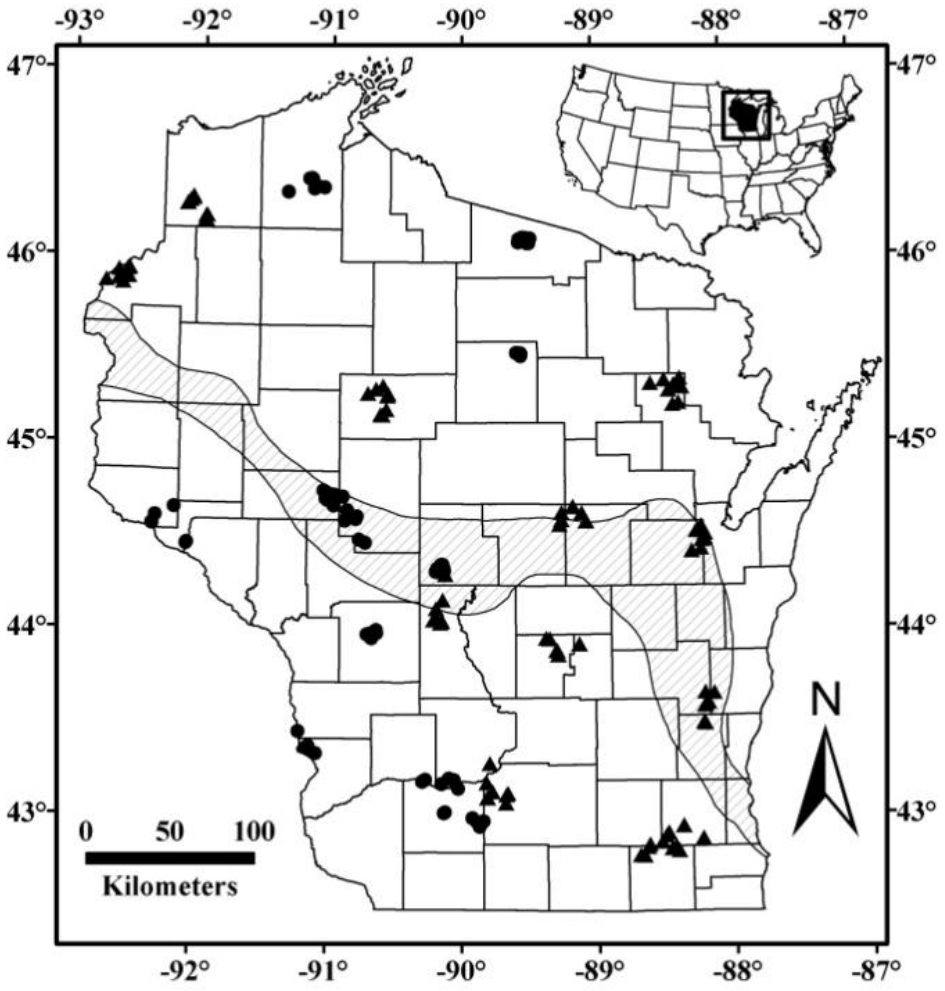


Figure 1. Map of Wisconsin depicting locations of small mammal trapping transects for 2009 (●) and 2010 (▲) and distribution of the tension zone in crosshatch based on Curtis (1959).

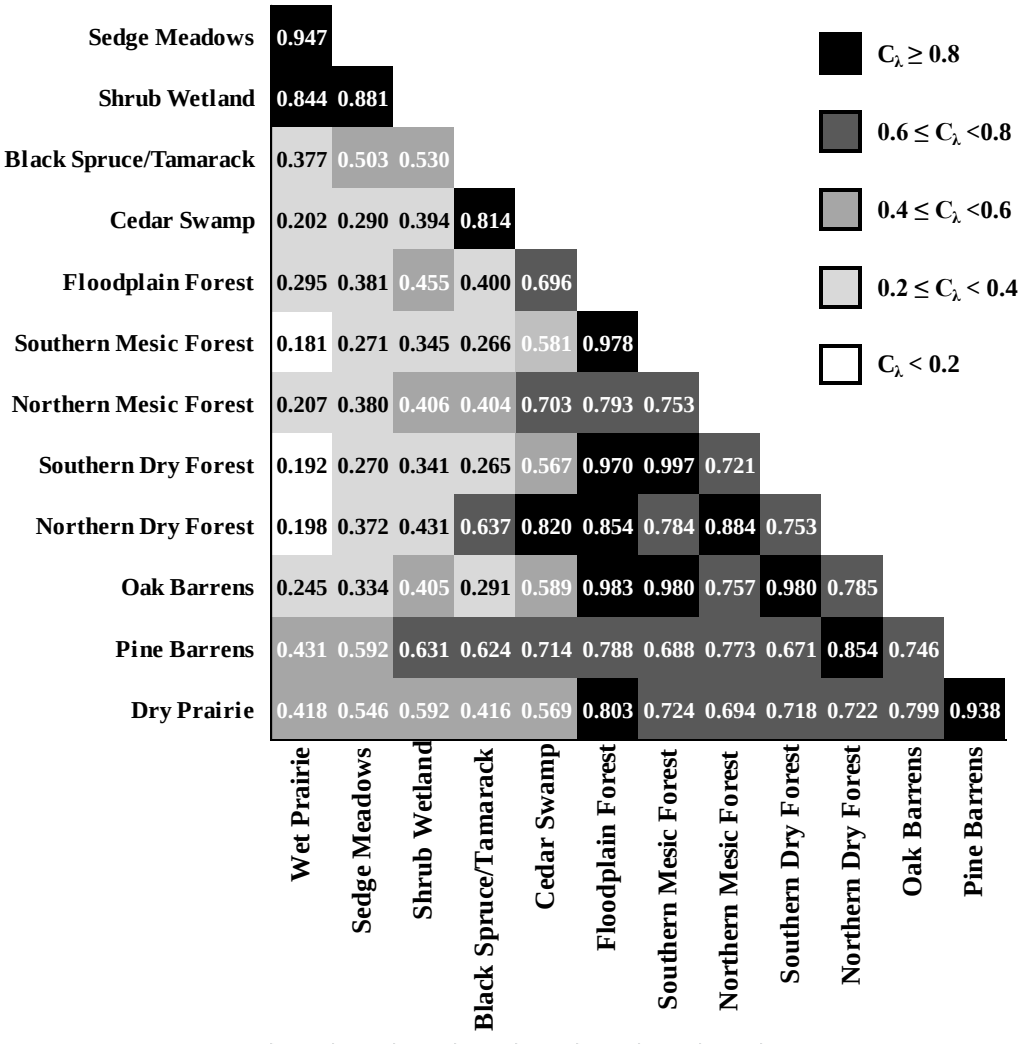


Figure 2. Similarity between natural plant communities based on small mammal species' abundances. Numbers represent results of Morisita's Index of Similarity (C_λ). Communities that are similar to each other (Morisita's index approaching 1) are indicated in black whereas dissimilar communities (Morisita's index approaching 0) are indicated in white. Plant communities are arranged from wet to dry (top to bottom and left to right) and from open communities on the peripheries to communities with many trees toward the middle.

Table 1. Description, abbreviation, and summary statistics of habitat covariates calculated for each transect (n = 180) in Wisconsin during the summer of 2009 and 2010. See methods section for description of measurements.

Habitat Covariate	Abbreviation	Range	Median	Ave.	SD	Used in analysis
Canopy closure of hardwoods (%)	Canopy	0-1	0.00	0.31	0.39	no
Canopy closure of softwoods (%)	Canopy	0-1	0.00	0.19	0.31	no
Total canopy closure of hardwoods (%)	Canopy	0-1	0.35	0.44	0.43	no
Herbaceous cover (%)	Herb	3.32-100	85.25	74.10	26.46	yes
Depth of leaf litter	Litter	0-21.9	2.75	3.69	4.17	yes
Cover of course woody debris (>3 cm diameter) (%)	CWD	0-5.73	0.58	1.06	1.24	yes
High shrub (>2 m and <10 m) (%)	ShrubH	0-99.74	3.97	13.58	20.21	yes
Low shrub (<2 m) (%)	ShrubL	0-92.11	13.76	20.99	23.09	yes
Basal area of snags (m^2/ha)	Snags	0-7.35	0.00	0.94	1.41	no
Basal area of hardwoods (m2/ha)	BasalH	0-33.52	0.46	6.60	9.27	yes
Basal area of softwoods (m2/ha)	BasalS	0-53.72	0.00	6.50	11.55	yes
Total basal area (m2/ha)	BasalT	0-57.39	7.35	13.11	14.43	no
Frequency and duration of wet periods	Soil	1-7	3.00	3.42	2.38	yes
Average maximum winter temperature from Dec., Jan., and Feb. (°C)	WinterMax	-4.87--0.91	-2.33	-2.75	1.20	no
Average minimum winter temperature from Dec., Jan., and Feb. (°C)	WinterT	-15.72--9.88	-12.72	-12.86	1.71	yes
Average maximum summer temperature from June, July, and Aug. (°C)	SummerMax	24.07-27.44	26.35	26.22	0.81	no
Average minimum summer temperature from June, July, and Aug. (°C)	SummerMin	11.48-16.19	13.72	13.69	1.20	no

Table 2. Catch per unit effort (CPUE), captures per 100 trap nights, for each small mammal species within natural communities. Gray scale colors indicate relative proportion of species CPUE in a community compared with the highest CPUE recorded across a communities; ≥ 0.8, 0.6 ≤ <0.8, 0.4≤ < 0.6, 0.2≤ <0.4, and white denotes proportions <0.2. Natural community abbreviations are as follows: wet prairie (WP), sedge meadows (SM), shrub wetland (SW), black spruce and tamarack (BST), cedar swamp (CS), floodplain forest (FF), southern mesic forest (SMF), northern mesic forest (NMF), southern dry Forest (SDF), northern dry forest (NDF), oak barrens (OB), pine barrens (PB), and dry prairie (DP). Plant communities are arranged from wet to dry (left to right) and from open communities on the peripheries to communities with many trees toward the middle.

Species	Total Captures*	WP	SM	SW	BST	CS	FF	SMF	NMF	SDF	NDF	OB	PB	DP
Peromyscus leucopus	1193	1.05	0.58	1.01	1.12	6.24	10.79	9.32	5.30	9.22	5.59	4.18	2.61	1.97
Myodes gapperi	450			0.19	3.65	7.37	1.59	0.42	0.62	0.29	2.67		0.75	
Sorex cinereus	446	2.02	1.08	1.01	2.68	2.14	1.30	0.42	0.96	0.81	1.21	0.58	1.21	0.80
Microtus pennsylvanicus	340	3.42	3.17	1.83	0.83	0.39	1.09		0.17	0.04		0.17	0.75	0.49
Blarina brevicauda	226	0.90	0.08	0.19	0.64	0.23	0.58	0.99	2.99	0.37	2.72	0.08	0.68	0.03
P. maniculatus gracilis †	122				0.09	3.09	0.14		2.82		0.15		0.03	
Zapus hudsonius	85	0.39	0.12	0.39	0.18	0.51	0.65	0.85	0.11	0.18	0.05	0.17	0.16	0.25
Sorex arcticus	81	0.27	0.54	1.25	0.33	0.06								
Ictidomys tridecemlineatus	72			0.04								0.12	1.21	0.92
Tamias striatus	61	0.04		0.08	0.13	0.17	0.36		0.39	0.29	0.76	0.17		0.09
Sorex hoyi	43	0.16			0.22	0.06	0.07		0.17	0.11	0.10	0.12	0.36	0.09

Table 2. Continued.

Species	Total Captures*	WP	SM	SW	BST	CS	FF	SMF	NMF	SDF	NDF	OB	PB	DP
Synaptomys cooperi	39			0.16	0.48	0.28			0.11		0.20		0.07	
Glaucomys volans	26				0.04	0.28	0.07		0.06		0.60		0.10	
P. maniculatus bairdii †	25	0.16												0.59
Microtus ochrogaster	16	0.08										0.54		0.03
Mustela ermine	16		0.08	0.27	0.13	0.06								
Condylura cristata	7		0.04		0.07	0.06				0.04				
Tamiasciurus hudsonius	6				0.02	0.17							0.03	
Glaucomys sabrinus	2				0.04									
Sorex palustris	2		0.04	0.04										
Reithrodontomys megalotis	1	0.04												
Sylvilagus floridanus	1													0.03
Mustela frenata	1					0.06								
n species	23†	11	9	12	16	16	10	5	11	9	10	9	12	11
n replicates	3261	14	14	14	25	10	8	4	10	15	11	12	16	19

* Total captures include 8 transects that were not classified with a natural community group.

† Woodland deer mouse (*Peromyscus maniculatus gracilis*) and the prairie deer mouse (*P. m. bairdii*) are recorded as separate taxa.

Table 3. Estimated coefficients (β_j) and standard errors (SE), from program PRESENCE, for covariates contained in the top models of occupancy for 12 Wisconsin small mammal species trapped in 2009 and 2010. Covariate descriptions described in methods section. Species abbreviations are as follows: *Blarina brevicauda* (BLBR), *Ictidomys tridecemlineatus*, (ICTR), *Microtus pennsylvanicus* (MIPE), *Myodes gapperi* (MYGA), *Peromyscus leucopus* (PELE), *Peromyscus maniculatus gracilis* (PEMAGR), *Sorex arcticus* (SOAR), *Sorex cinereus* (SOCI), *Sorex hoyi* (SOHO), *Synaptomys cooperi* (SYCO), *Tamias striatus* (TAST), and *Zapus hudsonius* (ZAHU). All candidate models can be found in Appendix 2.

Parameter and	BLBR		ICTR		MIPE		MYGA		PELE		PEMAGR	
Covariate	β_j	SE	β_j	SE	β_j	SE	β_j	SE	β_j	SE	β_j	SE
p												
Intercept	-2.37	1.01	12.667	2.477	-0.559	0.100	-0.598	0.249	11.878	1.464	0.070	0.424
Pitfall	0.205	0.104	–	–	–	–	–	–	–	–	–	–
Sherman	–	–	-0.723	0.133	–	–	–	–	-0.586	0.081	–	–
Day	–	–	–	–	–	–	0.018	0.004	–	–	0.018	0.009
Precip	–	–	–	–	–	–	–	–	–	–	–	–
TempH	–	–	–	–	–	–	–	–	–	–	–	–
ψ												
Intercept	-1.205	0.262	-4.177	0.836	-0.570	0.820	-5.215	1.697	0.102	0.194	-33.069	2.663
BasalH	0.046	0.020	-0.390	0.150	-0.042	0.024	–	–	0.135	0.034	0.166	0.039
BasalS			–	–	-0.111	0.028	0.099	0.025	–	–	0.102	0.023
ShrubH	0.018	0.010	–	–	–	–	–	–	–	–	–	–
ShrubL	–	–	–	–	–	–	–	–	–	–	–	–
Herb	–	–	–	–	0.027	0.007	–	–	–	–	–	–
CWD	–	–	–	–	–	–	0.619	0.185	–	–	–	–
Litter	–	–	–	–	–	–	–	–	–	–	–	–
Soil	–	–	0.714	0.155	-0.297	0.091	–	–	–	–	–	–
WinterT	–	–	–	–	–	–	-0.238	0.128	–	–	-2.012	0.170

Table 3.—Continued.

Parameter and	SOAR		SOCI		SOHO		SYCO		TAST		ZAHU	
Covariate	β_j	SE	β_j	SE	β_j	SE	β_j	SE	β_j	SE	β_j	SE
p												
Intercept	-2.341	1.041	-1.934	0.570	-5.186	1.948	-1.334	0.365	-1.311	0.321	-2.650	1.550
Pitfall	0.133	0.111	0.173	0.059	0.301	0.201	–	–	–	–	0.133	0.156
Sherman	–	–	–	–	–	–	–	–	–	–	–	–
Day	–	–	–	–	–	–	–	–	0.019	0.006	–	–
Precip	–	–	–	–	–	–	–	–	–	–	0.004	0.017
TempH	–	–	–	–	–	–	–	–	–	–	–	–
ψ												
Intercept	-7.038	1.105	-0.191	0.916	0.362	1.306	-12.653	2.902	-2.270	0.337	-1.522	0.300
BasalH	–	–	–	–	–	–	–	–	0.030	0.024	–	–
BasalS	–	–	–	–	–	–	0.042	0.024	–	–	–	–
ShrubH	–	–	–	–	–	–	–	–	–	–	–	–
ShrubL	–	–	0.045	0.031	0.029	0.028	0.032	0.013	–	–	–	–
Herb	0.087	0.011	0.021	0.009	–	–	–	–	–	–	–	–
CWD	–	–	–	–	–	–	–	–	0.322	0.177	–	–
Litter	0.820	0.398	–	–	-0.250	0.201	–	–	–	–	–	–
Soil	-1.790	0.713	-0.208	0.115	–	–	–	–	–	–	–	–
WinterT	–	–	–	–	–	–	-0.716	0.211	–	–	–	–

APPENDIX 1

Wisconsin natural plant community names and number of transects trapped within them, during the summers of 2009 and 2010. Natural plant communities were placed into13 aggregated groups, referred to as natural communities.*

Natural Community	Number of transects
Black Spruce/Tamarack	
Black Spruce Bog	10
Muskeg	7
Tamarack Rich Swamp	5
Tamarack Poor Swamp	3
Cedar Swamp	
Northern Wet Mesic Forest	10
Northern Mesic Forest	
Northern Mesic Forest	10
Northern Dry Forest	
Northern Dry Mesic Forest	10
Northern Dry Forest	1
Southern Dry Forest	
Southern Dry Mesic Forest	8
Southern Dry Forest	5
Central Sands Pine Oak Forest	2
Southern Mesic Forest	
Southern Mesic Forest	4
Floodplain Forest	
Floodplain Forest	8
Shrub wetlands	
Shrub Carr	6
Alder Thicket	5
Bog Relict/open bog	3

Natural Community	Number of transects
Sedge Meadows	
Southern Sedge Meadow	7
Central Poor Fen	4
Northern Sedge Meadow	3
Wet Prairies	
Wet Mesic Prairie	10
Mesic Prairie	3
Calcareous Fen	1
Dry Prairies	
Dry Mesic Prairie	8
Dry Prairie	7
Dry Sand prairie	4
Oak Barrens	
Oak Barrens	10
Oak Opening	2
Pine Barrens	
Pine Barrens	16

* Eight transects were not used in groupings because they did not have ≥4 transects; hardwood swamp (3), old meadow/prairie (2), white pine red maple swamp (2), southern hardwood swamp (1).

APPENDIX 2

Summary of AIC model selection for 12 Wisconsin small mammal species using single-season occupancy models. Models are ranked for each species by relative difference in AIC_c (ΔAICc); AIC model weights are denoted by w_i and number of parameters by *k*. Occupancy covariates (ψ) and detection covariates (*p*) are defined in the methods section.

Species and model	ΔAICc	w_i	*k*
Blarina brevicauda			
ψ(SHRUBh)(BAh) *p*(Pitfall)	0.00	0.354	5
ψ(BAh) *p*(Pitfall)	1.70	0.151	4
ψ(BAh)(CWD) *p*(Day)	3.35	0.066	5
ψ(SHRUBh) *p*(Pitfall)	3.41	0.064	4
ψ(Herb)(CWD) *p*(Pitfall)	3.73	0.055	5
ψ(CWD) *p*(Day)	3.75	0.054	4
ψ(Herb)(CWD)(BAh) *p*(Pitfall)	4.25	0.042	6
ψ(CWD) *p*(Pitfall)(Precip)	4.33	0.041	5
ψ(Herb) *p*(Pitfall)	4.46	0.038	4
ψ(BAh)(CWD) *p*(·)	4.62	0.035	4
ψ(Herb)(CWD)(SHRUBh)(BAh) *p*(·)	5.88	0.019	6
ψ(Herb)(SHRUBh) *p*(Temp)	6.24	0.016	5
ψ(Herb) *p*(Day)	6.23	0.016	4
ψ(Herb)(Litter)(Pitfall) *p*(·)	6.58	0.013	5
ψ(Herb)(CWD)(BAh) *p*(·)	6.70	0.012	5
ψ(·) *p*(Pitfall)(Day)	6.97	0.011	4
ψ(Herb)(BAh) *p*(Temp)	7.89	0.007	5
ψ(Herb)(CWD) *p*(Precip)	8.78	0.004	5
ψ(·) *p*(·)	11.59	0.001	2
ψ(Herb)(Litter) *p*(Precip)	11.88	0.001	5

Species and model	ΔAICc	w_i	k
Microtus pennsylvanicus			
ψ(SOIL)(BAh)(BAs)(Herb)	0.00	0.794	6
ψ(SOIL)(BAh)(BAs)	2.76	0.200	5
ψ(Herb)(Litter)SOIL) *p*(Pitfall)	11.03	0.003	6
ψ(Herb)(Litter) *p*(Pitfall)	11.58	0.002	5
ψ(SOIL)(Litter)(Herb)	15.75	0.000	5
ψ(Herb)(Litter)(SOIL) *p*(Day)	16.12	0.000	6
ψ(SOIL)(Herb) *p*(Pitfall)	16.62	0.000	5
ψ(Herb)(Litter)(SOIL) *p*(Precip)	17.75	0.000	6
ψ(Herb) *p*(Pitfall)(Precip)	17.92	0.000	5
ψ(Herb)(CWD)(BAs)	20.10	0.000	5
ψ(BAh)(BAs) *p*(Day)	20.19	0.000	5
ψ(Herb) *p*(Precip)	21.46	0.000	4
ψ(CWD)(BAh)(BAs) *p*(Precip)	23.17	0.000	6
ψ(Herb)(BAh)BAs) *p*(Day)	23.83	0.000	5
ψ(CWD)(Litter) *p*(Temp)	34.02	0.000	5
ψ(·) *p*(Litter)(Pitfall)	49.72	0.000	4
ψ(·) *p*(Pitfall)(Precip)	56.30	0.000	4
ψ(·) *p*(·)	56.63	0.000	2

Species and model	ΔAICc	w_i	k
Myodes gapperi			
ψ(BAs)(CWD)(Wtemp) *p*(Day)	0.00	0.567	6
ψ(CWD)(BAs) *p*(Day)	1.24	0.305	5
ψ(SHRUBh)(SHRUBl)(BAs) *p*(Temp)	3.69	0.090	6
ψ(BAs)(SOIL)(Wtemp) *p*(Day)	6.69	0.020	6
ψ(CWD)(BAs)(SOIL)	9.13	0.006	5
ψ(SHRUBh)(CWD)(BAs)	10.34	0.003	5
ψ(BAs)(Wtemp) *p*(Day)	10.39	0.003	5
ψ(CWD)(BAs)(Wtemp) *p*(Temp)	11.00	0.002	6
ψ(BAs) *p*(Day)	10.98	0.002	4
ψ(SOIL)(BAs)(SHRUBl)	14.32	0.000	5
ψ(SHRUBh)(SHRUBl)(CWD) *p*(Day)	14.54	0.000	6
ψ(CWD)(BAs)(Wtemp)	14.45	0.000	5
ψ(BAs)(CWD) *p*(Precip)	14.53	0.000	5
ψ(SHRUBl)(BAs)(Wtemp)	17.19	0.000	5
ψ(BAs)(SOIL)(Wtemp) *p*(Precip)	20.22	0.000	6
ψ(CWD)(Wtemp) *p*(Day)	20.60	0.000	5
ψ(BAs)	25.47	0.000	3
ψ(Herb)(CWD)	51.58	0.000	4
ψ(·) *p*(Wtemp)(Day)	68.45	0.000	4
ψ(·) *p*(·)	80.61	0.000	2

Species and model	ΔAICc	w_i	k
Peromyscus leucopus			
ψ(BAh) *p*(Sherman)	0.00	0.557	4
ψ(BAh) *p*(Sherman)(Day)	2.11	0.194	5
ψ(BAh)(CWD) *p*(Sherman)(Day)	2.65	0.148	6
ψ(Herb)(CWD) *p*(Sherman)	3.49	0.097	5
ψ(CWD) *p*(Sherman)	11.17	0.002	4
ψ(BAh)(SOIL) *p*(Sherman)	13.85	0.001	5
ψ(BAh)(CWD)(SOIL) *p*(Sherman)	14.96	0.000	6
ψ(BAh)(CWD) *p*(Sherman)	19.71	0.000	5
ψ(·) *p*(Sherman)(Day)	29.35	0.000	4
ψ(BAh)(SOIL)(Wtemp)	56.88	0.000	5
ψ(BAh)(CWD)(SOIL) *p*(Day)	58.82	0.000	6
ψ(CWD)(BAh)(Wtemp)	58.97	0.000	5
ψ(BAh)(CWD)(SHRUBl)	60.08	0.000	5
ψ(BAh)(Wtemp) *p*(Day)	62.44	0.000	5
ψ(SHRUBl)(BAh) *p*(Day)	62.70	0.000	5
ψ(BAh)(CWD) *p*(Day)	64.33	0.000	5
ψ(BAh)(CWD) *p*(Day)	64.33	0.000	5
ψ(SOIL)(BAh)(CWD)	82.69	0.000	5
ψ(BAh)	86.05	0.000	3
ψ(·) *p*(·)	90.17	0.000	2

Species and model	ΔAICc	w_i	k
Peromyscus maniculatus gracilis			
ψ(BAh)(BAs)(Wtemp) *p*(Day)	0.00	0.653	6
ψ(CWD)(BAs)(Bah)(Wtemp)	1.46	0.315	6
ψ(CWD)(BAs)(Wtemp) *p*(Day)	6.95	0.020	6
ψ(CWD)(BAs)(Wtemp)	9.22	0.006	5
ψ(CWD)(Wtemp) *p*(Day)	10.87	0.003	5
ψ(CWD)(BAs)(SOIL)(Wtemp)	11.22	0.002	6
ψ(BAs)(Wtemp) *p*(Sherman)	15.23	0.000	5
ψ(BAs)(Wtemp) *p*(Day)	15.84	0.000	5
ψ(BAs)(SOIL)(Wtemp)	19.92	0.000	5
ψ(BAh)(BAs)(CWD) *p*(Day)	40.23	0.000	6
ψ(CWD)(Herb)(BAs) *p*(Sherman)	41.68	0.000	6
ψ(BAh)(BAs)(CWD)	42.39	0.000	5
ψ(·) (day) *p*(Sherman)	70.06	0.000	4
ψ(·) *p*(·)	71.74	0.000	2

Species and model	ΔAICc	w_i	k
Sorex arcticus			
ψ(SOIL)(Herb)(Litter) *p*(Pitfall)	0.00	0.659	6
ψ(SOIL)(Herb)(Litter)(Wtemp)	1.80	0.268	6
ψ(SOIL)(Herb)(SHRUBh)	6.10	0.031	5
ψ(SOIL)(Herb)(Wtemp)	7.13	0.019	5
ψ(SOIL)(Litter)(Wtemp)	8.07	0.012	5
ψ(SOIL)(Herb)(Wtemp) *p*(Pitfall)	8.31	0.010	6
ψ(SOIL)(Wtemp) *p*(Precip)	14.01	0.001	5
ψ(SOIL)(SHRUBh)(Wtemp)	15.24	0.000	5
ψ(SOIL) *p*(Pitfall)(Precip)	15.25	0.000	5
ψ(SOIL)(Wtemp) *p*(Day)	16.41	0.000	5
ψ(SOIL)(SHRUBh)(Wtemp) *p*(Day)	17.38	0.000	6
ψ(Herb)(Litter)(SHRUBl) *p*(Pitfall)	18.98	0.000	6
ψ(Herb)(SHRUBh) p(Pitfall)	22.87	0.000	5
ψ(·) *p*(·)	50.42	0.000	2
ψ(·) *p*(Pitfall)(Precip)	52.24	0.000	4

Species and model	ΔAICc	w_i	k
Sorex cinereus			
ψ(Herb)(SHRUBl)(SOIL) *p*(Pitfall)	0.00	0.550	6
ψ(SOIL) *p*(Pitfall)(Precip)	1.37	0.277	5
ψ(SOIL)(Herb) *p*(Precip)(Temp)	5.07	0.044	6
ψ(Herb) *p*(Pitfall)(Day)	5.09	0.043	5
ψ(Herb) *p*(Pitfall)	5.87	0.029	4
ψ(·) *p*(Precip)(Pitfall)	6.62	0.020	4
ψ(SOIL) *p*(Pitfall)	6.82	0.018	4
ψ(Litter)(SOIL) *p*(Pitfall)	8.52	0.008	5
ψ(SOIL)(Herb)(Litter) *p*(Day)	9.68	0.004	6
ψ(SOIL) *p*(Precip)	9.84	0.004	4
ψ(SHRUBl) *p*(Precip)	11.34	0.002	4
ψ(Herb)(Litter) *p*(Precip)	13.47	0.001	5
ψ(Herb)(Litter) *p*(Day)	14.98	0.000	5
ψ(·) *p*(Precip)(Day)	15.17	0.000	4
ψ(·) *p*(·)	20.65	0.000	2
ψ(BAh)(BAs)(SOIL)	56.50	0.000	5
ψ(SOIL)(Herb)	57.13	0.000	4
ψ(Herb)(SHRUBl)(SOIL)	59.25	0.000	5
ψ(Herb)(Litter)(SOIL)	59.25	0.000	5

Species and model	ΔAICc	w_i	k
Sorex hoyi			
ψ(Litter)(SHRUBl) *p*(Pitfall)	0.00	0.325	5
ψ(Litter)(Wtemp) *p*(Pitfall)	1.81	0.132	5
ψ(Herb)(Litter) *p*(Pitfall)	1.92	0.125	5
ψ(SOIL)(Litter)	1.93	0.124	4
ψ(SOIL) *p*(Pitfall)	3.25	0.064	4
ψ(Litter)(SOIL) *p*(Day)	3.83	0.048	5
ψ(·) p(Pitfall)(Precip)	3.97	0.045	4
ψ(·) *p*(Pitfall)(Day)	4.32	0.037	4
ψ(Herb)(Litter)(Wtemp)	4.88	0.028	5
ψ(·) *p*(·)	4.70	0.031	2
ψ(Herb) *p*(·)	6.54	0.012	3
ψ(Herb)(SHRUBl) *p*(Day)	6.84	0.011	5
ψ(SOIL)(Wtemp)	7.19	0.009	4
ψ(Herb)(Wtemp)	7.96	0.006	4
ψ(CWD)(BAs) *p*(Precip)	9.29	0.003	5

Species and model	ΔAICc	w_i	k
Ictidomys tridecemlineatus			
ψ(SOIL)(BAh) *p*(Sherman)	0.00	0.987	5
ψ(SOIL)(Herb) *p*(Sherman)	8.63	0.013	5
ψ(SOIL)(BAh) *p*(Day)	22.72	0.000	5
ψ(SOIL)(BAh)(Herb)	25.29	0.000	5
ψ(SOIL)(Herb)	32.43	0.000	4
ψ(SOIL)(Herb) *p*(Temp)	34.43	0.000	5
ψ(Herb) *p*(Sherman)	46.62	0.000	4
ψ(Herb) *p*(Sherman)(Precip)	46.83	0.000	5
ψ(·) *p*(Sherman)(Precip)	50.83	0.000	4
ψ(BAh)(BAs)(Herb)	57.60	0.000	5
ψ(Herb)(Litter) *p*(Day)	66.60	0.000	5
ψ(·) p(·)	72.22	0.000	2

Species and model	ΔAICc	w_i	k
Synaptomys cooperi			
ψ(BAs)(SHRUBl)(Wtemp)	0.00	0.316	5
ψ(SHRUBl)(Wtemp)	0.92	0.199	4
ψ(BAs)(SOIL)(Wtemp)(SHRUBl)	1.95	0.119	6
ψ(BAs)(SHRUBl)(Wtemp) *p*(Day)	1.98	0.118	6
ψ(SHRUBl)(Herb)(BAs)(Wtemp)	2.11	0.110	6
ψ(SOIL)(SHRUBl)(Wtemp)	2.67	0.083	5
ψ(BAs)(SOIL)(Wtemp)	5.38	0.021	5
ψ(SOIL)(Wtemp) *p*(Pitfall)	6.15	0.015	5
ψ(BAs)(CWD)(Wtemp)	6.78	0.011	5
ψ(BAs)(SHRUBl)(SOIL)	7.52	0.007	5
ψ(·) p(·)	24.44	0.000	2
ψ(·)(Pitfall)(Precip)	27.81	0.000	4

Species and model	ΔAICc	w_i	k
Tamias striatus			
ψ(BAh)(CWD) *p*(Day)	0.00	0.370	5
ψ(BAh)(BAs)(CWD) *p*(Day)	1.49	0.176	6
ψ(BAs)(CWD) *p*(Day)	1.40	0.184	5
ψ(CWD)(BAh) *p*(Day)(Sherman)	1.56	0.170	6
ψ(CWD)(BAh) *p*(Sherman)	5.81	0.020	5
ψ(·) *p*(Sherman)(Day)	5.94	0.019	4
ψ(BAh)(BAs)(SHRUBh)	6.81	0.012	5
ψ(BAh)(BAs)(CWD)	6.85	0.012	5
ψ(CWD)(BAs) *p*(Sherman)	7.00	0.011	5
ψ(SOIL)(BAh)(BAs)	7.06	0.011	5
ψ(BAh)(BAs)(CWD) *p*(Sherman)	7.28	0.010	6
ψ(BAh)(Herb) *p*(Sherman)	9.14	0.004	5
ψ(·) p(·)	10.22	0.002	2

Species and model	ΔAICc	w_i	k
Zapus hudsonius			
ψ(·) *p*(Pitfall)(Precip)	0.00	0.489	4
ψ(·) *p*(Pitfall)(Precip)(Temp)(Day)	1.23	0.265	6
ψ(Herb)(Pitfall)(Precip)	2.01	0.179	5
ψ(·) *p*(Precip)	5.64	0.029	3
ψ(SOIL)(BAh)(BAs) *p*(Precip)	7.28	0.013	6
ψ(Herb) *p*(Precip)	7.72	0.010	4
ψ(SOIL)(Herb) *p*(Precip)	9.04	0.005	5
ψ(Herb)(CWD) *p*(Precip)	9.21	0.005	5
ψ(·) *p*(Pitfall)	11.72	0.001	3
ψ(Litter) *p*(Pitfall)	12.80	0.001	4
ψ(·) *p*(·)	12.82	0.001	2
ψ(SOIL)(CWD)(BAh)(BAs)	14.78	0.000	6
ψ(BAh)(BAs)(Herb) *p*(Pitfall)	14.96	0.000	6
ψ(SOIL)(Herb) *p*(Pitfall)	14.87	0.000	5
ψ(·) *p*(Day)(Temp)	14.79	0.000	4
ψ(Herb)(Litter)	15.68	0.000	4
ψ(SHRUBh)(Herb)(Litter)	16.01	0.000	5
ψ(SOIL)(Herb)(Litter)	16.07	0.000	5
ψ(SHRUBl)(Herb)(Litter)	16.80	0.000	5
ψ(CWD)(Herb)(Litter)	16.84	0.000	5

APPENDIX A

DIFFERENTIATION OF MASKED SHREW (*SOREX CINEREUS*) AND PYGMY SHREW (*SOREX HOYI*)

Although many studies forgo differentiation between masked and pygmy shrews, these species can be identified in the field using a number of morphological differences. The most reliable way to distinguish these shrews is by looking at the dentition in the upper tooth row. Masked shrews have 4 visible small unicuspid teeth and pygmy shrews have 3 visible unicuspid teeth (Figure 1). This can be done in the field with whole specimens by pulling back the upper gum. However, live shrews quickly expire when handled extensively and this is best used on animals that are already deceased. A hand lens may be needed to aid in viewing these small teeth.

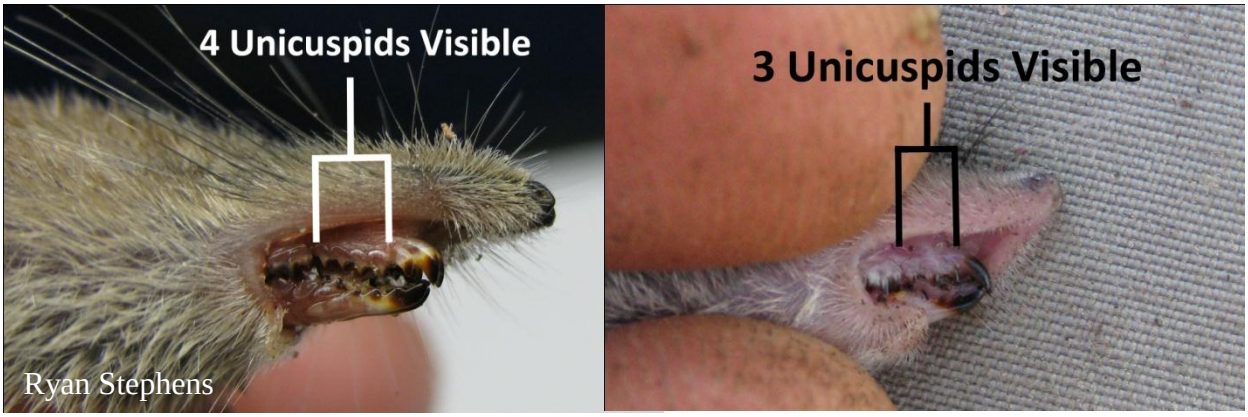


Figure 1. Unicuspid teeth for masked shrew (a) and pygmy shrew (b). Note that teeth are visible on un-skinned shrews.

Masked and pygmy shrews can also be identified by tail length. Tails should be measured from the base of the tail to the end of the caudal vertebra, excluding the hairs at the tip of the tail. Masked shrews have tail lengths > 33 mm and pygmy shrews have tails

≤ 33 mm in length (Figure 2). Masked shrews tend to be larger than pygmy shrews (figure 2), but this does not always hold true across age groups. Masked shrews also tend to have a more brown hue to their pelage than the grayer pelage of the pygmy shrew (Figure 2 & 3). In addition, pygmy shrews have a more obtuse rostrum than the masked shrew (Figure 3). With these simple morphological characteristics masked shrews and pygmy shrews can be distinguished in the field.

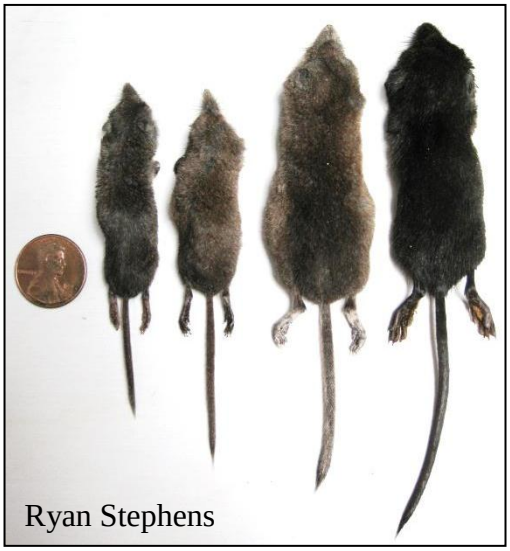


Figure 2. Wisconsin shrews of the genus *Sorex*. From left to right: pygmy shrew, masked shrew, arctic shrew, and water shrew.



Figure 3. Cranial views of pygmy shrew (left) and masked shrew (right). Note the more obtuse rostrum of the pygmy shrew.

APPENDIX B

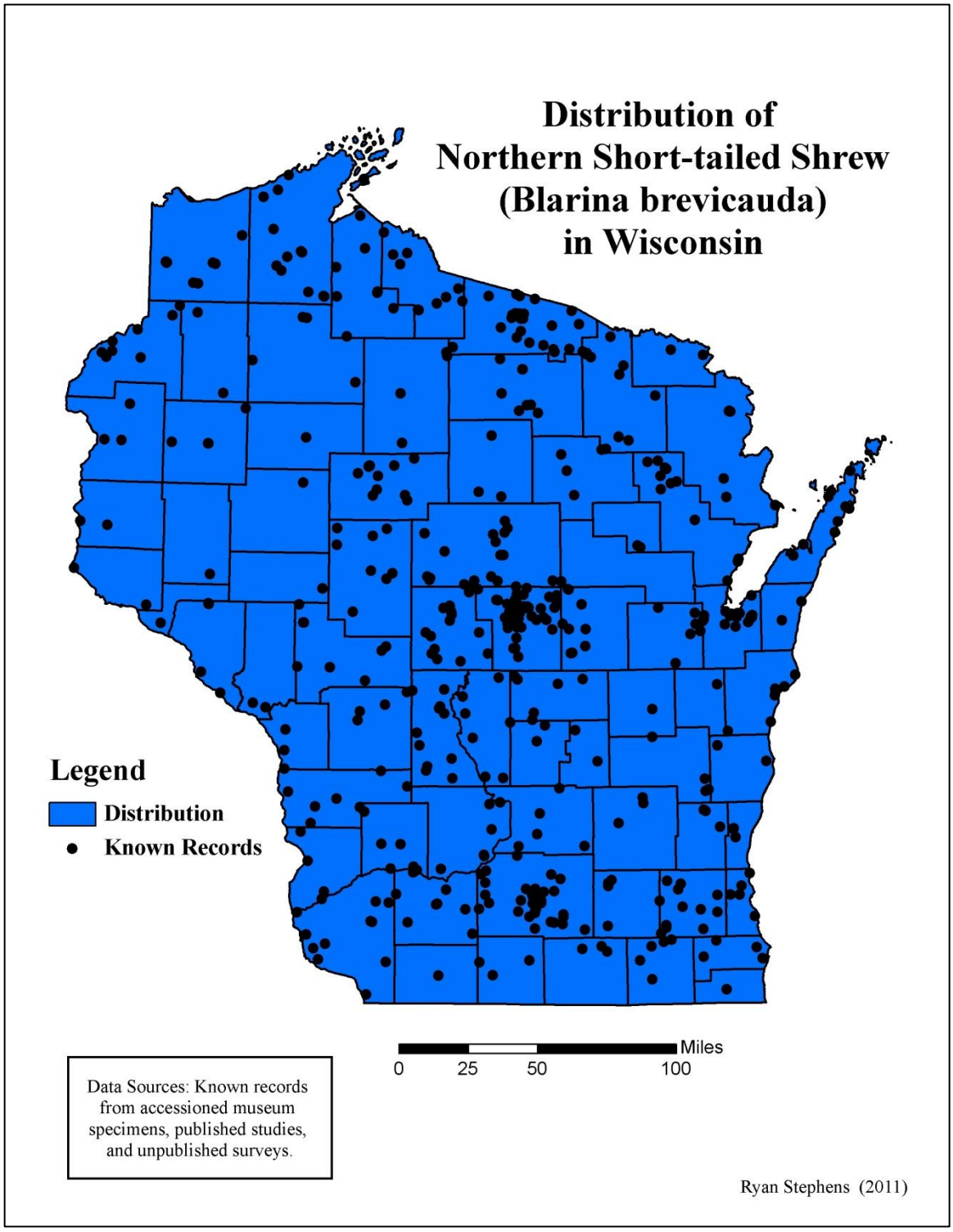
DISTRIBUTIONAL RANGE MAPS OF WISCONSIN SMALL MAMMALS

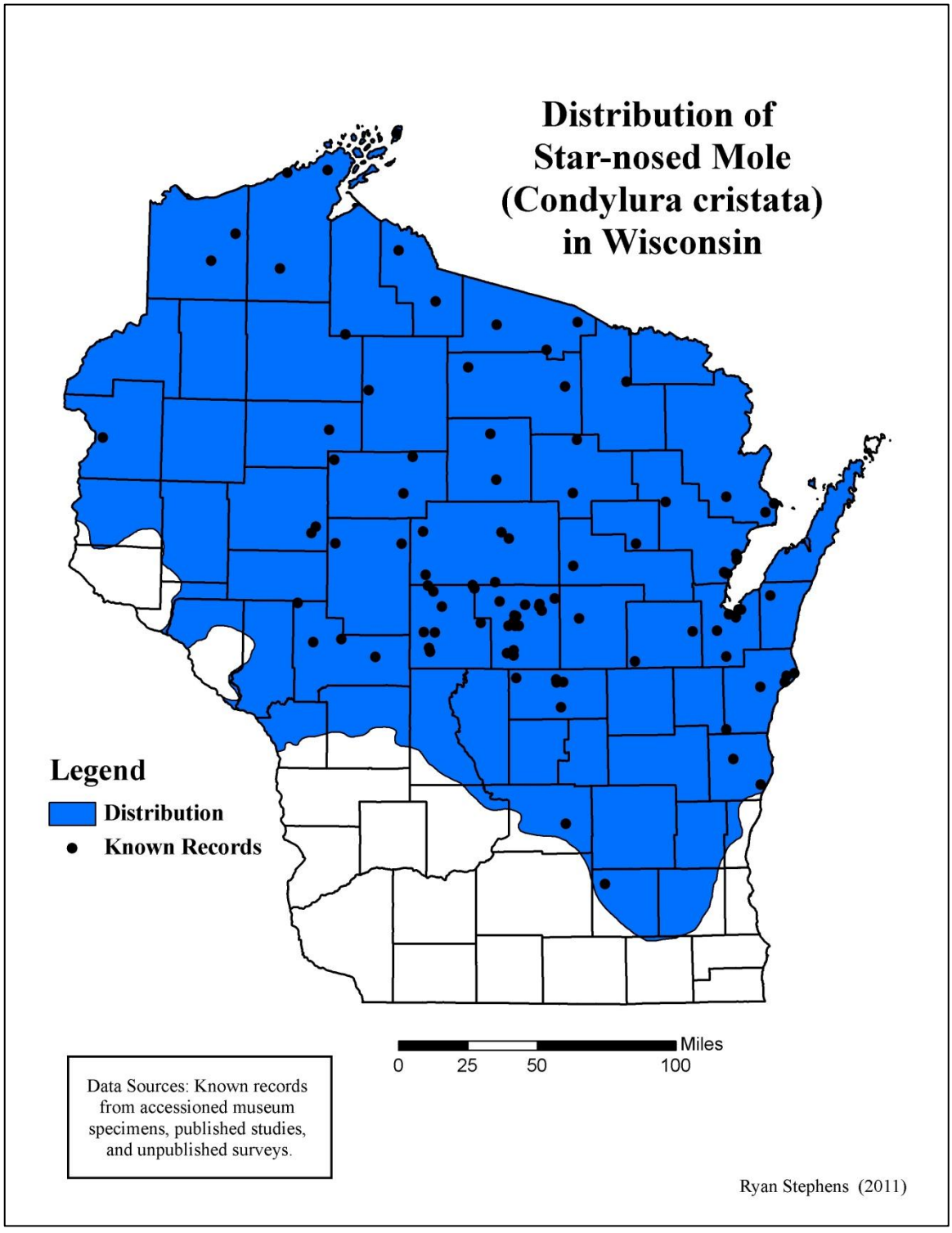
The following distributional range maps were created from museum records, published trapping records, and results from my own trapping efforts. Geo-referenced museum records were acquired from the WDNR (J. Rosenberg, unpublished data). Museum records were obtained by searching accredited museums in MaNIS (Mammal Networked Information System). Additionally, records from other regional museums with electronic databases, but that were not in MaNIS were also searched. All records were mapped within a geographic information system (GIS). For the purpose of mapping, redundant locations were deleted. Specimen specific location data ranged from coordinates to features such as lakes or townships. Because of the imprecise nature of many locations, a buffer was added to account for this inaccuracy, with the exception of latitude and longitude coordinates. A buffer of 0.4 km was added to addresses, road junctions, rivers, and roads, whereas a buffer of 3.2 km was added to all other locations. Locations described using the public land survey system (PLSS) were mapped to the smallest subdivision and were not buffered. Imprecise location data, such as those with only county designation were excluded. For the purpose of mapping localities, polygons created from the buffers were changed to centroids.

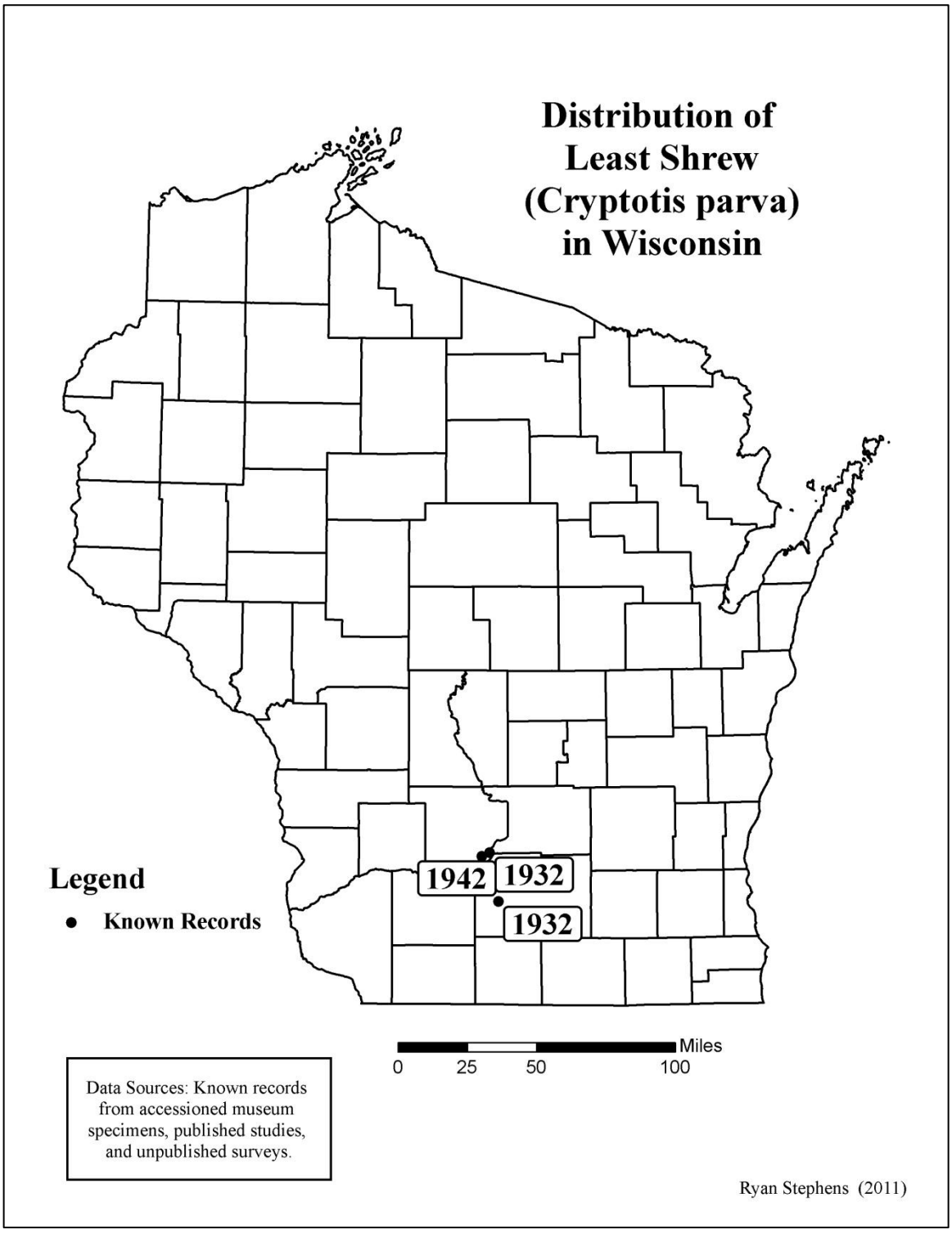
Published studies used in species distribution mapping included Chapman (Small mammal use of three riparian management schemes in southwestern Wisconsin. Master's thesis, University of Wisconsin, Madison. 85pp; 1999) and Fennell (Diversity and abundance of small mammals in old growth and managed forests of northern Wisconsin and

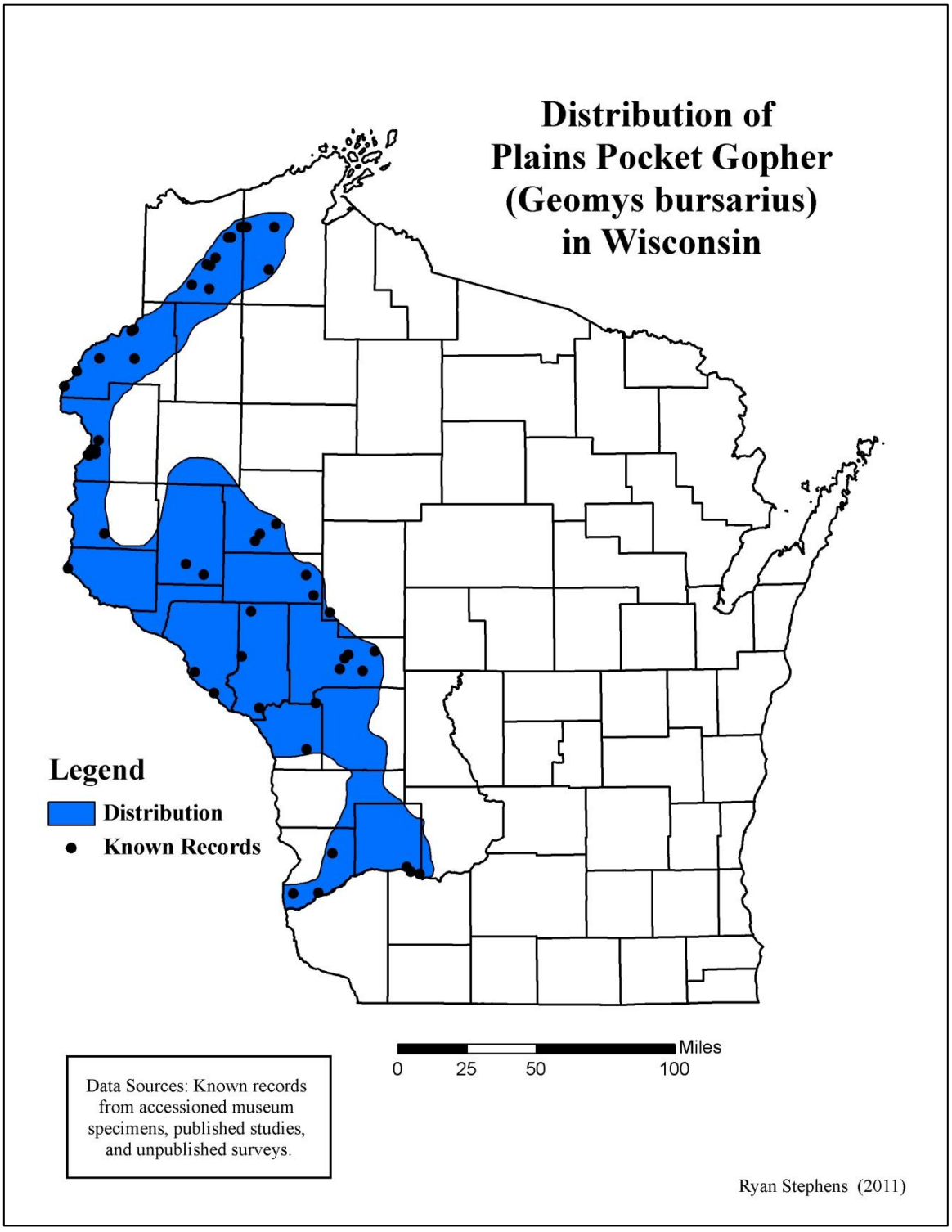
Upper Michigan. Master of Science Thesis, University of Wisconsin-Green Bay, Green Bay, WI, USA. 66pp; 2000). Locations from Chapman (1999) were recorded in PLSS metrics and mapped as centroids. Finnell (2000) provided latitude and longitude coordinates and locations of species were mapped as such. I also included records from my own field work conducted from 2009 to 2011. This included a pilot study in May 2009, prior to field work for this thesis. Trapping included 2 parallel transects of 180 meters from May 19 to 23. Each transect had 20 Sherman live traps spaced every 10 meters and a 0.95 litter pitfall trap every 20 m. One transect was baited with peanut butter and oats and the other with bird seed. For the purpose of mapping, the beginning of the transect was used. I also used results from thesis field work conducted during the summer of 2009-2010 and from survey work for the WDNR in the summer of 2011. Methodology of trapping for these studies are described in Chapter 3. Locations and animals captured from my field work can be found in Appendix E and D, respectively.

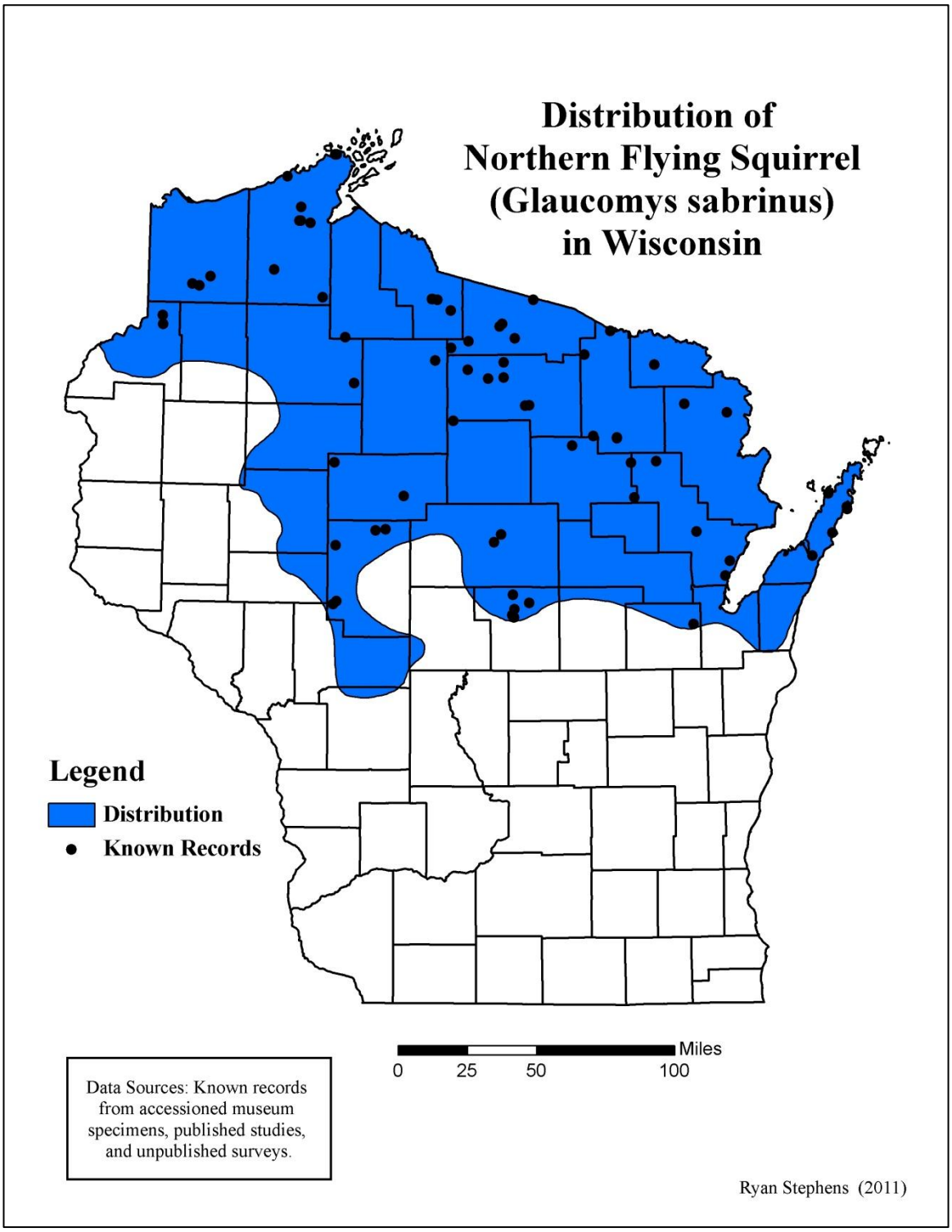
After mapping the distributional data, I drew the projected range of each species based on habitat across the state. I used both pre-European settlement vegetation (http://dnr.wi.gov/maps/gis/documents/orig_vegetation_cover_points.pdf) and current land cover (http://dnr.wi.gov/maps/gis/datalandcover.html) data to draw distributional boundaries within the state. I drew inference from habitat affinities based on the literature and my personal observation. Additionally, I used soil data (http://www.wi.nrcs.usda.gov/technical/soil/index.html) for fossorial species such as moles and pocket gophers to help guide my decisions. Distribution and range maps are available from the author by request.

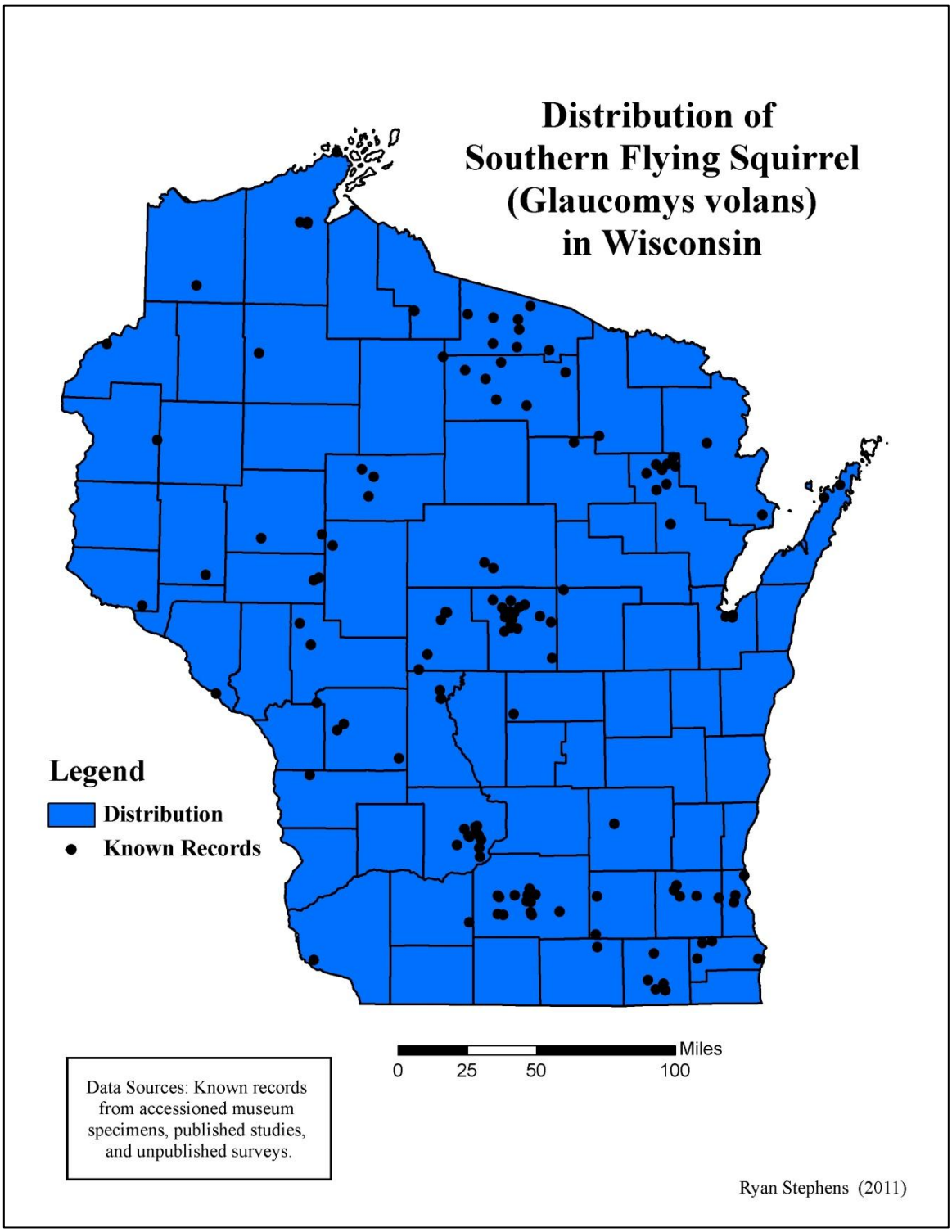

Distribution of
Northern Short-tailed Shrew
(Blarina brevicauda)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

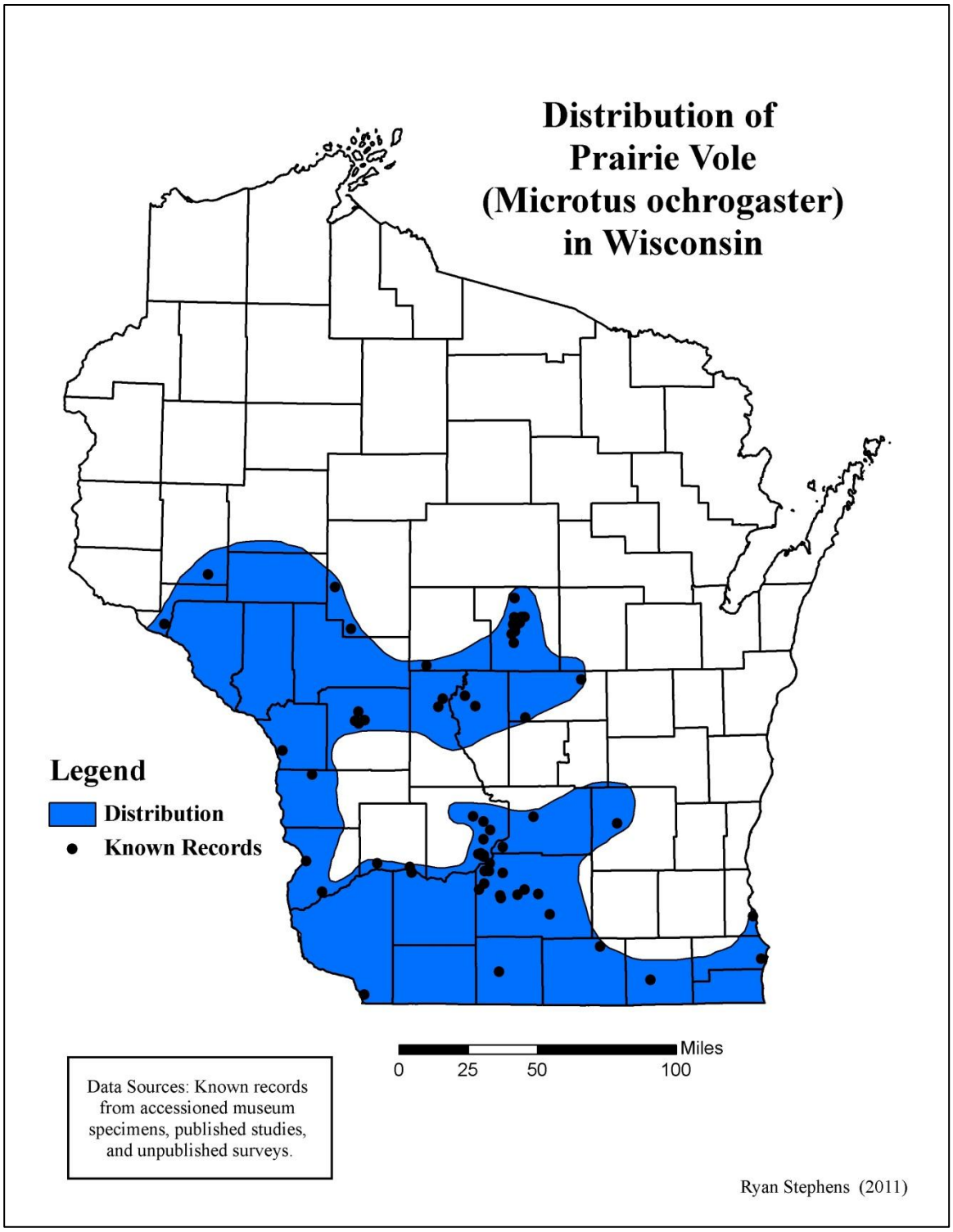

Distribution of
Star-nosed Mole
(Condylura cristata)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

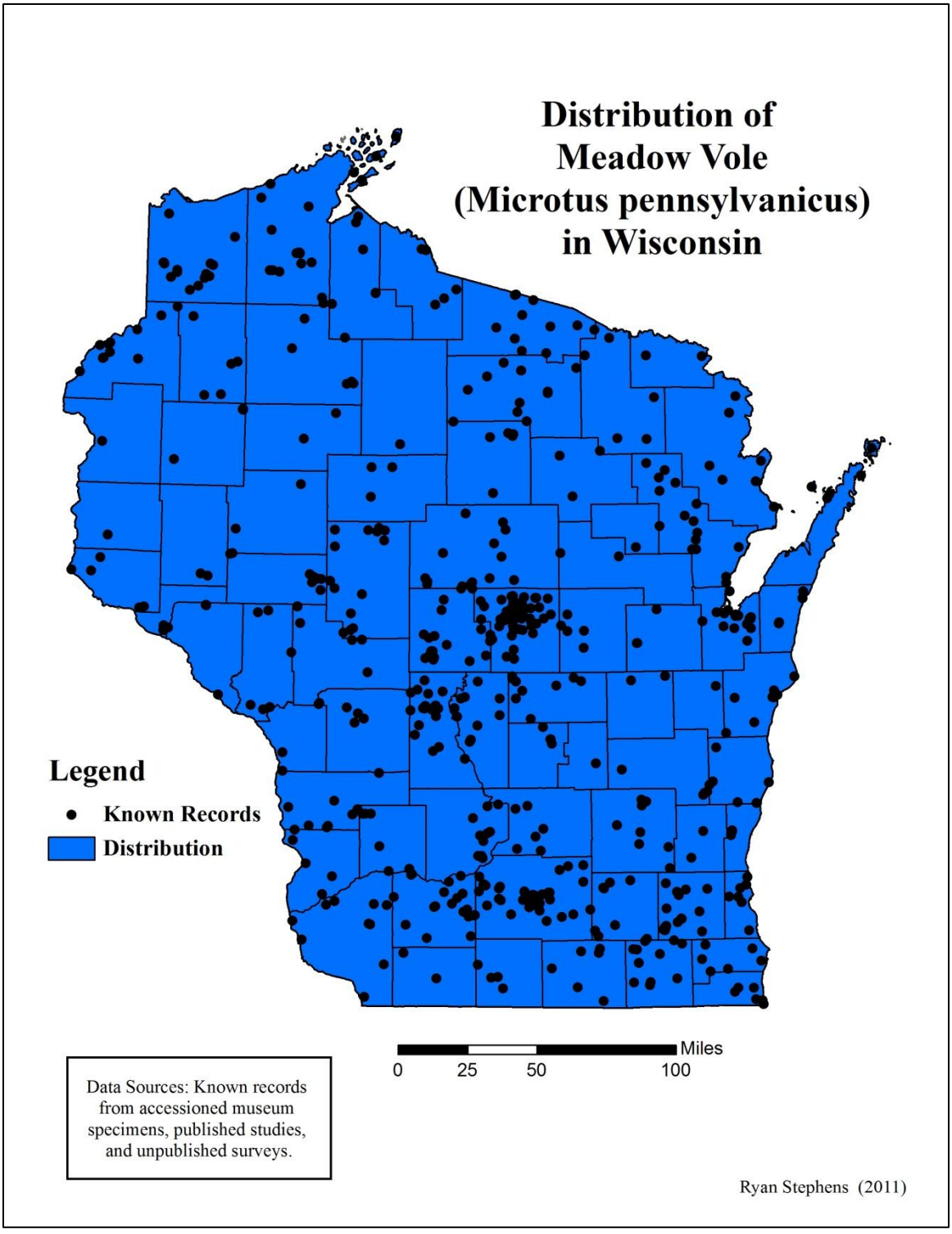

Distribution of
Least Shrew
(Cryptotis parva)
in Wisconsin
Legend
Known Records
1942
1932
1932
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

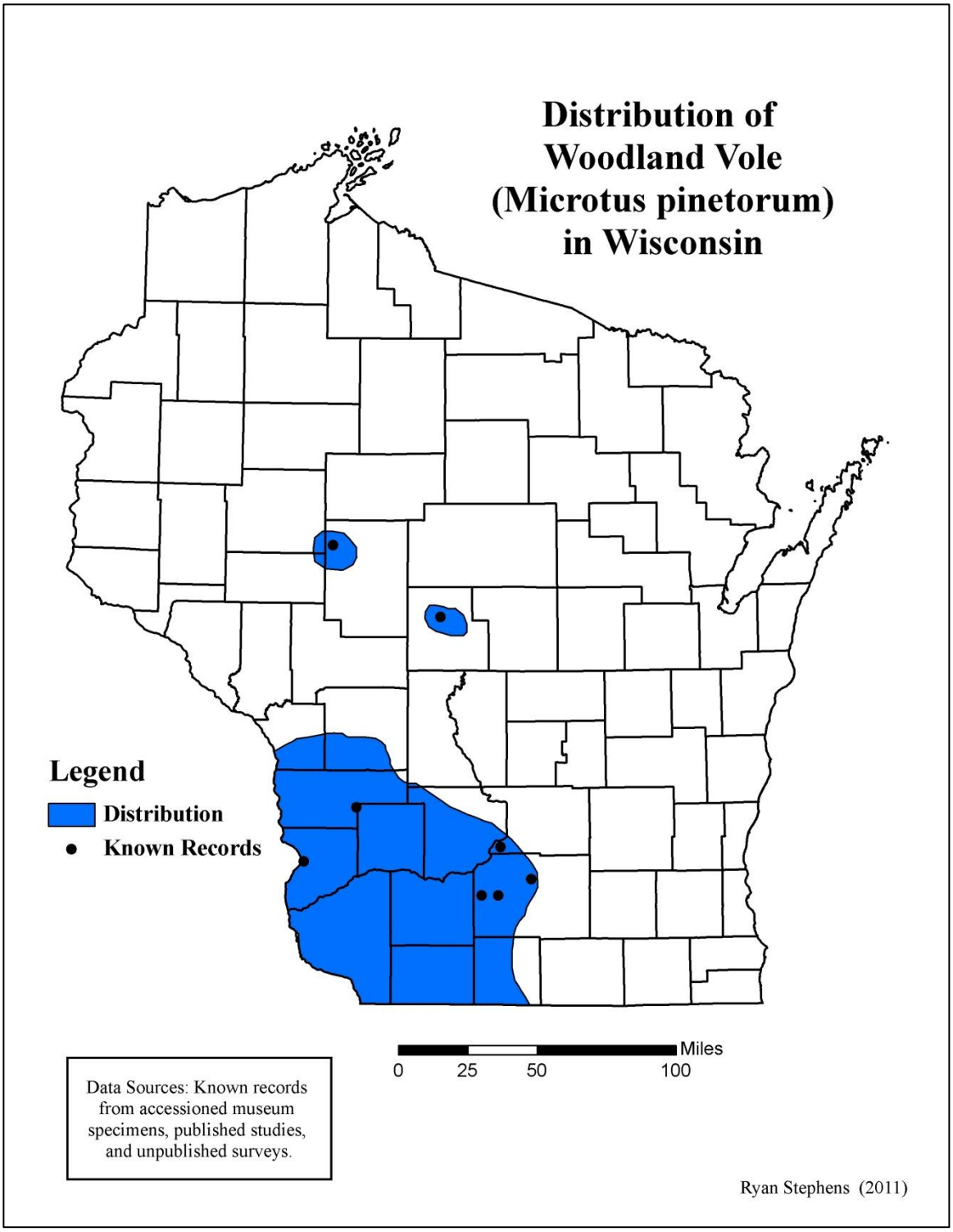

Distribution of
Plains Pocket Gopher
(Geomys bursarius)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

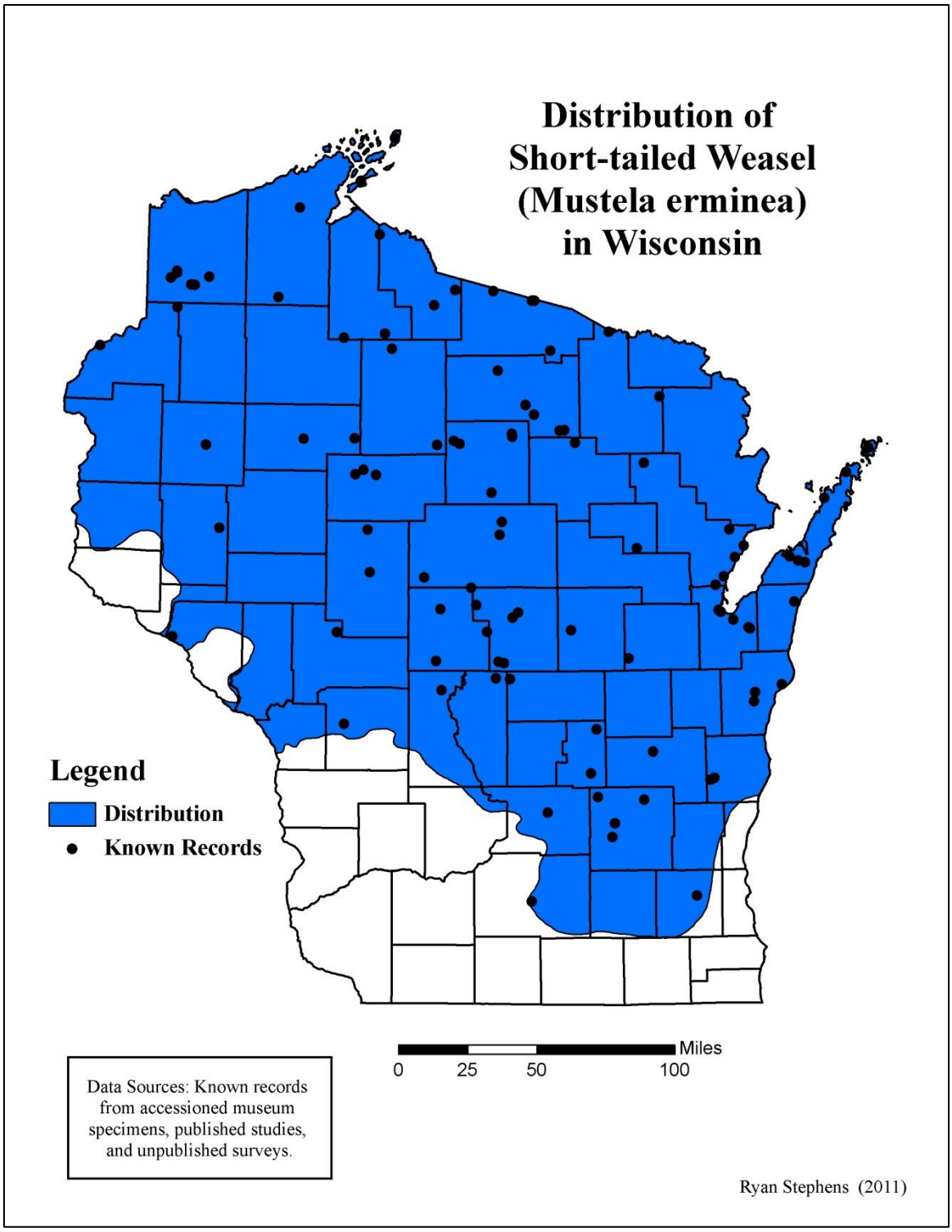

Distribution of
Northern Flying Squirrel
(Glaucomys sabrinus)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

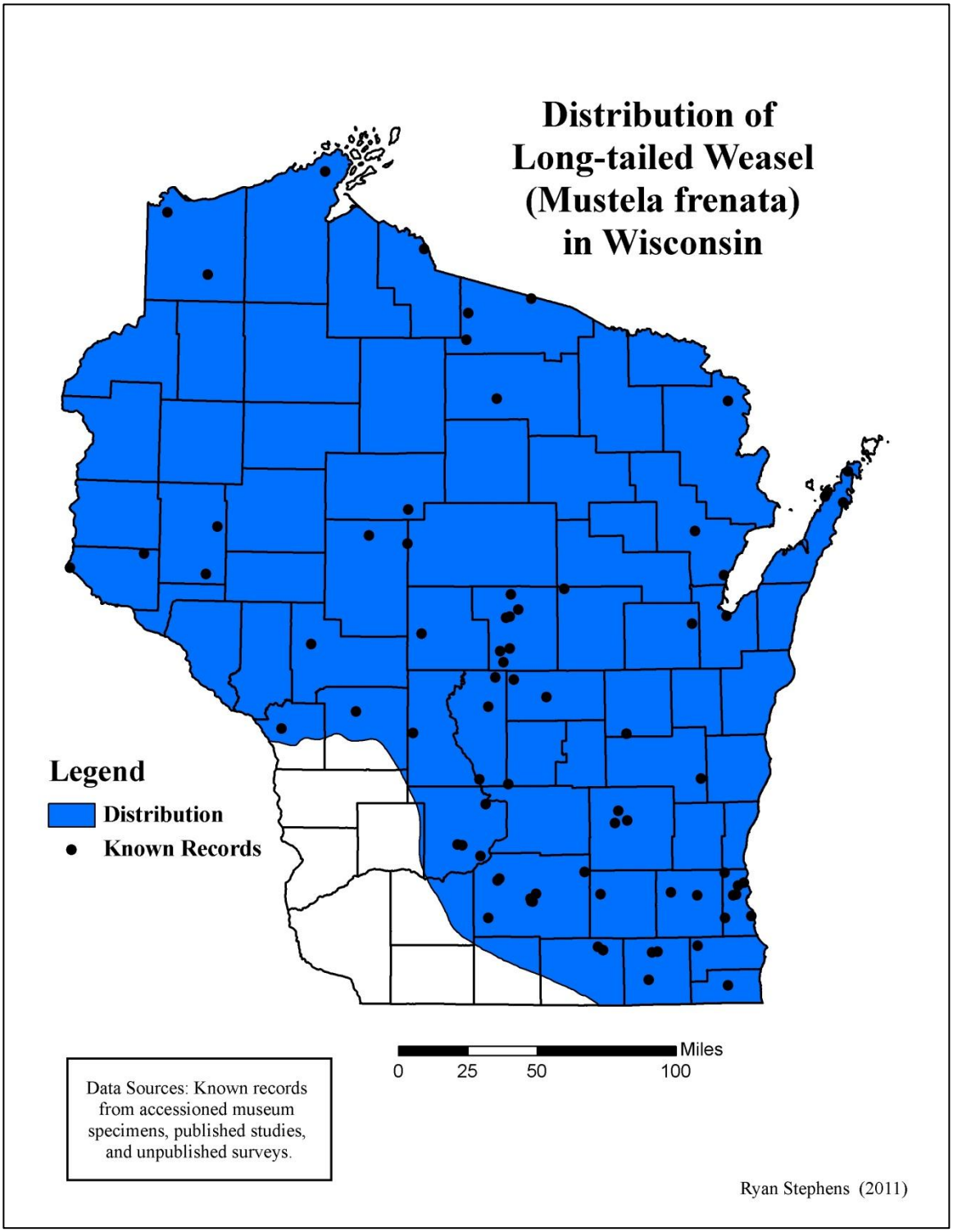

Distribution of
Southern Flying Squirrel
(Glaucomys volans)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

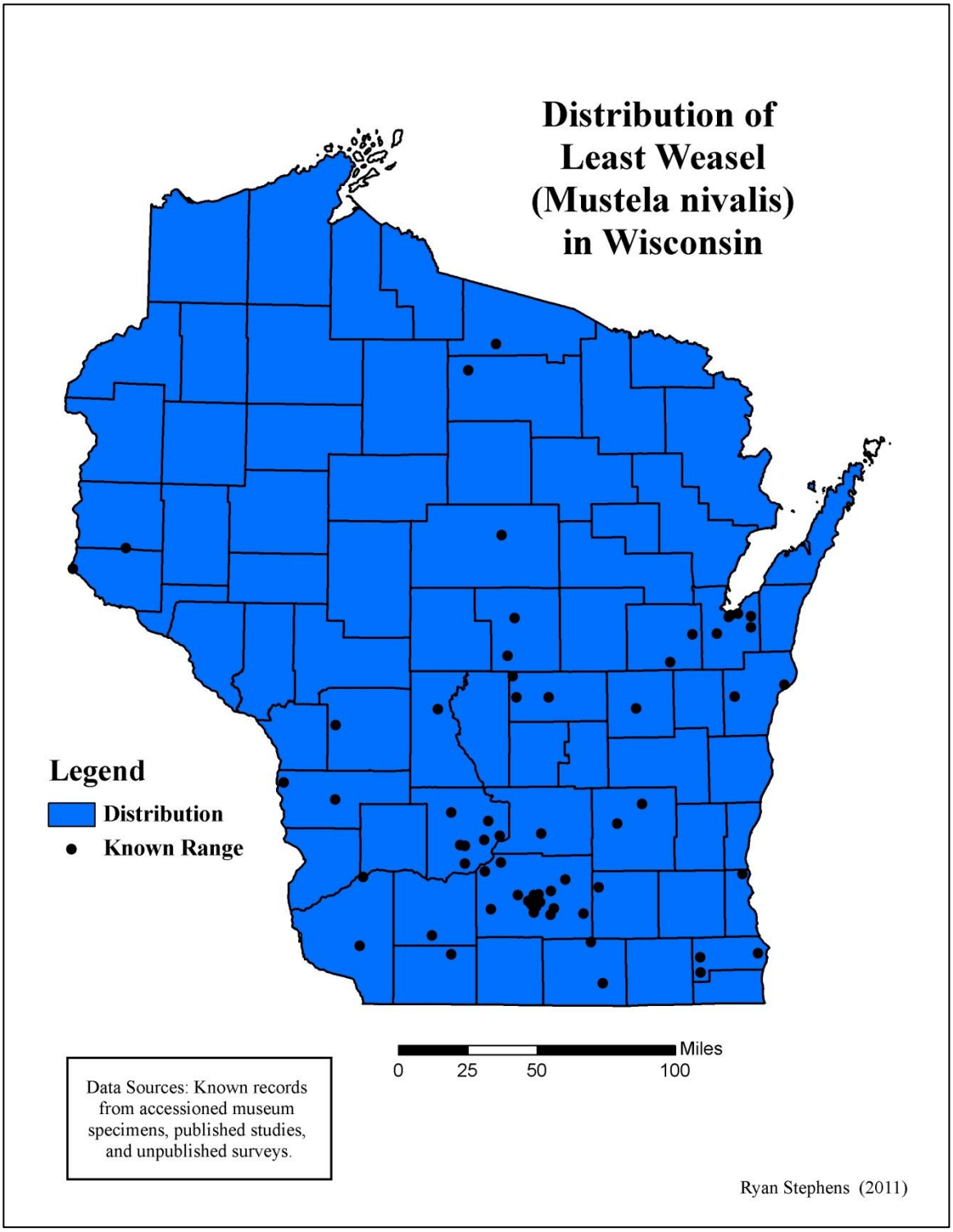

Distribution of
Prairie Vole
(Microtus ochrogaster)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

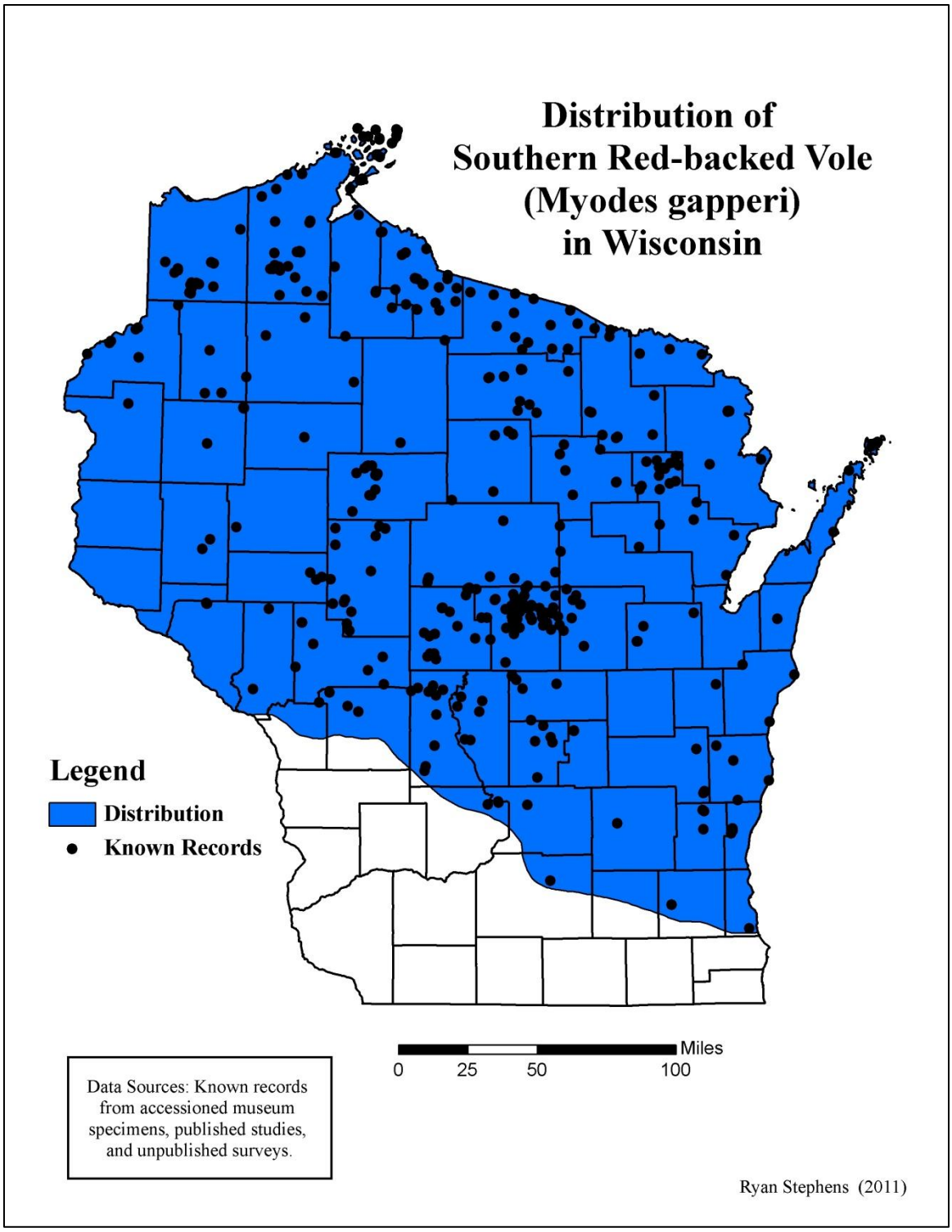

Distribution of
Meadow Vole
(Microtus pennsylvanicus)
in Wisconsin
Legend
Known Records
Distribution
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

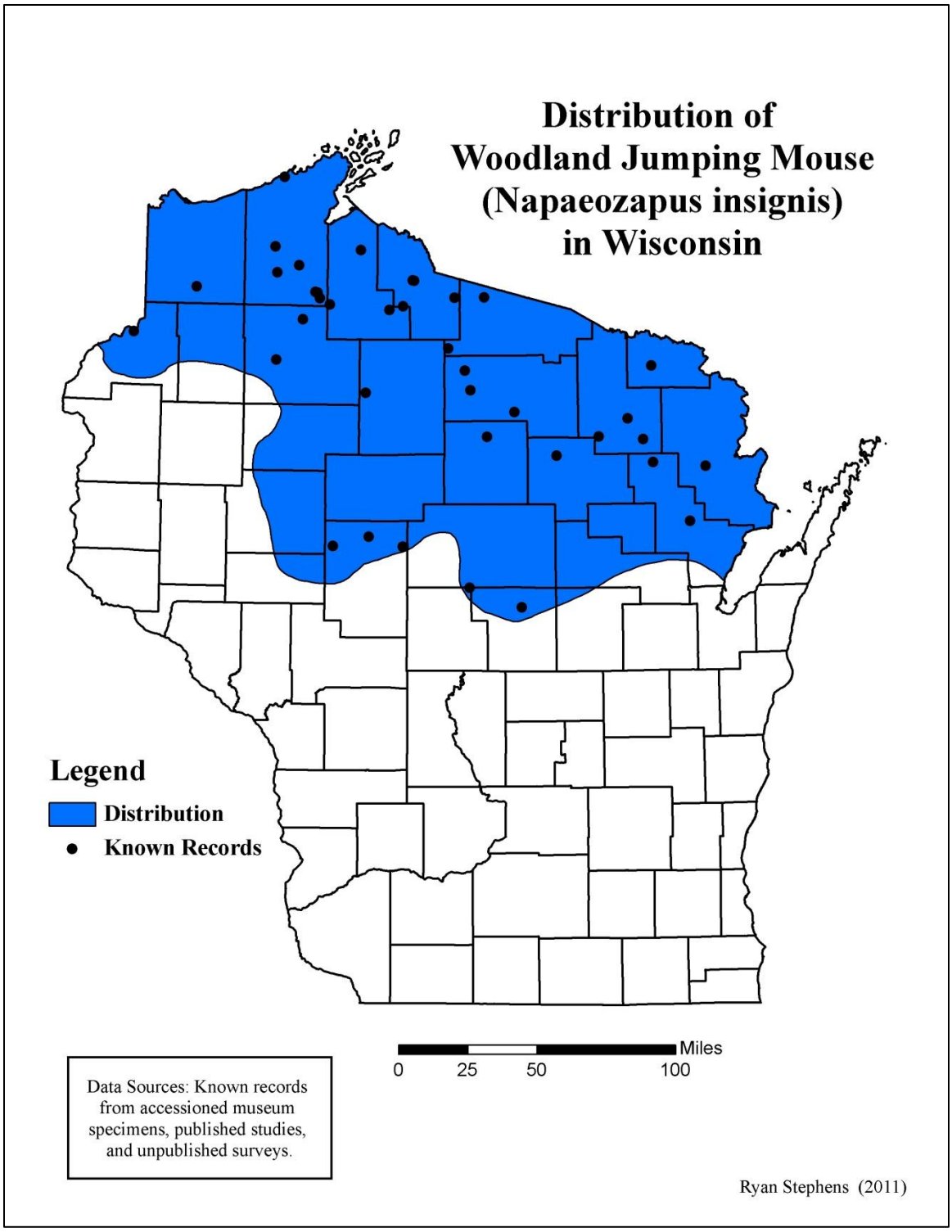

Distribution of
Woodland Vole
(Microtus pinetorum)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

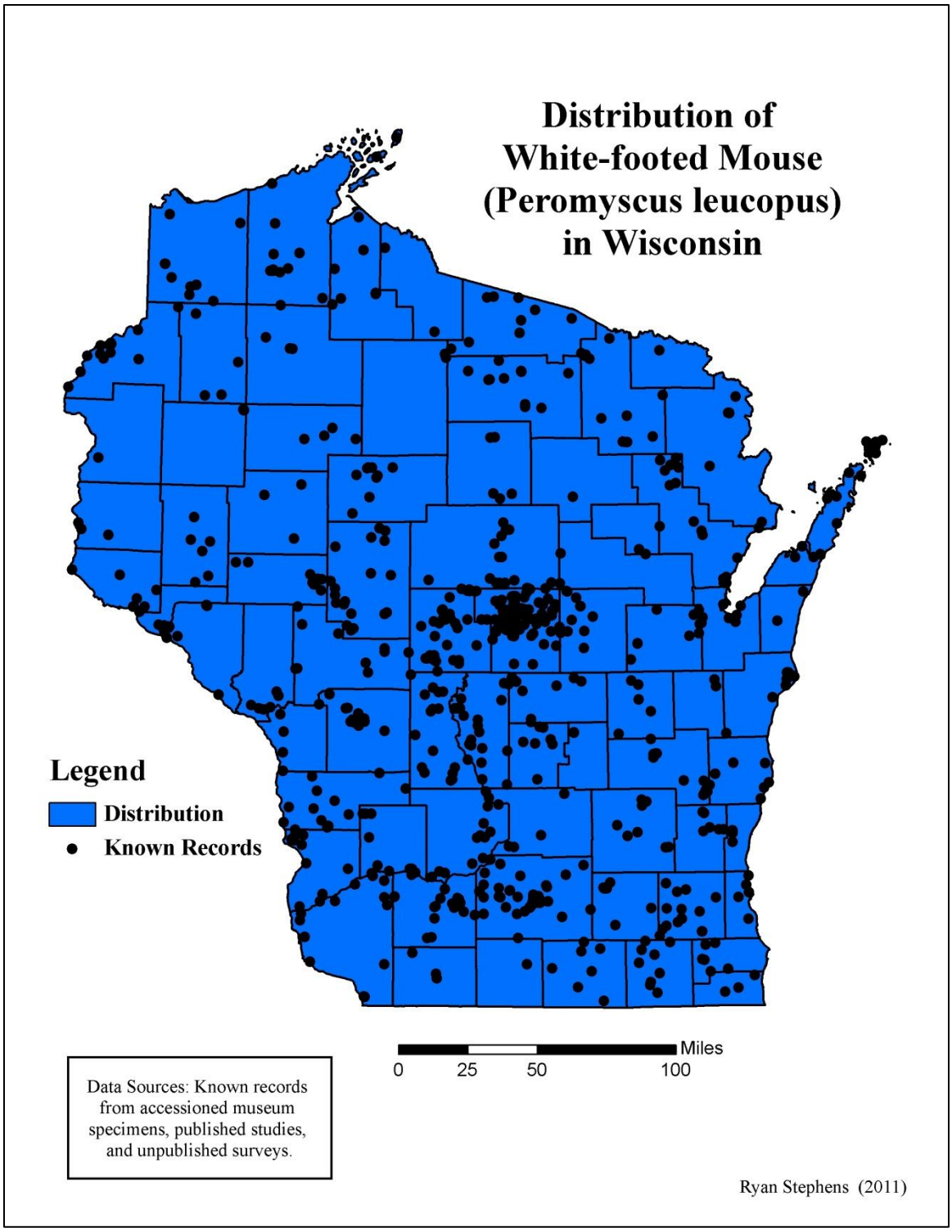

Distribution of
Short-tailed Weasel
(Mustela erminea)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

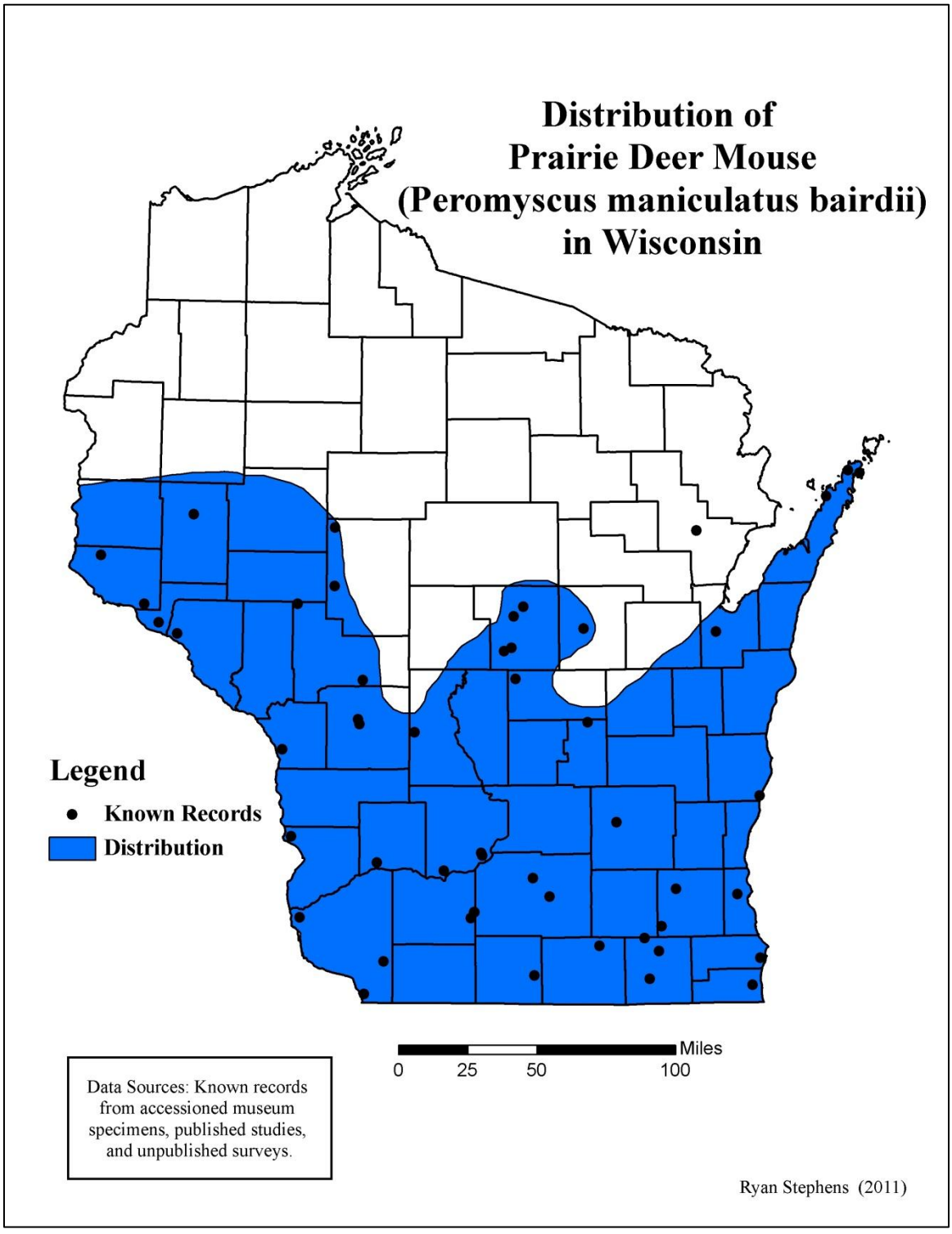

Distribution of
Long-tailed Weasel
(Mustela frenata)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

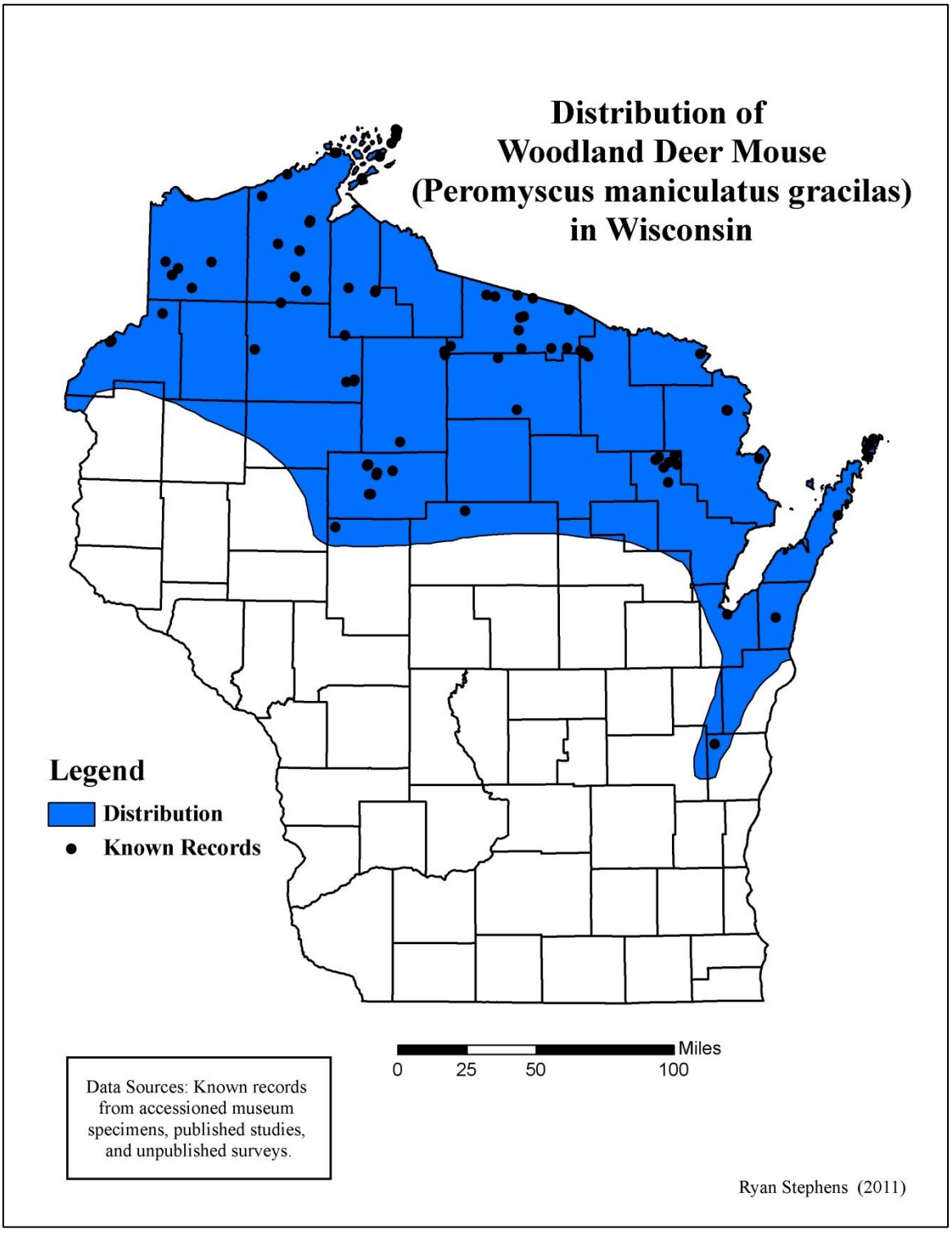

Distribution of
Least Weasel
(Mustela nivalis)
in Wisconsin
Legend
Distribution
Known Range
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

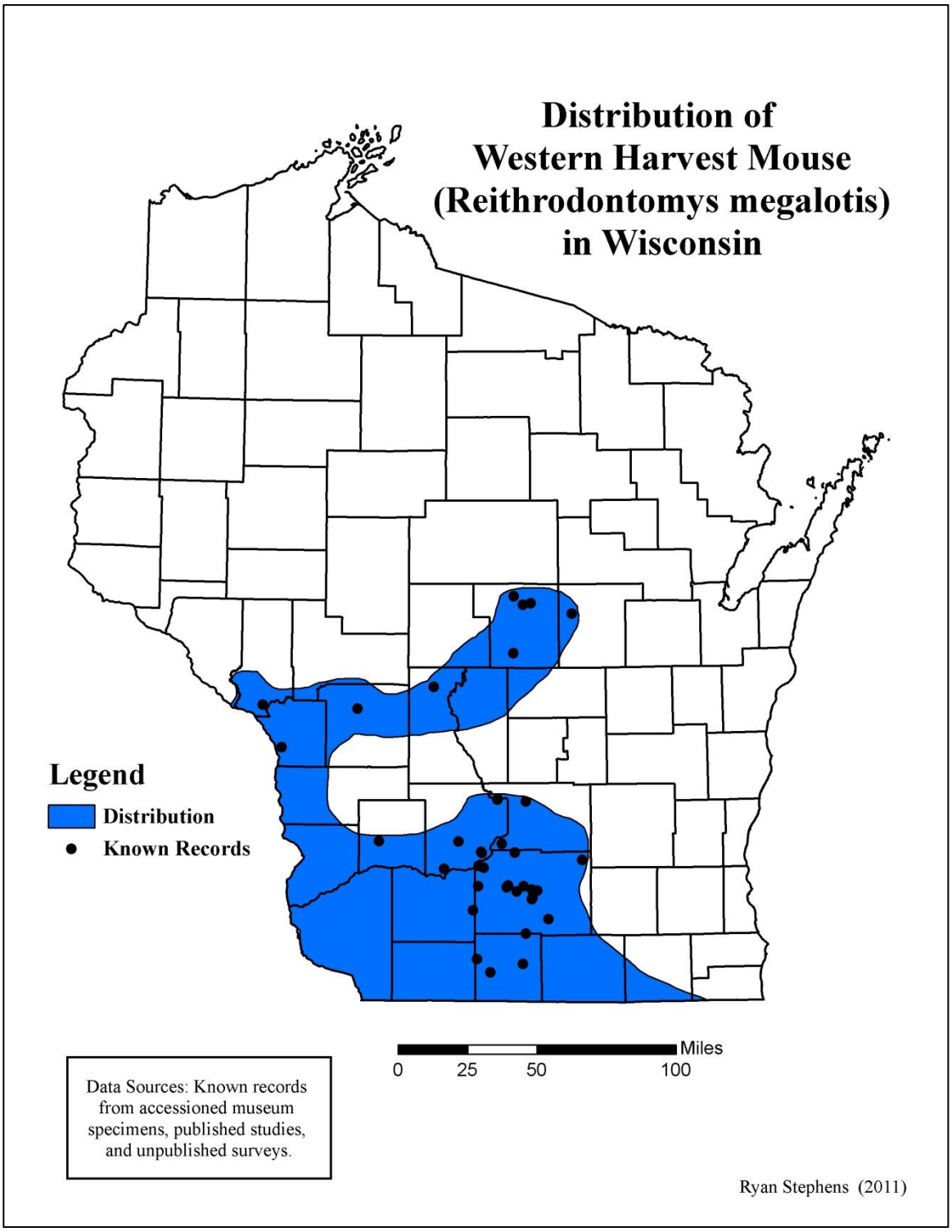

Distribution of
Southern Red-backed Vole
(Myodes gapperi)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

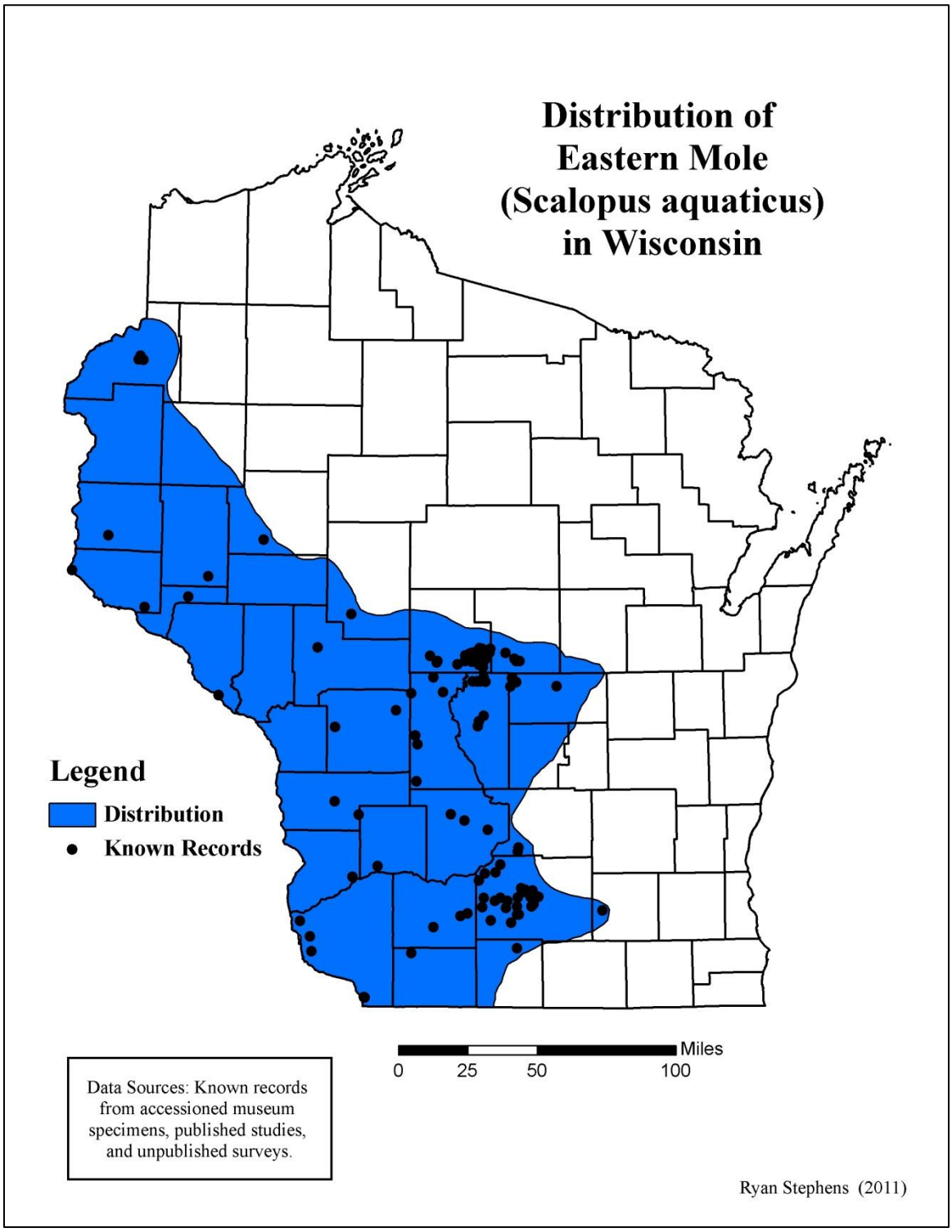

Distribution of
Woodland Jumping Mouse
(Napaeozapus insignis)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

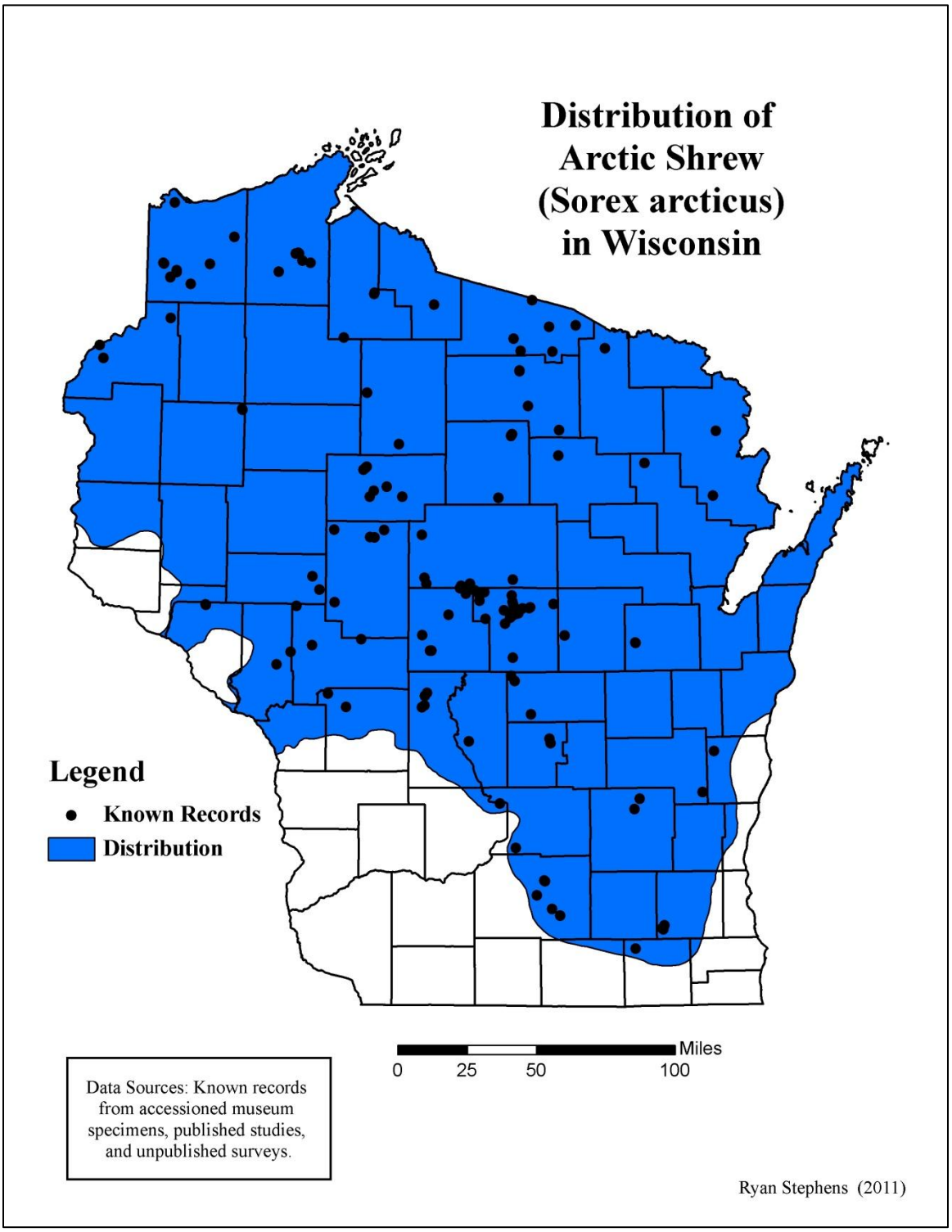

Distribution of
White-footed Mouse
(Peromyscus leucopus)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

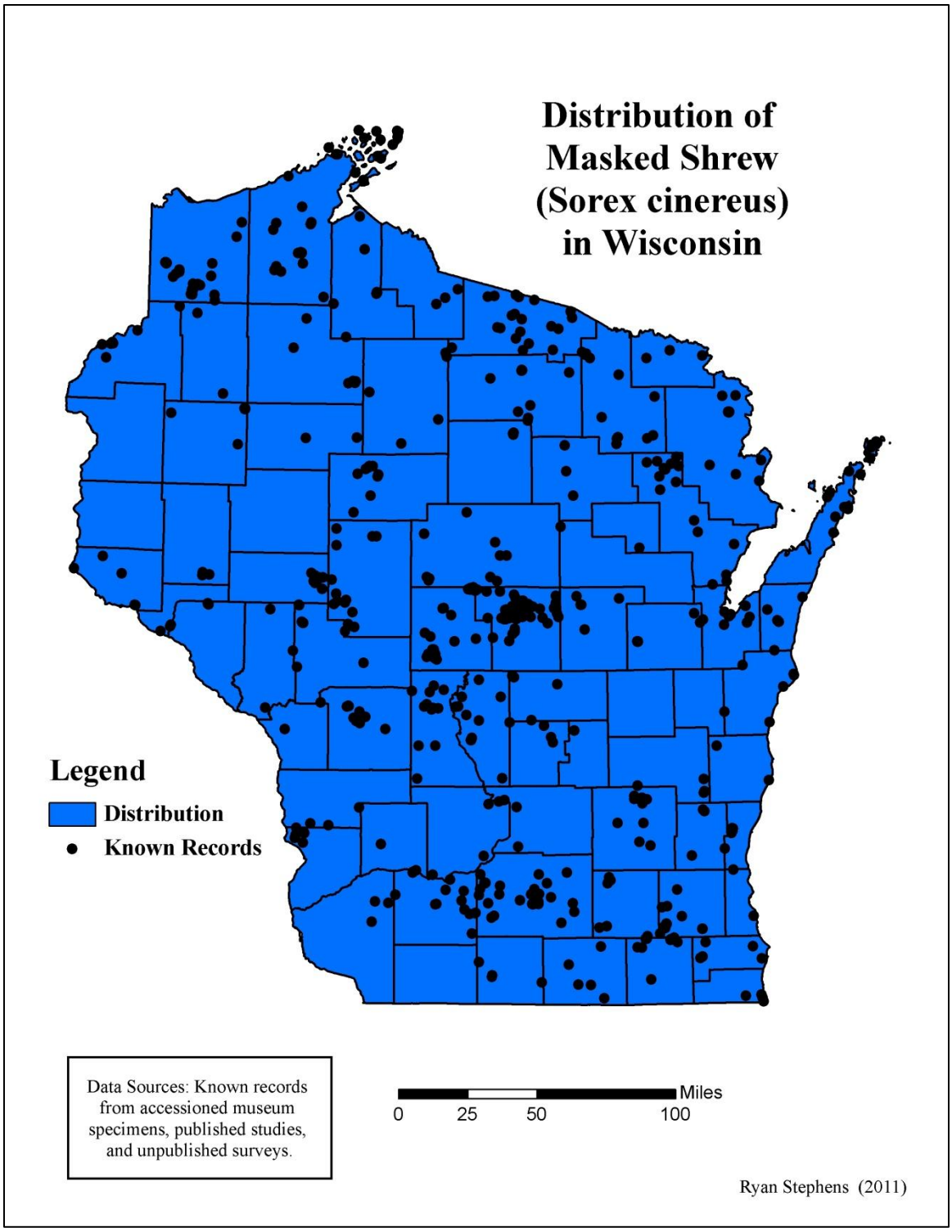

Distribution of
Prairie Deer Mouse
(Peromyscus maniculatus bairdii)
in Wisconsin
Legend
Known Records
Distribution
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

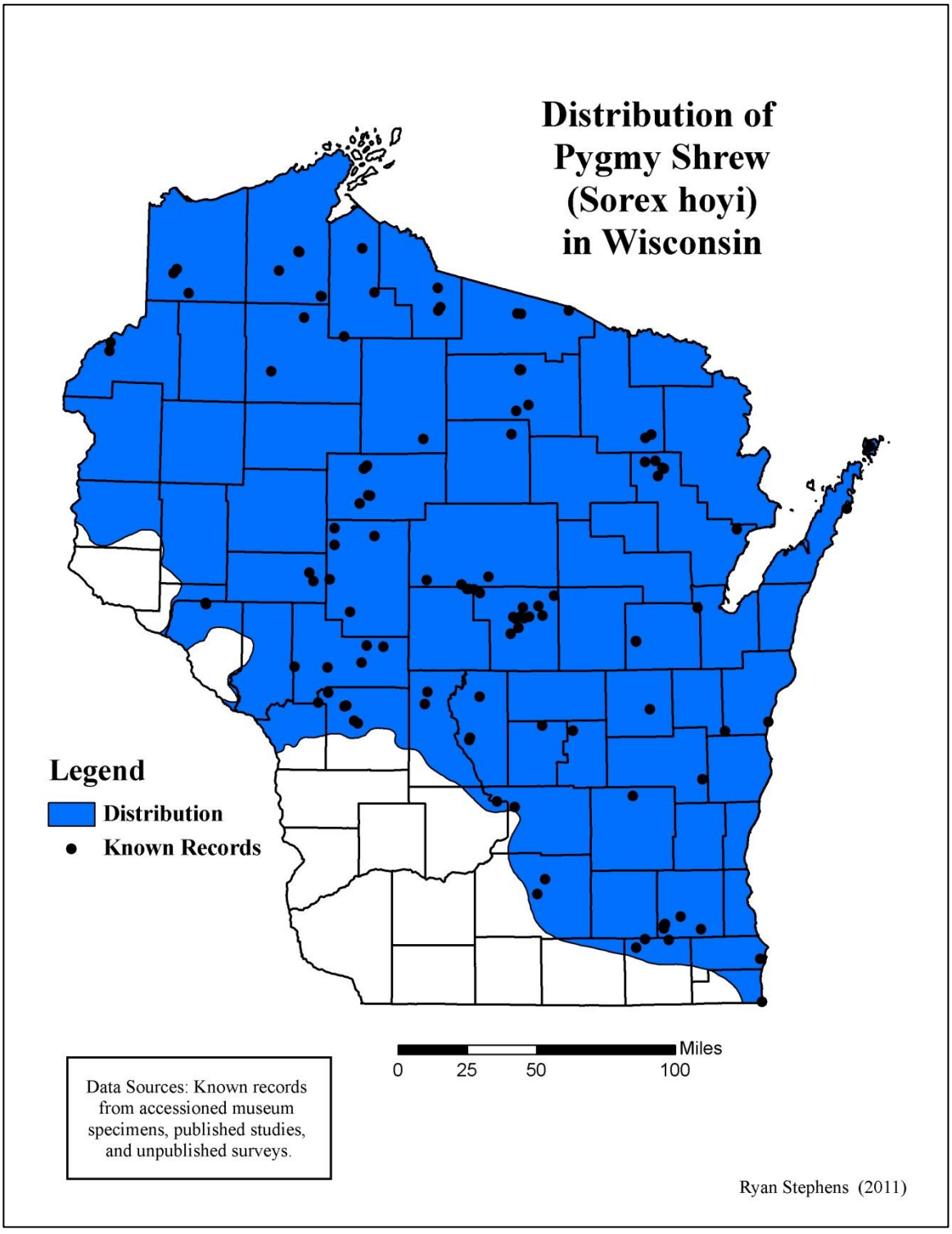

Distribution of
Woodland Deer Mouse
(Peromyscus maniculatus gracilas)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

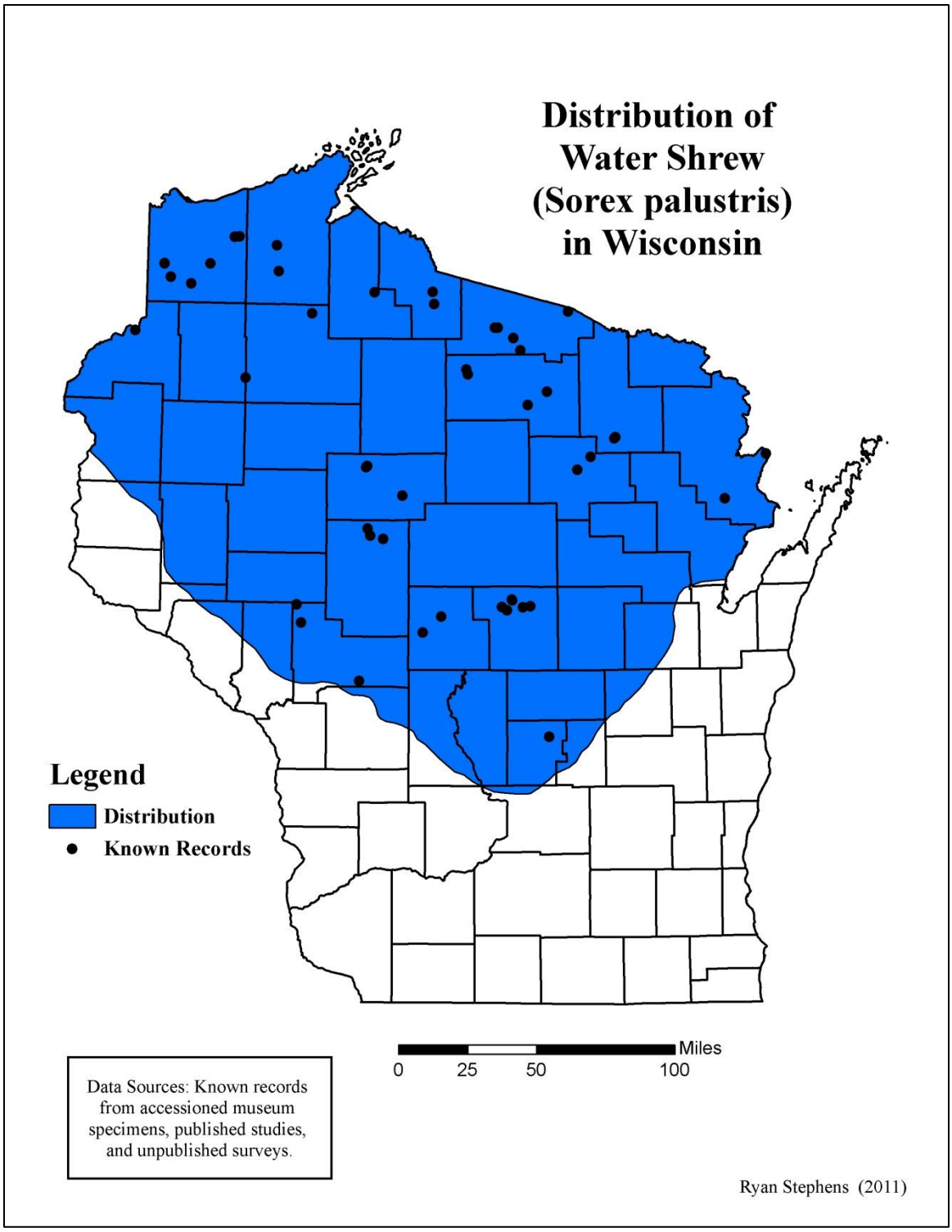

Distribution of
Western Harvest Mouse
(Reithrodontomys megalotis)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

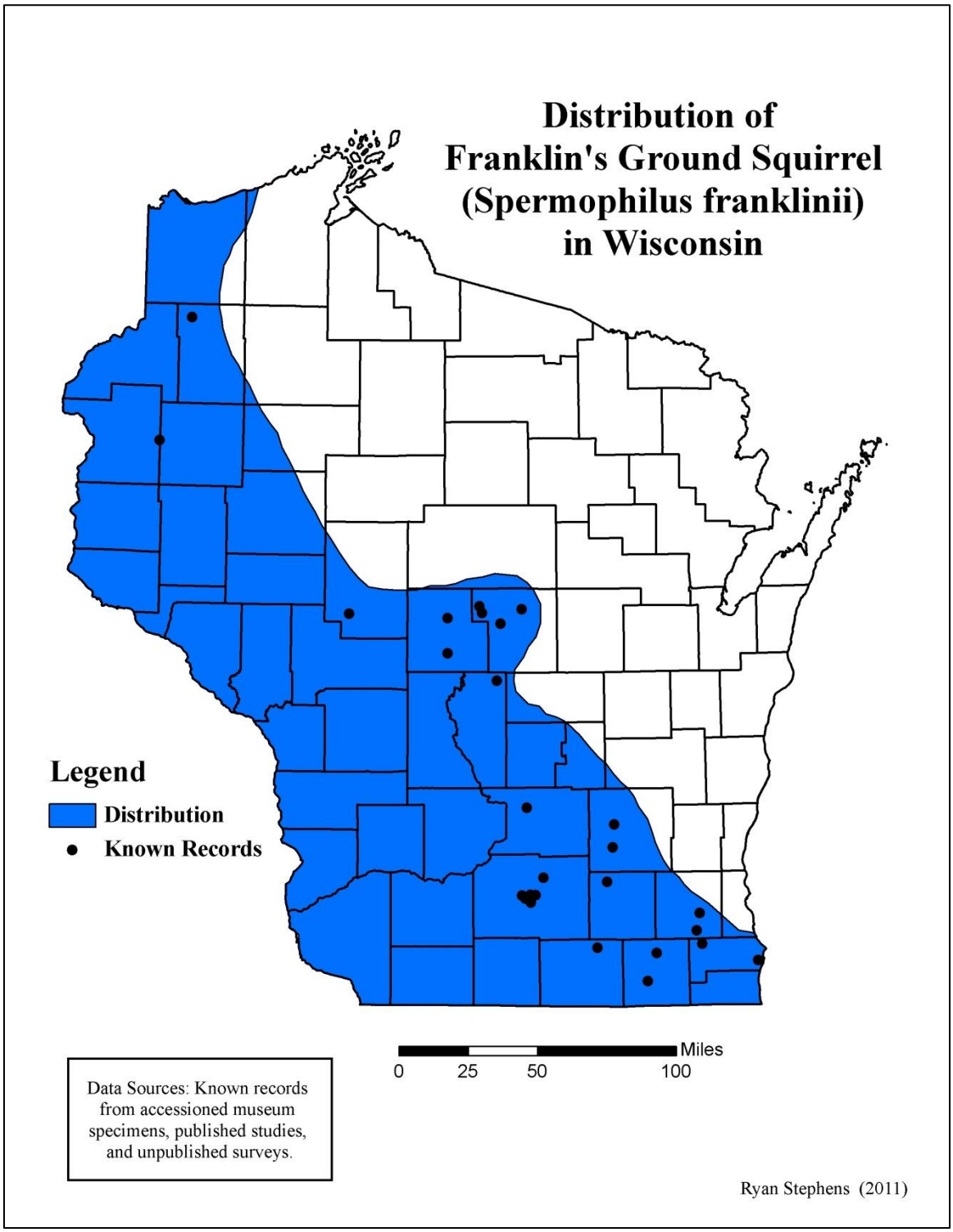

Distribution of
Eastern Mole
(Scalopus aquaticus)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

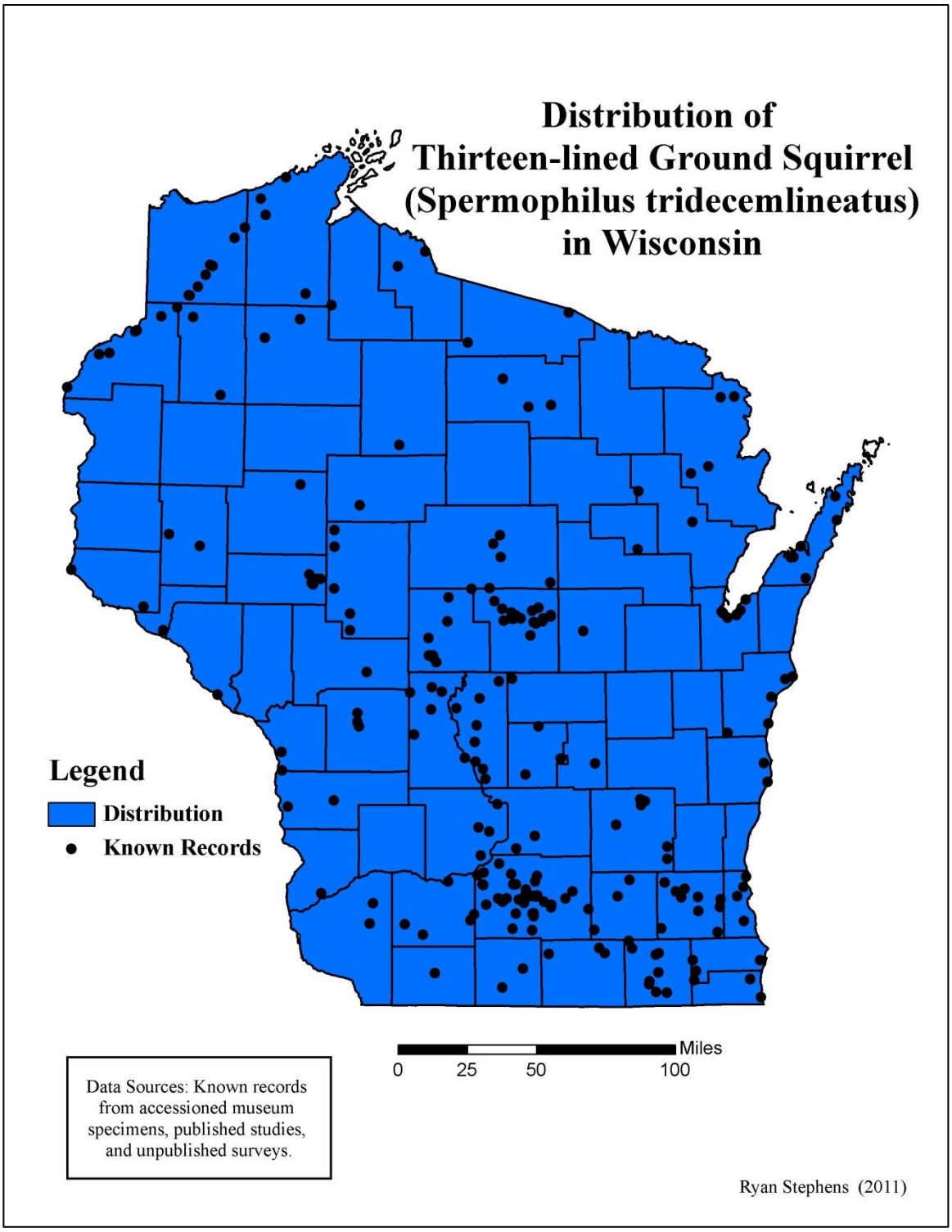

Distribution of
Arctic Shrew
(Sorex arcticus)
in Wisconsin
Legend
Known Records
Distribution
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

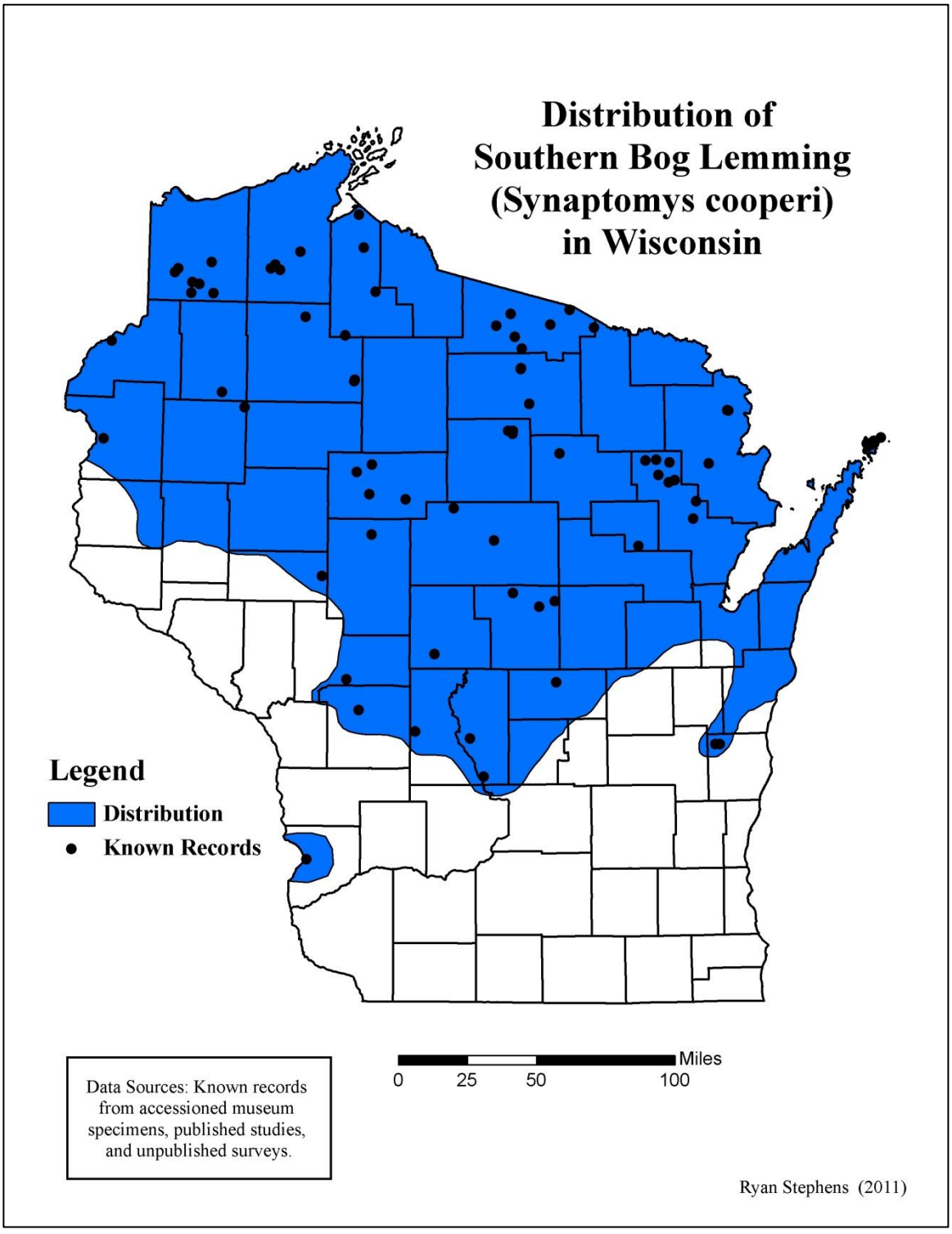

Distribution of
Masked Shrew
(Sorex cinereus)
in Wisconsin
Legend
Distribution
Known Records
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
0
25
50
100
Miles
Ryan Stephens (2011)

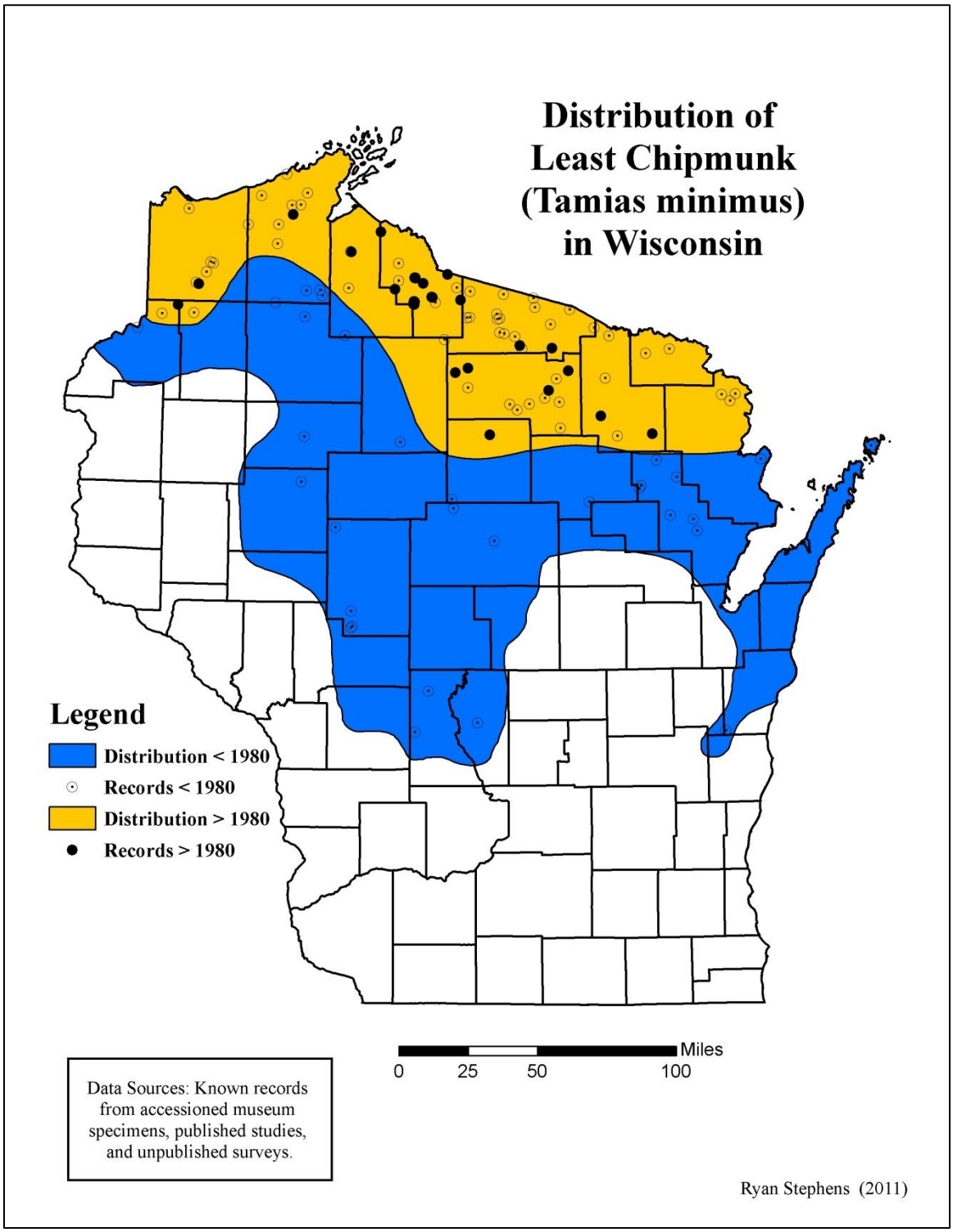

Distribution of
Pygmy Shrew
(Sorex hoyi)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

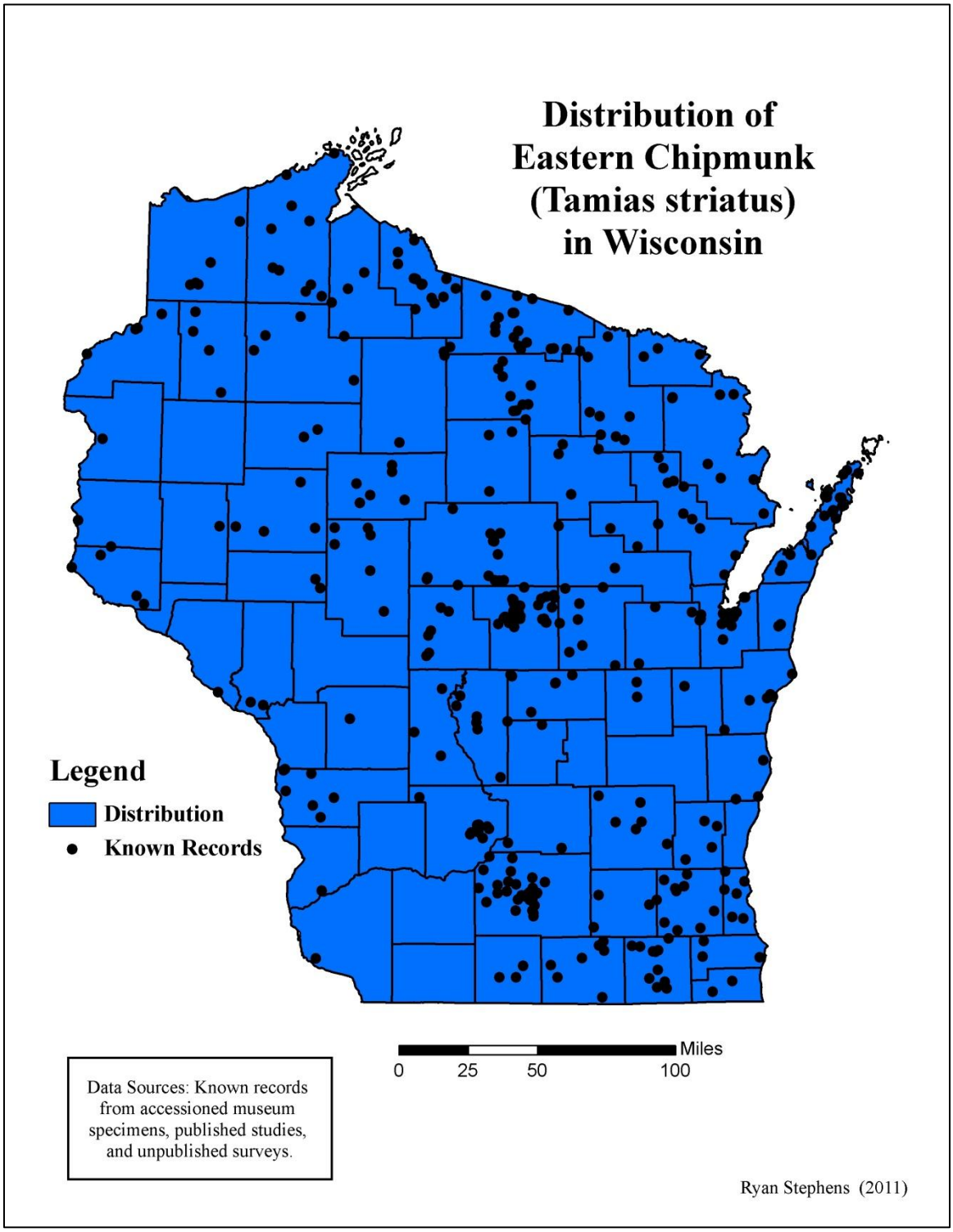

Distribution of
Water Shrew
(Sorex palustris)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

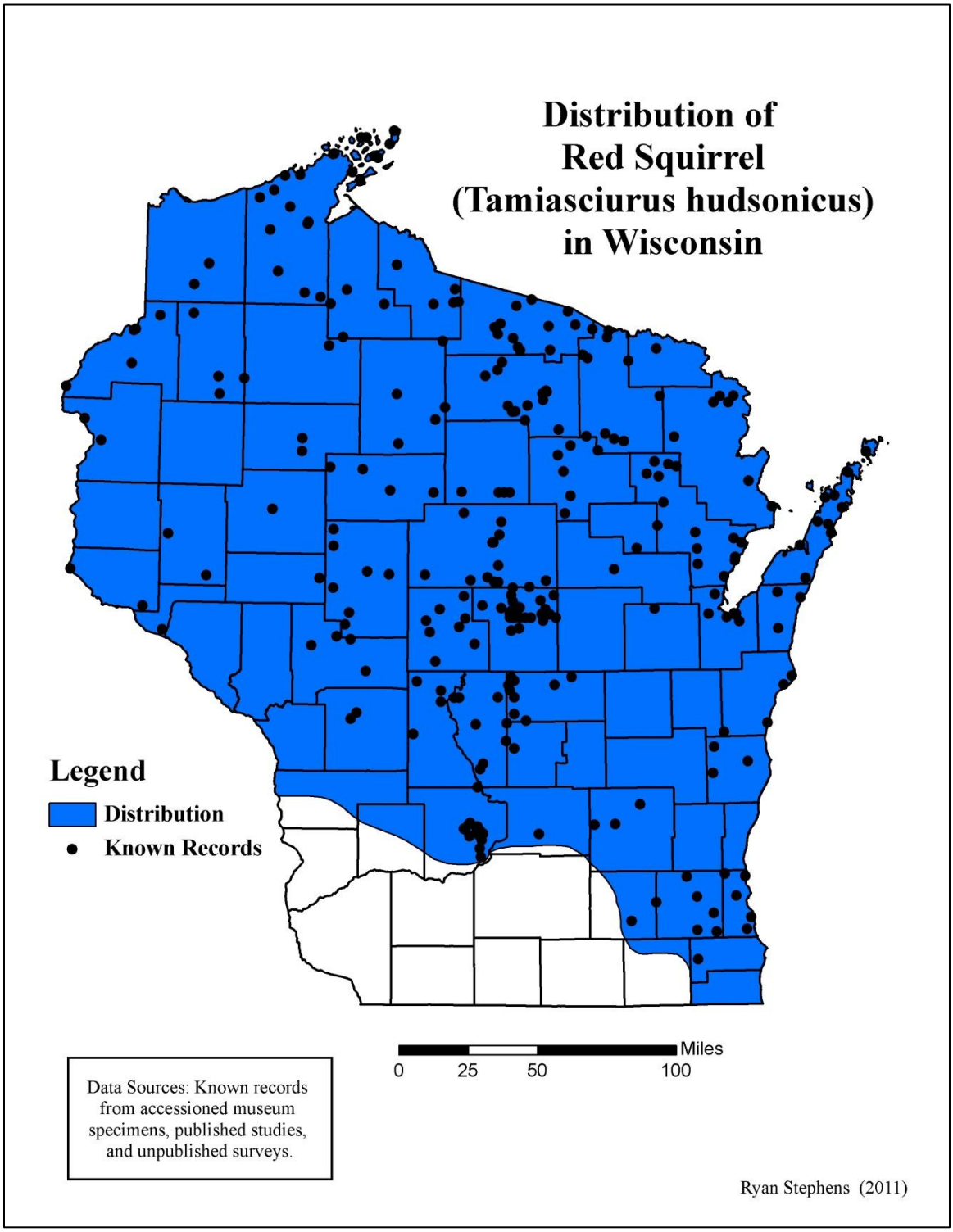

Distribution of
Franklin's Ground Squirrel
(Spermophilus franklinii)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

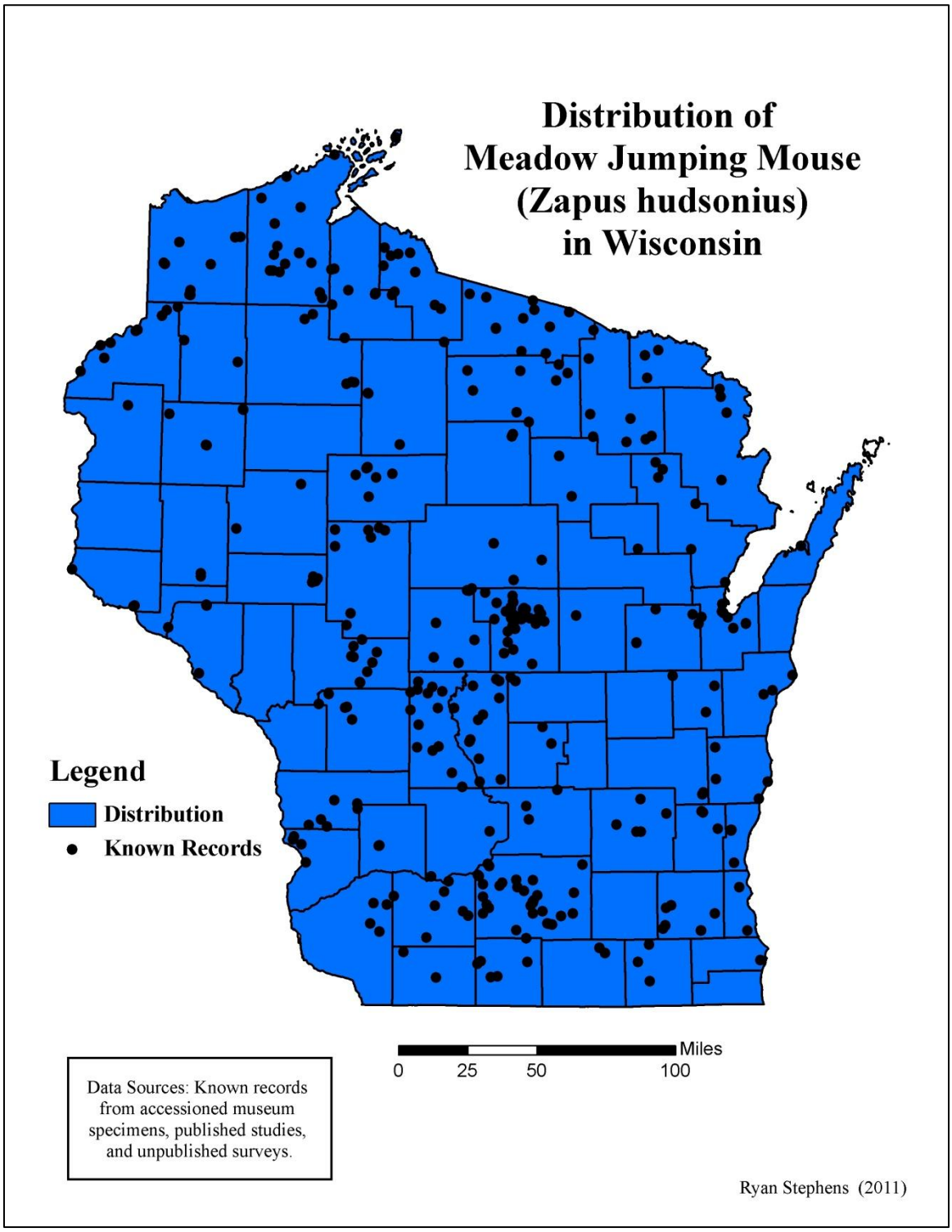

Distribution of
Thirteen-lined Ground Squirrel
(Spermophilus tridecemlineatus)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)


Distribution of
Southern Bog Lemming
(Synaptomys cooperi)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)


Distribution of
Least Chipmunk
(Tamias minimus)
in Wisconsin
Legend
Distribution < 1980
Records < 1980
Distribution > 1980
Records > 1980
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)


Distribution of
Eastern Chipmunk
(Tamias striatus)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)


Distribution of
Red Squirrel
(Tamiasciurus hudsonicus)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)


Distribution of
Meadow Jumping Mouse
(Zapus hudsonius)
in Wisconsin
Legend
Distribution
Known Records
Miles
0
25
50
100
Data Sources: Known records from accessioned museum specimens, published studies, and unpublished surveys.
Ryan Stephens (2011)

APPENDIX C

LOCATIONS OF FIELD WORK SITES

List of locations, habitat, and dates trapped during field work from 2009 to 2011. Locations include those from a pilot study prior to thesis field work, field work for this thesis, and survey work conducted for the WDNR. Voucher specimens collected from locations are listed in Appendix E.

Locations trapped during a pilot study prior to thesis field work.

ID	Habitat Type	County	Zone	Y	X	Date
PS1	White Pine-Red Maple Swamp	Portage	16	312127	4938191	May 19-23, 2009
PS2	Northern Dry-Mesic Forest	Portage	16	319972	4938148	May 19-23, 2009
PS3	Old field	Portage	16	314393	4933934	May 19-23, 2009
PS4	Northern Dry-Mesic Forest	Portage	16	315291	4935295	May 19-23, 2009

Locations trapped during thesis field work from 2009 to 2010.

Transect (ID)	County	Date
1--8	Lincoln County	June 7 -13, 2009
9--15	Bayfield County	June 19-22, 2009
16--23	Vilas County	June 24-27, 2009
24--29	Pepin and Pierce Counties	July 3-6, 2009
30--35	Crawford and Vernon Counties	July 8-11, 2009
36--43	Monroe County	July 22-25, 2009
44--51	Sandhill State Wildlife Refuge, Wood County	July 27-30, 2009
52--60	Eau Claire County	Aug. 6-9, 2009
61--68	Clark County	Aug. 11-14, 2009
69--76	Sauk, Iowa, and Richland Counties	Aug. 20-23, 2009
77--83	Iowa and Dane Counties	Aug. 25-28, 2009
84--92	Dane and Sauk Counties	June 3-6, 2010
93--101	Green Lake and Marquette Counties	June 8-11, 2010
102--109	Jefferson, Walworth and Waukesha Counties	June 17-20, 2010
110--117	Walworth and Waukesha Counties	June 22-25, 2010
118--125	Brown and Outagamie Counties	July 7-10, 2010
126--132	Fond Du Lac, Washington and Sheboygan Counties	July 12-15, 2010
133--140	Burnett County	July 21-24, 2010
141--148	Douglas County	July 26-29, 2010
149--156	Oconto County	Aug. 5-8, 2010
157--164	Portage and Waupaca Counties	Aug. 10-13, 2010
165--172	Taylor County	Aug. 19-22, 2010
173--180	Juneau and Wood Counties	Aug. 24-27, 2010

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
1	Northern Dry-Mesic Forest	NDMF	16	300484	5040821	300604	5040965
2	Alder Thicket	AT	16	300785	5040512	300775	5040349
3	Northern Sedge Meadow	NSM	16	300146	5039657	300304	5039594
4	Black Spruce Bog	BSB	16	300127	5040537	300145	5040355
5	Northern Mesic Forest	NMF	16	297831	5041254	298018	5041194
6	Northern Mesic Forest	NMF	16	297773	5041235	297906	5041047
7	Northern Wet-Mesic Forest	NWMF	16	300333	5039700	300176	5039729
8	Northern Wet-Mesic Forest	NWMF	16	300278	5039227	300295	5039394
9	Black Spruce Bog	BSB	15	641930	5143081	642068	5142978
10	Alder Thicket	AT	15	641769	5143432	641644	5143311
11	Hardwood Swamp	HS	15	640292	5143056	640114	5143046
12	Northern Mesic Forest	NMF	15	643118	5137005	643121	5137194
13	Shrub-Carr	SC	15	644305	5139214	644286	5139027
14	Hardwood Swamp	HS	15	649164	5138000	649022	5138096
15	Northern Mesic Forest	NDMF	15	627755	5134789	627617	5134923
16	Northern Dry-Mesic Forest	NDMF	16	301447	5107175	301415	5106980
17	Muskeg	M	16	302011	5108903	301835	5108956
18	Black Spruce Bog	BSB	16	303558	5109683	303681	5109776
19	Northern Dry-Mesic Forest	NDMF	16	306269	5109498	306274	5109315
20	Pine Barrens	PB	16	308549	5109121	308447	5109266
21	Northern Dry Forest	NDF	16	304549	5109606	304579	5109793
22	Northern Mesic Forest	NMF	16	307934	5106336	307837	5106496
23	Northern Mesic Forest	NMF	16	306624	5106434	306827	5106445
24	Floodplain Forest	FF	15	573846	4923807	573961	4923704
25	Southern Dry Forest	SDMF	15	574373	4924493	574267	4924617
26	Southern Mesic Forest	SMF	15	566157	4945362	565990	4945459

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
27	Floodplain Forest	FF	15	553410	4935322	553353	4935142
28	Floodplain Forest	FF	15	552976	4935429	552972	4935248
29	Dry Prairie (Goat Prairie)	DP	15	554981	4940028	554809	4940107
30	Dry Prairie (Goat Prairie)	DP	15	650889	4803454	651058	4803354
31	Southern Dry-Mesic Forest	SDMF	15	655630	4800828	655758	4800919
32	Dry Prairie (Goat Prairie)	DP	15	649679	4803829	649507	4803920
33	Floodplain Forest	FF	15	650740	4803485	650603	4803574
34	Dry Prairie (Goat Prairie)	DP	15	644669	4813510	644862	4813485
35	Mesic Prairie	DMP	15	651146	4805077	651249	4805205
36	Dry Sand Prairie	DSP	15	686886	4870527	686728	4870394
37	Oak Barrens	OB	15	686137	4871052	686294	4871154
38	Dry Mesic Prairie	DMP	15	686109	4871331	686247	4871479
39	Dry Sand Prairie	DSP	15	686104	4873044	685922	4873152
40	Central Poor Fen	CPF	15	689352	4875231	689235	4875372
41	Oak Barrens	OB	15	684461	4872884	684586	4873042
42	Oak Barrens	OB	15	683964	4872852	683928	4872653
43	Oak Barrens	OB	15	689436	4873418	689616	4873542
44	Southern Sedge Meadow	SSM	15	724485	4913185	724316	4913251
45	Southern Sedge Meadow	SSM	15	723654	4911416	723492	4911375
46	Southern Dry Forest	SDF	15	724543	4911418	724702	4911513
47	Pine Barrens	PB	15	728649	4912006	728653	4912190
48	Southern Sedge Meadow	SSM	15	728287	4910806	728163	4910912
49	Central Poor Fen	CPF	15	726675	4915649	726659	4915826
50	Shrub-Carr	SC	15	727572	4915659	727678	4915829
51	Pine Barrens	PB	15	728338	4913276	728473	4913419
52	Northern Dry-Mesic Forest	NDMF	15	658437	4953760	658540	4953606

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
53	Pine Barrens	PB	15	656358	4953111	656412	4952927
54	Pine Barrens	PB	15	657270	4951905	657290	4952080
55	Pine Barrens	PB	15	657473	4952773	657334	4952909
56	Pine Barrens	PB	15	661429	4955181	661594	4955263
57	Pine Barrens	DMP	15	659501	4955268	659361	4955139
58	Pine Barrens	PB	15	654856	4957569	655011	4957635
59	Central Poor Fen	CPF	15	656950	4956226	657034	4956374
60	Alder Thicket	AT	15	661391	4948542	661265	4948669
61	White Pine-Red Maple Swamp	WPRMS	15	674882	4941172	674923	4941013
62	Oak Barrens	OB	15	680991	4927348	680964	4927179
63	White Pine-Red Maple Swamp	WPRMS	15	677203	4928842	677080	4928962
64	Pine Barrens	PB	15	666752	4954246	666892	4954330
65	Tamarack Poor Swamp	TPS	15	670320	4941869	670417	4941726
66	Black Spruce Bog (Swamp)	BSB	15	668448	4940134	668557	4939977
67	Northern Dry-Mesic Forest	NDMF	15	675464	4942855	675595	4942745
68	Southern Dry-Mesic Forest	SDF	15	669638	4946110	669577	4946280
69	Pine Barrens	PB	15	721914	4787288	721904	4787115
70	Oak Barrens	OB	15	731643	4784974	731806	4785036
71	Dry Prairie (Goat Prairie)	DP	15	735955	4788248	735843	4788373
72	Dry Prairie (Goat Prairie)	DP	15	739033	4787692	739183	4787715
73	Dry Sand Prairie	DSP	15	738922	4787183	738772	4787293
74	Wet-Mesic Prairie	WMP	15	720371	4786165	720231	4786237
75	Wet-Mesic Prairie	WMP	15	720062	4785955	719905	4785916
76	Dry-Mesic Prairie	DMP	15	741859	4782482	741861	4782663
77	Dry-Mesic Prairie	DMP	16	266160	4759620	266227	4759460
78	Dry-Mesic Prairie	MP	15	733815	4767832	733842	4767666

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
79	Dry-Mesic Prairie	MP	15	734509	4768096	734355	4768146
80	Dry-Mesic Prairie	DMP	16	268352	4762830	268174	4762863
81	Old Meadow	OM	16	268552	4762839	268365	4762917
82	Old Meadow	OM	16	261831	4765027	261915	4764891
83	Wet-Mesic Prairie	WMP	16	264809	4762325	264742	4762163
84	Dry Sand Prairie	DSP	16	273400	4797057	273604	4797052
85	Oak Barrens	OB	16	270977	4785591	271166	4785576
86	Dry-Mesic Prairie	DMP	16	274430	4780119	274611	4780113
87	Wet-Mesic Prairie	WMP	16	271244	4776400	271124	4776526
88	Oak Barrens	OB	16	271575	4776473	271386	4776500
89	Southern Dry Forest	SDF	16	282474	4773135	282290	4773000
90	Southern Sedge Meadow	SSM	16	282857	4777995	282802	4777824
91	Dry Prairie(Goat Prairie)	DP	16	282591	4777930	282730	4777960
92	Wet-Mesic Prairie	WMP	16	283667	4778998	283603	4778839
93	Southern Dry-Mesic Forest	SDMF	16	329454	4866567	329396	4866383
94	Southern Hardwood Swamp	FF	16	329507	4866649	329352	4866713
95	Bog Relict	BR	16	316584	4860395	316415	4860470
96	Tamarack(rich) Swamp	TRS	16	316584	4860206	316666	4860366
97	Southern Sedge Meadow	SSM	16	315976	4863089	316096	4862954
98	Tamarack(rich) Swamp	TRS	16	315596	4863182	315777	4863181
99	Alder Thicket	AT	16	311721	4870280	311837	4870184
100	Central Sands Pine-Oak Forest	CSPOF	16	311738	4870113	311882	4869982
101	Oak Barrens	OB	16	309584	4870694	309573	4870498
102	Dry-Mesic Prairie	DMP	16	378853	4752517	378830	4752691
103	Calcareous Fen	CF	16	378940	4752249	378963	4752421
104	Wet-Mesic Prairie	WMP	16	367371	4745765	367526	4745665

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
105	Wet-Mesic Prairie	WMP	16	377456	4750586	377412	4750764
106	Wet-Mesic Prairie	WMP	16	366580	4744294	366392	4744329
107	Wet-Mesic Prairie	WMP	16	361499	4739512	361654	4739599
108	Southern Dry Forest	SDF	16	364192	4739209	364122	4739362
109	Southern Dry Forest	SDF	16	374829	4747010	374965	4747131
110	Southern Sedge Meadow	SSM	16	380806	4743186	380694	4743031
111	Oak Opening	OO	16	380855	4743230	380693	4743337
112	Bog Relict	BR	16	383139	4744219	382999	4744360
113	Tamarack Rich Swamp	TRS	16	384948	4741591	384834	4741766
114	Southern Mesic Forest	SMF	16	399424	4748895	399420	4748711
115	Southern Hardwood Swamp	SHS	16	399602	4748913	399589	4748736
116	Oak Opening	OO	16	387867	4756571	387902	4756764
117	Wet-Mesic Prairie	WMP	16	387968	4756445	388071	4756609
118	Mesic Prairie	MP	16	406395	4928157	406227	4928281
119	Northern Mesic Forest	NMF	16	405654	4927441	405541	4927258
120	Southern Mesic Forest	SDMF	16	404085	4921495	403903	4921422
121	Southern Dry Mesic Forest	SMF	16	398282	4920187	398213	4919977
122	Southern Dry Mesic Forest	SDMF	16	404649	4926756	404531	4926569
123	Southern Dry Mesic Forest	SDMF	16	406388	4930401	406535	4930535
124	Southern Mesic Forest	SDMF	16	404356	4934906	404487	4935052
125	Northern Wet Mesic Forest	NWMF	16	401274	4932028	401280	4932260
126	Southern Dry Mesic Forest	SMF	16	402401	4817886	402223	4817884
127	Floodplain Forest	FF	16	403193	4817130	403121	4817277
128	Tamarack Rich Swamp	TRS	16	403135	4827871	403122	4827692
129	Shrub Carr	SC	16	403619	4828710	403728	4828872
130	Tamarack Rich Swamp	TRS	16	403458	4835684	403517	4835865

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
131	Southern Sedge Meadow	SSM	16	408768	4835283	408944	4835314
132	Southern Dry Mesic Forest	SDMF	16	405399	4829630	405343	4829458
133	Pine Barrens	PB	15	528318	5080638	528442	5080803
134	Northern Sedge Meadow	NSM	15	530963	5078454	531108	5078321
135	Pine Barrens	PB	15	534406	5081700	534407	5081906
136	Pine Barrens	PB	15	534822	5086808	534685	5086658
137	Northern Wet Mesic Forest	NWMF	15	534507	5087324	534336	5087448
138	Black Spruce Bog	BSB	15	533624	5086248	533496	5086386
139	Shrub Carr	SC	15	528460	5085673	528499	5085860
140	Northern Dry Mesic Forest	NDMF	15	521013	5079184	521036	5079404
141	Open Bog	OBO	15	579717	5116871	579597	5116728
142	Pine Barrens	PB	15	578858	5116898	578816	5117095
143	Northern Sedge Meadow	NSM	15	579450	5119660	579326	5119523
144	Tamarack Poor Swamp	TPS	15	579892	5119608	580030	5119480
145	Shrub Carr	SC	15	568043	5126484	568132	5126684
146	Muskeg	M	15	569786	5128250	569753	5128432
147	Black Spruce Bog	BSB	15	571664	5129607	571495	5129620
148	Tamarack Poor Swamp	TPS	15	571609	5130820	571541	5130638
149	Muskeg	M	16	377130	5020828	376953	5020747
150	Northern Mesic Forest	NMF	16	385096	5022512	385249	5022467
151	Floodplain Forest	FF	16	387709	5016267	387809	5016430
152	Northern Wet Mesic Forest	NWMF	16	391070	5019360	390878	5019365
153	Northern Wet Mesic Forest	NWMF	16	394303	5023324	394484	5023243
154	Northern Wet Mesic Forest	NWMF	16	395651	5017913	395473	5017802
155	Muskeg	M	16	393660	5008756	393473	5008792
156	Northern Dry Mesic Forest	NDMF	16	390110	5007735	389961	5007628

ID	Natural Community Type	Habitat Code	Zone	Start UTM (Y)	Start UTM (X)	End UTM (Y)	End UTM (X)
157	Black Spruce Bog	BSB	16	321493	4945089	321422	4945252
158	Northern Wet Mesic Forest	NWMF	16	328217	4948727	328191	4948538
159	Northern Mesic Forest	NMF	16	328496	4948483	328427	4948314
160	Black Spruce Bog	BSB	16	333571	4944555	333462	4944715
161	Northern Wet Mesic Forest	NWMF	16	335654	4939542	335764	4939425
162	Northern Dry Mesic Forest	NDMF	16	335929	4939570	336100	4939519
163	Alder Thicket	AT	16	321367	4941111	321208	4941024
164	Northern Dry Mesic Forest	NDMF	16	320118	4938076	319966	4938076
165	Northern Mesic Forest	NMF	15	687452	5003849	687440	5003647
166	Hardwood Swamp	HS	15	688554	5003610	688411	5003738
167	Muskeg	M	15	690755	5007009	690657	5007175
168	Northern Mesic Forest	NMF	15	691072	5015148	691265	5015117
169	Northern Wet Mesic Forest	NWMF	15	691539	5016238	691730	5016259
170	Muskeg	M	15	688375	5020921	688176	5020942
171	Black Spruce Bog	BSB	15	684144	5019037	684125	5019231
172	Black Spruce Bog	BSB	15	679477	5016341	679467	5016143
173	Pine Barrens	PB	15	728290	4894745	728468	4894695
174	Shrub Carr	SC	15	724669	4889410	724632	4889239
175	Muskeg	M	15	724617	4883914	724510	4883767
176	Central Poor Fen	CPF	15	723284	4882489	723171	4882633
177	Central Sands Pine-Oak Forest	CSPOF	15	727514	4881059	727699	4881011
178	Oak Barrens	OB	15	728468	4882105	728595	4882255
179	Pine Barrens	PB	15	728467	4881843	728324	4881981
180	Floodplain Forest	FF	15	729428	4910007	729531	4910178

Locations trapped during survey work for the WDNR during the summer of 2011.

ID	Habitat Type	County	Start N	Start W	End N	End W	Date
T1	Old Field	Iowa	43.04611	-89.94392	43.04728	-89.94541	May 25-28, 2011
T2	Southern Hardwood Forest	Iowa	43.06667	-89.95529	43.06591	-89.95693	May 25-28, 2011
T3	Sedge Meadow/Old Field	Iowa	43.07219	-89.96626	43.07316	-89.96788	May 25-28, 2011
T4	Shrub Carr	Iowa	43.04279	-90.00157	43.04346	-90.00375	May 25-28, 2011
T5	Southern Hardwood Forest	Iowa	43.02098	-89.99265	43.02184	-89.99089	May 25-28, 2011
T6	Old Field	Grant	43.02098	-89.99265	43.02184	-89.99089	May 25-28, 2011
T7	Old Meadow	Iowa	43.07788	-90.41749	43.07737	-90.41548	May 25-28, 2011
T8	Southern Hardwood Forest	Iowa	43.07809	-90.41626	43.07946	-90.41497	May 25-28, 2011
T9	Old Field	Vernon	43.44387	-90.88898	43.44490	-90.89067	May 30-June 2, 2011
T10	Southern Hardwood Forest	Vernon	43.43733	-90.89877	43.43625	-90.90022	May 30-June 2, 2011
T11	Shrub Carr/Sedge Meadow	Vernon	43.43770	-90.89803	43.43833	-90.89983	May 30-June 2, 2011
T12	Southern Hardwood Forest	Crawford	43.39452	-91.06999	43.39561	-91.07201	May 30-June 2, 2011
T13	Southern Hardwood Forest	Crawford	43.40160	-91.10059	43.40215	-91.09886	May 30-June 2, 2011
T14	Shrub Carr/Sedge Meadow	Crawford	43.42282	-91.12854	43.42256	-91.13089	May 30-June 2, 2011
T15	Goat Prairie	Crawford	43.39352	-91.13085	43.39382	-91.12960	May 30-June 2, 2011
T16	Dry Sand Prairie	Jackson	44.58692	-91.12898	44.58691	-91.13142	June 8-11, 2011
T17	Sedge Meadow/Alder Thicket	Jackson	44.58762	-91.13154	44.58765	-91.13387	June 8-11, 2011
T18	Grassland	Jackson	44.50031	-91.10799	44.50029	-91.11041	June 8-11, 2011
T19	Old Field	Jackson	44.49406	-91.10229	44.49519	-91.10049	June 8-11, 2011
T20	Southern Hardwood Forest	Jackson	44.49376	-91.09888	44.49379	-91.09670	June 8-11, 2011
T21	Shrub Carr/Sedge Meadow	Trempealeau	44.34807	-91.17051	44.34654	-91.16971	June 8-11, 2011
T22	Northern Dry Mesic Forest	Jackson	44.26287	-91.14243	44.26300	-91.14005	June 8-11, 2011
T23	Old Field	Jackson	44.26508	-91.13061	44.26497	-91.12826	June 8-11, 2011
T24	Overgrown Field/Barrens	Monroe	43.98877	-90.73832	43.99008	-90.73659	June 13-16, 2011

ID	Habitat Type	County	Start N	Start W	End N	End W	Date
T25	Alder Thicket	Monroe	44.00005	-90.72475	43.99847	-90.72565	June 13-16, 2011
T26	Pine Barrens	Monroe	44.05988	-90.76183	44.06144	-90.76167	June 13-16, 2011
T27	Sedge Meadow	Monroe	44.06387	-90.76348	44.06243	-90.76244	June 13-16, 2011
T28	Pine Barrens	Monroe	44.05899	-90.77494	44.06067	-90.77538	June 13-16, 2011
T29	Clear Cut Northern Dry Mesic Forest	Monroe	44.13124	-90.89339	44.13171	-90.89562	June 13-16, 2011
T30	Grassland	Monroe	44.08517	-90.96315	44.08347	-90.96326	June 13-16, 2011
T31	Northern Dry Mesic Forest	Monroe	44.07909	-90.96715	44.07874	-90.96484	June 13-16, 2011
T32	Meadow of Reed Canary Grass	Portage	44.61977	-89.79326	44.61823	-89.79443	June 23-26, 2011
T33	Sedge Meadow	Portage	44.65236	-89.79440	44.65068	-89.79465	June 23-26, 2011
T34	Black Spruce Swamp	Portage	44.67233	-89.83484	44.67223	-89.83725	June 23-26, 2011
T35	Northern Mesic Forest	Portage	44.67310	-89.82616	44.67411	-89.82791	June 23-26, 2011
T36	Black Spruce Swamp	Portage	44.66754	-89.84177	44.66876	-89.84008	June 23-26, 2011
T37	Sedge Meadow	Marathon	44.70861	-89.86468	44.70694	-89.86452	June 23-26, 2011
T38	Alder Thicket	Marathon	44.68496	-89.93666	44.68644	-89.93749	June 23-26, 2011
T39	Tamarack Poor Swamp	Marathon	44.69814	-89.92705	44.69695	-89.92865	June 23-26, 2011
T40	Alder Thicket	Marathon	44.68103	-89.87697	44.68103	-89.87952	June 28-July 1, 2011
T41	Open Bog	Marathon	44.68047	-89.88046	44.67870	-89.87991	June 28-July 1, 2011
T42	Meadow of Reed Canary Grass	Marathon	44.65652	-89.89215	44.65809	-89.89319	June 28-July 1, 2011
T43	Old Field	Marathon	44.70777	-89.92370	44.70862	-89.92577	June 28-July 1, 2011
T44	Meadow of Reed Canary Grass	Marathon	44.73821	-90.19821	44.73986	-90.19724	June 28-July 1, 2011
T45	Northern Mesic Forest	Wood	44.73189	-90.17558	44.73223	-90.17793	June 28-July 1, 2011
T46	Ash Swamp	Wood	44.72220	-90.18283	44.72091	-90.18137	June 28-July 1, 2011
T47	Alder Thicket	Wood	44.70844	-90.18512	44.70919	-90.18307	June 28-July 1, 2011

APPENDIX D

TOTAL CAPTURES OF SMALL MAMMALS FROM FIELD WORK, 2009-2011

List of animals captured during field work during the summers of 2009 through 2011. Animals include those from a pilot study conducted prior to thesis field work, field work for this thesis, and survey work conducted for the WDNR. Locations of transects can be found in Appendix C and a list of collected voucher specimens can be found in Appendix E. Species are represented as four letter acronyms as follows: *Peromyscus maniculatus gracilis* (PEMAG), *P. leucopus* (PELE), *P. maniculatus bairdii* (PEMAB), *Microtus pennsylvanicus* (MIPE), *Sorex cinereus* (SOCI), *Blarina brevicauda* (BLBR), *Myodes gapperi* (MYGA), *Spermophilus tridecemlineatus* (SPTR), *Zapus hudsonius* (ZAHU), *Sorex arcticus* (SOAR), *Microtus ochrogaster* (MIOC), *Synaptomys cooperi* (SYCO), *Tamias striatus* (TAST), *Sorex hoyi* (SOHO), *Glaucomys volans* (GLVO), *Condylura cristata* (COCR), *Glaucomys sabrinus* (GLSA), *Mustela erminea* (MUER), *Tamiasciurus hudsonius* (TAHU), *Reithrodontomys megalotis* (REME), *Sylvilagus floridanus* (SYFL), *Sorex palustris* (SOPA), *Mustela frenata* (MUFR), and *Mus musculus* (MUMU).

Animals captured during a pilot study conducted prior to thesis field work, May 2009. Methodology is described in Appendix B and locations and dates trapped can be found in Appendix C.

ID	PELE	MYGA	MIPE	SOCI	ZAHU	SYCO	TAHU	TAST	BLBR	GLVO	SOHO
PS1	16	11	0	0	6	2	0	0	0	0	0
PS2	2	0	0	4	0	0	0	2	1	0	0
PS3	0	0	8	2	0	0	0	0	0	0	1
PS4	6	7	0	0	0	0	2	0	0	1	0

Animals captured during thesis field work, summers of 2009-2010. Methodology is described in Chapter 1 and locations and dates trapped can be found in Appendix C.

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
1-NDMF	1	0	0	0	1	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
2-AT	0	0	0	2	0	0	0	0	3	5	0	0	0	0	0	0	0	2	0	0	0	0	0
3-NSM	0	0	0	6	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0
4-BSB	0	0	0	0	9	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
5-NMF	3	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-NMF	5	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
7-NWMF	2	1	0	0	3	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8-NWMF	1	0	0	1	0	0	9	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0
9-BSB	0	0	0	1	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10-AT	0	0	0	2	2	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
11-HS	0	0	0	2	2	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
12-NMF	0	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13-SC	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
14-HS	4	1	0	3	0	0	0	0	2	2	0	0	0	0	0	1	0	0	0	0	0	0	0
15-NDMF	0	5	0	0	5	6	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
16-NDMF	0	3	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-M	0	0	0	0	2	14	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
18-BSB	0	0	0	0	4	5	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
19-NDMF	1	0	0	0	0	15	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
20-PB	0	0	0	6	0	16	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
21-NDF	1	0	0	0	0	7	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
22-NMF	7	2	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-NMF	1	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-FF	0	15	0	6	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-SDMF	0	6	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-SMF	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-FF	0	21	0	0	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-FF	0	18	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-DP	0	9	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
30-DP	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-SDMF	0	16	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32-DP	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33-FF	0	22	0	8	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34-DP	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35-DMP	0	2	0	0	3	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36-DSP	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37-OB	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38-DMP	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
39-DSP	0	0	8	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40-CPF	0	4	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41-OB	0	7	0	0	0	1	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
42-OB	0	20	0	1	1	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	0	0	0
43-OB	0	17	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
44-SSM	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45-SSM	0	2	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
46-SDF	0	30	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
47-PB	0	3	0	1	3	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
48-SSM	0	9	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49-CPF	0	0	0	4	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
50-SC	0	0	0	1	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
51-PB	0	2	0	0	3	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52-NDMF	0	29	0	0	2	0	24	0	1	0	0	0	2	0	5	0	0	0	0	0	0	0	0
53-PB	0	2	0	5	2	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54-PB	0	2	0	0	5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55-PB	0	6	0	0	4	0	0	7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
56-PB	0	16	0	2	2	0	1	1	0	0	0	1	0	0	3	0	0	0	1	0	0	0	0
57-DMP	0	4	0	8	3	0	0	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58-PB	0	18	0	3	6	0	2	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
59-CPF	0	0	0	22	2	0	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0
60-AT	0	2	0	4	4	1	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0
61-WPRMS	0	15	0	0	8	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62-OB	0	4	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63-WPRMS	0	17	0	0	2	0	16	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
64-PB	0	1	0	2	1	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
65-TPS	0	1	0	0	6	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0
66-BSB	0	0	0	0	1	0	6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
67-NDMF	0	19	0	0	4	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68-SDF	0	15	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69-PB	0	2	0	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
70-OB	0	6	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71-DP	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72-DP	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73-DSP	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74-WMP	0	13	0	18	6	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75-WMP	0	2	0	3	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
76-DMP	0	0	0	5	9	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77-DMP	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78-MP	0	1	0	18	20	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79-MP	0	6	0	14	1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80-DMP	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81-OM	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82-OM	0	4	0	2	1	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83-WMP	0	0	0	5	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84-DSP	0	0	1	2	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85-OB	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86-DMP	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87-WMP	0	2	0	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
88-OB	0	14	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
89-SDF	0	12	0	0	8	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
90-SSM	0	0	0	4	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91-DP	0	16	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
92-WMP	0	0	0	4	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93-SDMF	0	8	0	0	0	0	3	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
94-FF	0	8	0	0	2	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95-BR	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96-TRS	0	3	0	0	1	0	2	0	5	1	0	0	0	0	0	1	0	0	0	0	0	0	0
97-SSM	0	0	0	9	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
98-TRS	0	3	0	9	7	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99-AT	0	12	0	1	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100-CSPOF	0	15	0	0	1	1	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
101-OB	0	13	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102-DMP	0	4	0	1	8	0	0	0	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0
103-CF	0	0	0	6	1	0	0	0	1	3	0	0	0	2	0	0	0	0	0	0	0	0	0
104-WMP	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105-WMP	0	0	0	2	4	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
106-WMP	0	1	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107-WMP	0	0	0	2	3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
108-SDF	0	43	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
109-SDF	0	9	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110-SSM	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111-OO	0	7	0	0	5	1	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
112-BR	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113-TRS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114-SMF	0	3	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115-SHS	0	8	0	1	6	0	0	0	1	0	0	0	4	1	0	0	0	0	0	0	0	0	0
116-OO	0	8	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
117-WMP	0	2	0	2	6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
118-MP	0	0	0	4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
119-NMF	0	13	0	0	0	2	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
120-SDMF	0	18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121-SMF	0	33	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122-SDMF	0	9	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123-SDMF	0	13	0	0	0	5	0	0	2	0	0	0	3	0	0	0	0	0	0	0	0	0	0
124-SDMF	0	35	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
125-NWMF	0	14	0	0	10	1	12	0	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0
126-SMF	0	29	0	0	2	4	3	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127-FF	0	26	0	0	6	5	7	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128-TRS	0	6	0	2	5	0	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129-SC	0	3	0	9	1	1	3	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0
130-TRS	0	12	0	0	2	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
131-SSM	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
132-SDMF	0	22	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133-PB	1	6	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134-NSM	0	0	0	21	1	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
135-PB	0	5	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
136-PB	0	14	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
137-NWMF	19	16	0	6	5	1	17	0	1	0	0	3	0	0	0	1	0	0	0	0	0	0	0
138-BSB	1	9	0	4	3	0	21	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
139-SC	0	2	0	13	2	0	0	0	3	7	0	0	0	0	0	0	0	1	0	0	0	0	0

Transect ID	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
140-NDMF	0	21	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
141-OBO	0	0	0	0	7	0	2	1	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
142-PB	0	1	0	0	1	0	14	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
143-NSM	0	0	0	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
144-TPS	1	0	0	0	1	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145-SC	0	2	0	8	2	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	1	0
146-M	0	0	0	0	9	0	15	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
147-BSB	0	0	0	4	7	0	13	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
148-TPS	2	0	0	6	9	0	2	0	0	1	0	1	0	1	0	0	0	2	0	0	0	0	0
149-M	0	0	0	1	13	2	19	0	0	1	0	5	0	1	0	0	0	1	0	0	0	0	0
150-NMF	9	34	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
151-FF	2	20	0	1	2	1	3	0	0	0	0	0	5	1	1	0	0	0	0	0	0	0	0
152-NWMF	9	21	0	0	2	0	21	0	0	0	0	1	0	0	1	0	0	0	2	0	0	0	0
153-NWMF	8	26	0	0	1	0	27	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
154-NWMF	8	4	0	0	2	0	10	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0
155-M	0	8	0	4	6	1	2	0	0	0	0	8	3	0	0	0	0	0	0	0	0	0	0
156-NDMF	0	13	0	0	0	1	7	0	0	0	0	1	1	0	7	0	0	0	0	0	0	0	0
157-BSB	0	0	0	0	8	2	10	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
158-NWMF	0	19	0	0	0	1	11	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	1
159-NMF	0	21	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160-BSB	0	7	0	0	4	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161-NWMF	0	8	0	0	7	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162-NDMF	0	11	0	0	5	0	3	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
163-AT	0	5	0	0	1	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0

Transect	PEMAG	PELE	PEMAB	MIPE	SOCI	BLBR	MYGA	SPTR	ZAHU	SOAR	MIOC	SYCO	TAST	SOHO	GLVO	COCR	GLSA	MUER	TAHU	REME	SYFL	SOPA	MUFR
164-NDMF	0	10	0	0	7	2	6	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
165-NMF	16	7	0	0	10	0	8	0	1	0	0	1	0	3	0	0	0	0	0	0	0	0	0
166-HS	3	0	0	7	0	2	2	0	0	7	0	0	3	1	2	0	0	0	0	0	0	0	0
167-M	0	0	0	0	0	2	12	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
168-NMF	9	12	0	0	6	1	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
169-NWMF	8	2	0	0	8	0	13	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
170-M	0	1	0	1	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
171-BSB	0	0	0	0	6	0	9	0	0	4	0	0	0	2	1	0	0	1	1	0	0	0	0
172-BSB	0	1	0	0	9	2	11	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
173-PB	0	2	0	0	1	0	4	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
174-SC	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
175-M	0	0	0	6	3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
176-CPF	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
177-CSPOF	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
178-OB	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179-PB	0	0	0	3	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180-FF	0	19	0	0	1	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Animals captured during survey work for the WDNR, summer 2011. Methodology is described in Chapter 3 and locations and dates trapped can be found in Appendix C.

ID	PELE	SOCI	MIPE	SOAR	MYGA	BLBR	ZAHU	SOHO	TAST	COCR	GLVO	SOPA	MUMU	MUER	PEMAB
T1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
T2	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T3	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0
T4	7	0	6	0	0	0	0	0	0	0	0	0	0	0	0
T5	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T6	2	1	1	0	0	1	2	0	0	0	0	0	0	0	0
T7	2	4	11	0	0	0	1	0	0	0	0	0	0	0	0
T8	45	0	0	0	0	1	0	0	0	0	0	0	0	0	0
T9	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0
T10	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0
T11	1	4	11	0	0	0	1	0	0	0	0	0	0	0	0
T12	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0
T13	6	2	0	0	0	1	0	0	0	0	0	0	0	0	0
T14	4	17	2	0	0	0	0	0	0	0	0	0	0	0	0
T15	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T16	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
T17	2	3	4	13	0	1	0	0	0	1	0	1	0	0	0
T18	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0
T19	0	4	0	0	1	2	0	0	0	0	0	0	0	0	0
T20	8	11	0	0	2	4	0	0	0	0	1	1	0	0	0
T21	0	6	4	8	0	0	0	0	0	0	0	0	0	0	0

ID	PELE	SOCI	MIPE	SOAR	MYGA	BLBR	ZAHU	SOHO	TAST	COCR	GLVO	SOPA	MUMU	MUER	PEMAB
T22	23	3	0	0	3	4	0	1	0	0	0	0	0	0	0
T23	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T24	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0
T25	1	5	0	0	0	0	9	0	0	0	0	0	0	0	0
T26	3	3	0	0	2	0	0	0	0	0	0	0	0	0	0
T27	0	6	1	5	0	0	1	2	0	0	0	0	0	0	0
T28	7	2	0	0	0	0	1	2	0	0	0	0	1	0	0
T29	3	0	0	1	2	0	1	2	0	0	0	0	0	0	0
T30	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
T31	8	16	2	0	9	0	2	1	0	0	1	0	0	0	0
T32	0	0	6	4	0	0	0	0	0	0	0	0	0	0	0
T33	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
T34	1	4	0	0	0	0	0	1	0	0	0	0	0	0	0
T35	6	3	0	1	1	2	0	0	0	0	0	0	0	0	0
T36	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0
T37	0	0	5	3	0	0	0	0	0	0	0	0	0	0	0
T38	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0
T39	0	0	1	7	0	2	0	1	0	0	0	0	0	0	0
T40	1	10	0	1	1	1	0	0	0	0	0	0	0	0	0
T41	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
T42	0	0	0	5	0	2	0	0	0	0	0	0	0	0	0
T43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T44	0	1	7	3	0	1	0	0	0	1	0	0	0	1	0

ID	PELE	SOCI	MIPE	SOAR	MYGA	BLBR	ZAHU	SOHO	TAST	COCR	GLVO	SOPA	MUMU	MUER	PEMAB
T45	6	4	0	0	2	2	0	0	5	0	0	0	0	0	0
T46	0	2	1	0	5	3	0	1	3	0	0	0	0	0	0
T47	0	0	5	1	1	0	0	0	0	0	0	0	0	0	0

APPENDIX E

LIST OF PREPARED VOUCHER SPECIMENS

List of voucher specimens captured during field work conducted by Ryan Stephens from 2009 to 2011. This appendix is arranged by species and includes preparator, date captured, reproductive data, standard museum measurements, museum and catalog number where voucher is held, and final preparation. The ID column corresponds with the locations described in Appendix C, where "PS" refers to a pilot study that was conducted in 2009 prior to thesis work, "number only" refers to locations trapped during thesis work from 2009-2010, and "T" refers to locations trapped during field work for the WDNR during the summer of 2011. Vouchers were deposed in: University of Wisconsin Stevens Point Museum of Natural History, Stevens Point, WI (UWSP); National Museum of Natural History, Washington D.C. (NMNH); Harvard Museum of Comparative Zoology, Cambridge, MA (HMCZ); and University of Alaska Museum, Fairbanks, AK (UAF). Vouchers with a (D) or (T) after the museum acronym denote specimens that have skins used by the WDNR as teaching specimens or that are in a display at Treehaven field station (W2540 Pickerel Creek Road Tomahawk, WI 54487), respectively. Tissues from vouchers prepared as skins or skeletons include kidney, heart, liver, and skeletal muscle stored in 70% ethanol. Fluid specimens were injected and stored in 70% ethanol. Tissues from these specimens include spleen and liver. At the time of this publication all specimens from 2009 have been processed; however, a number of specimens collected in 2010 and 2011 are frozen and have yet to be processed.

Blarina brevicauda

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Mark Mueller	1	12	6/25/2009	F		X		110-25-14-X≡16g	UWSP	9968	X	X			
Ryan Stephens	503	15	6/19/2009	F		X		112-27-15-X≡17.5g	UWSP	10004			X	X	X
Ryan Stephens	513	15	6/19/2009	F		6		126-25-16-X≡19g	HMCZ	67227	X	X	X		
Ryan Stephens	526	15	6/20/2009	M	11			114-24-14-X≡13.5g	UWSP	10025			X	X	X
Ryan Stephens	1468	15	6/26/2009	M	X			91-22-16-X≡14g	UWSP	10084			X	X	X
Ryan Stephens	538	15	6/22/2009	M	3			114-24-16-X≡16.5g	UWSP	10011			X	X	X
Ryan Stephens	537	15	6/22/2009	M	5			122-24-15-X≡19.75g	UWSP	10006			X	X	X
Ryan Stephens	519	15	6/19/2009	M	8			126-25-16-X≡22g	HMCZ	67228	X	X	X		
Jacob Heidemann	1	16	6/12/2009	F		X		99-21-12-X≡12g	UWSP	9904	X		X	X	
Ryan Stephens	1467	16	6/26/2009	F		X		102-26-16-X≡12.25g	UWSP	10085			X	X	X
Ryan Stephens	1473	16	6/26/2009	F		X		111-23-15-X≡14.5g	UWSP	10088			X	X	X
Ryan Stephens	1469	16	6/26/2009	F		X		117-26-14-X≡16g	UWSP	10092			X	X	X
Ryan Stephens	1130	16	6/24/2009	F		Lac.		122-26-15-X≡18g	UWSP	10159		X	X		
Ryan Stephens	1129	16	6/24/2009	F		X		126-27-15-X≡20g	UWSP	9842		X	X		
Emily Hart	1	16	6/24/2009	M	X			104-27-13-X≡13g	UWSP	9857	X	X	X		
John Keniry	1	16	6/24/2009	X				116-20-11-X≡18g	UWSP	9880	X	X	X		
Ryan Freidel	1	17	6/22/2009	F		X		113-22-11-X≡12.5g	UWSP	9931	X	X	X		
Ryan Stephens	961	17	6/25/2009	F		X		113-25-14-X≡16.46g	UWSP	10155		X			
Brennen Nading	1	17	6/22/2009	F		X		110-24-15-X≡17g	UWSP	9879	X	X	X		
Ryan Stephens	1139	17	6/22/2009	F		X		125-26-14-X≡18.3g	NMNH	600014	X	X	X		
Ryan Stephens	1470	17	6/26/2009	M	3			120-26-16-X≡18g	UWSP	10091			X	X	X
Ryan Stephens	1471	17	6/26/2009	M	X			109-24-16-X≡19g	UWSP	10090			X	X	X
Ryan Stephens	1466	18	6/26/2009	F		X		112-24-15-X≡14.25g	UWSP	10086			X	X	X
Michael Manel	2	19	6/29/2009	F		X		101-22-12-X≡12g	UWSP	9882	X	X	X		
Ryan Stephens	567	19	6/26/2009	F		X		111-21-15-X≡15.25g	UWSP	10051			X	X	X

Blarina brevicauda continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Caitlin Enright	1	19	6/27/2009	F		X		111-24-13-X≡17g	UWSP	9927	X	X	X		
Christine Congdon	1	19	6/27/2009	F		X		106-19-9-X≡17g	UWSP	9922	X	X	X		
Courtney Blumberg	2	19	6/29/2009	M	1			72-25-15-X≡9g	UWSP	9874	X	X	X		
Darren Ladwig	2	19	6/29/2009	M	1			101-12-13-X≡11g	UWSP	9930	X	X	X		
Andy Stetter	1	19	6/25/2009	M	1.8			112-21-12-X≡11.5g	UWSP	9873	X	X	X		
Ryan Stephens	1120	19	6/27/2009	M				111-26-15-X≡12g	HMCZ	67238		X	X		
Ryan Stephens	1128	19	6/25/2009	M	1			109-24-15-X≡14g	HMCZ	67241	X	X	X		
Ryan Stephens	1162	19	6/29/2009	M	2			126-26-15-X≡21g	UWSP	9791		X	X		
Natasha Siegel	1	19	6/27/2009	M	2			102-19-14-X≡Xg	UWSP	9932	X			X	
Ryan Stephens	951	20	6/27/2009	F		X		103-25-15-X≡8.83g	UWSP	9556	X	X			
Ben Doty	2	20	6/22/2009	F		X		102-22-12-X≡12g	UWSP	9877	X	X	X		
Ryan Stephens	565	20	6/26/2009	F		X		111-24-15-X≡14.25g	UWSP	10044			X	X	X
Ryan Stephens	564	20	6/26/2009	F		X		117-26-15-X≡15.25g	UWSP	10043			X	X	X
Pierce FollansbeeDelong	2	20	6/22/2009	F		X		121-28-14-X≡18g	UWSP	10119	X	X	X		
Ryan Stephens	943	20	6/25/2009	F		X		121-25-15-X≡18.2g	UWSP(D)	10153		X			
Ryan Stephens	944	20	6/25/2009	M	2			105-24-14-X≡11.77g	UWSP	9575	X	X			
Jennifer LaMontagne	2	20	6/22/2009	M	X			129-30-20-X≡15g	UWSP	9914	X		X	X	
Jessica Piispanen	1	20	6/25/2009	M	7			120-22-15-X≡22.5g	UWSP	10109	X				
Ryan Stephens	936	21	6/25/2009	M	1			100-24-15-X≡10.53g	UWSP(D)	10152		X			
Ryan Stephens	1472	21	6/26/2009	M	X			112-24-15-X≡14.75g	UWSP	10089			X	X	X
Jake Zimmerman	2	21	6/24/2009	M	1			116-30-15-X≡17g	UWSP	9870	X	X	X		
Lisa McCabe	1	22	6/25/2009	F		X		100-19-6-X≡15g	UWSP	9936	X	X	X		
Ryan Stephens	1121	22	6/25/2009	F		X		117-24-16-X≡16g	HMCZ	67239		X	X		
Ryan Stephens	1122	22	6/25/2009	F		X		116-25-15-X≡16g	HMCZ	67240		X	X		
Ryan Stephens	563	22	6/26/2009	F		X		111-24-16-X≡17.7g	UWSP	10042			X	X	X

Blarina brevicauda continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Dan McElwee	1	22	6/27/2009	F		X		150-30-14-X≡18g	UWSP	9967	X	X	X		
Wesley Ellarson	1	22	6/25/2009	M	1			111-21-12-X≡14.9g	UWSP	9923	X	X	X		
Naryssa Christensen	1	22	6/25/2009	M	X			114-20-14-X≡15g	UWSP	9920	X	X	X		
Ryan Stephens	1161	22	6/27/2009	X				106-25-14-X≡14g	UWSP	9790		X	X		
Ryan Stephens	561	23	6/26/2009	F		X		104-24-14-X≡13g	UWSP	10040			X	X	X
Pierce FollansbeeDelong	1	23	6/25/2009	F		X		120-32-13-X≡14.5g	UWSP	10128	X	X	X		
Ryan Stephens	562	23	6/26/2009	F		X		105-23-15-X≡14.5g	UWSP	10041			X	X	X
Amy Thrall	1	23	6/25/2009	F		X		98-21-11-4≡14.9g	UWSP	10126	X		X	X	
Ryan Stephens	558	23	6/25/2009	F		X		111-25-14-X≡15.5g	UWSP	10013			X	X	X
Brennen Rausch	1	23	6/25/2009	F		X		115-18-13-X≡18g	UWSP	10125	X		X	X	
Ryan Stephens	1178	23	6/24/2009	M	1			114-22-14-X≡14.5g	NMNH	600020		X	X		
Eric Wiederhoeft	1	23	6/25/2009	M	2			102-23-11-X≡16g	UWSP	10124	X	X			
Andy Kramer	1	23	6/25/2009	M	2			115-25-14-X≡17.6g	UWSP	10127	X	X	X		
Ryan Stephens	1177	23	6/24/2009	M	2			127-23-16-X≡19g	UWSP	9833		X	X		
Ryan Stephens	645	41	7/24/2009	M	3			111-29-15-X≡17g	HMCZ	67229	X	X	X		
Ryan Stephens	781	50	7/30/2009	F		X		117-24-16-X≡20.28g	HMCZ	67233	X	X	X		
Ryan Stephens	681	60	8/7/2009	M	4			102-22-15-X≡12g	HMCZ	67230	X	X	X		
Katelyn Brauner	1	71	8/21/2009	M	X			105-21-11-X≡16g	UWSP	9910	X		X	X	
Ryan Stephens	738	74	8/22/2009	F		X		130-25-16-X≡23.5g	HMCZ	67231	X	X	X		
Brennen Nading	2	75	8/21/2009	F		X		103-27-15-X≡16.5g	UWSP	9858	X	X	X		
Christine Congdon	2	75	8/21/2009	F		X		109-19-12-X≡17g	UWSP	9876	X	X	X		
Ryan Stephens	733	75	8/21/2009	M	2			127-29-16-X≡21.75g	HMCZ	67243	X	X	X		
Ryan Stephens	1144	75	8/21/2009	M	3			125-24-15-X≡27g	NMNH	600015	X	X	X		
Sam Jones	2	78	8/25/2009	F		X		99-18-13-X≡10.5g	UWSP	9856	X	X	X		
Tanya Wolf	2	78	8/28/2009	F		X		124-32-14-5≡18g	UWSP	9949	X	X	X		

Blarina brevicauda continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Emily Hart	2	78	8/27/2009	F		X		83-24-13-X≡19g	UWSP	9965	X	X	X		
Darren Ladwig	1	78	8/28/2009	M	X			115-23-13-X≡16g	UWSP	9960	X	X	X		
Ryan Stephens	1151	78	8/28/2009	M	1			125-24-15-X≡19.5g	UWSP	10164		X	X		
Ryan Stephens	1149	78	8/28/2009	M	2			122-23-16-X≡21.5g	UWSP	10162		X	X		
Ryan Stephens	749	79	8/25/2009	F		X		111-26-15-X≡14.5g	HMCZ	67232	X	X	X		
Kurt Miedtke	1	79	8/27/2009	F		7		113-18-16-X≡21g	UWSP	9964	X	X	X		
Loren Ayers	1	82	8/27/2009	M	2			115-24-16-X≡19g	UWSP	9987	X		X	X	
Ryan Stephens	451	PS1	5/27/2009	M	5			107-25-14-X≡13.99g	HMCZ	67226	X	X	X		
Ryan Stephens	441	PS3	5/22/2009	M	3			126-23-15-X≡20.56g	UWSP	9565	X	X			
Ryan Stephens	1131	16	6/24/2010	F		X		109-22-15-X≡13.5g	HMCZ	67242		X	X		
Ryan Stephens	1188	100	6/9/2010	M	1			113-24-15-X≡15g	UWSP	10170		X	X		
Nate Huck	6	109	6/17/2010	M	3			106-23-15-X≡14.5g	UWSP	9996	X	X			
Ryan Stephens	1061	114	6/24/2010	M	3			120-22-16-X≡23g	HMCZ	67235	X	X	X		
Ryan Stephens	1060	114	6/24/2010	M	2			120-22-15-X≡26g	HMCZ	67234	X	X	X		
Nigel Golden	1	119	7/9/2010	F		X		106-29-15-X≡17g	UWSP	10101	X	X	X		
Ryan Stephens	1457	123	7/8/2010	F		X		112-24-15-X≡21g	UWSP	9993	X	X	X		
Ryan Stephens	1456	124	7/8/2010	M	2			122-26-15-X≡17g	UWSP	10181		X	X		
Ryan Stephens	1134	127	7/12/2010	F		X		120-25-16-X≡16g	UWSP	9780		X	X		
Ryan Stephens	1460	127	7/15/2010	M	2			115-24-15-X≡14g	UWSP	10182		X	X		
Ryan Stephens	1133	127	7/12/2010	M	1			122-25-15-X≡19g	UWSP	9779		X	X		
Mari Shirley	2	127	7/15/2010	M	3			100-20-13-X≡25g	UWSP	10002	X	X	X		
Ryan Stephens	1187	134	7/24/2010	F		X		122-26-16-X≡20g	UWSP	10169		X	X		
Ryan Stephens	1172	137	7/23/2010	M	1			120-28-17-X≡16g	UWSP	9831		X	X		
Ryan Stephens	1233	149	8/8/2010	M	3			113-25-16-X≡17g	UWSP	9534	X	X	X		
Ryan Stephens	1258	155	8/7/2010	F		X		155-25-15-X≡14g	UWSP	9812		X	X		

Blarina brevicauda continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1214	156	8/8/2010	M	2			124-26-15-X≡22g	UWSP	9816		X	X		
Luke Williamson	2	159	8/13/2010	F		8		125-18-14-3≡19.5g	UWSP	9872	X	X	X		
Phil Vogrinc	2	159	8/10/2010	F		X		118-27-15-6≡20g	UWSP	9952	X	X	X		
Andy Schantz	2	159	8/12/2010	M	9			114-27-19-X≡15.2g	UWSP	9918	X	X	X		
Amanda Zalewski	10	161	8/10/2010	M	X			112-20-11-4≡17g	NMNH	600238	X	X	X		
Ryan Stephens	1095	164	8/12/2010	M	3			111-24-15-X≡15.5g	HMCZ	67236	X	X	X		
Ryan Stephens	1427	168	8/19/2010	M	1			110-23-15-X≡13g	UAF	113826	X	X	X		
Ryan Stephens	1108	180	8/25/2010	F		X		120-28-15-X≡16g	HMCZ	67237	X	X	X		
Ryan Stephens	1286	T19	6/8/2011	M	7			120-25-15-X≡21.8g	UAF	113828	X	X	X		
Ryan Stephens	1312	T46	6/28/2011	M	8			131-26-15-X≡26g	UAF	113825	X	X	X		
Ryan Stephens	1268	T6	5/26/2011	M	10			118-24-16-X≡28g	UAF	113827	X	X	X		
Ryan Stephens	1273	T8	5/26/2011	M	8			126-25-16-X≡25g	UAF	113829	X	X	X		

Condylura cristata

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	477	3	6/8/2009	F			7	193-75-29-X≡63.5g	UWSP(T)	10138		X	X		
Ryan Stephens	517	14	6/19/2009	F		X		182-67-27-X≡43.5g	UWSP(D)	10146		X	X		
Ryan Stephens	708	65	8/11/2009	F		X		165-65-26-X≡34g	UAM	113795	X	X	X		
Ryan Stephens	1030	93	6/9/2010	M	2			165-63-24-X≡44g	NMNH	570994	X	X	X		
Ryan Stephens	1032	96	6/9/2010	M	5			185-72-28-X≡57g	UWSP	9460	X	X	X		
Ryan Stephens	1082	137	7/24/2010	M	2			172-64-27-X≡41g	UWSP	9751	X	X	X		
Ryan Stephens	1089	147	7/27/2010	M	X			182-78-27-X≡44g	NMNH	600004	X	X	X		
Ryan Stephens	1293	T17	6/10/2011	M	4			175-72-25-X≡45.5g	UWSP	113848	X	X	X		
Ryan Stephens	1310	T36	6/23/2011	F		X		182-68-26-X≡44.5g	UAF	113794	X	X	X		
Ryan Stephens	1315	T44	6/29/2011	F		X		180-69-27-X≡53g	UAF	113824	X	X	X		

Glaucomys sabrinus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	714	65	8/12/2009	M	5			256-116-31-23≡77g	UWSP	9712	X	X	X		
Ryan Stephens	712	66	8/12/2009	F		X		264-116-35-23≡94.5g	UWSP(T)	10150		X	X		

Glaucomys volans

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	672	52	8/6/2009	F		X		223-99-29-18≡51g	UWSP	9704	X	X			
Ryan Stephens	683	52	8/7/2009	F		X		239-106-31-20≡70g	NMNH	570963	X	X	X		
Ryan Stephens	671	52	8/6/2009	F		X		225-93-31-17≡82.5g	UWSP	9703	X	X	X		
Ryan Stephens	450	PS4	5/23/2009	F			3	234-104-29-18≡66.23g	UWSP	9694	X	X	X		
Ryan Stephens	1079	138	7/22/2010	F		X		219-94-31-19≡62g	NMNH	600002	X	X	X		
Ryan Stephens	1208	152	8/5/2010	F		X		235-98-30-19≡66.5g	UWSP	9510	X	X	X		
Ryan Stephens	1218	153	8/5/2010	M	6			210-89-30-18≡54g	UWSP	9511	X	X	X		
Ryan Stephens	1117	154	7/5/2010	F		X		232-104-30-17≡69.5g	NMNH	600012	X	X	X		
Ryan Stephens	1425	166	8/20/2010	F			3	231-105-33-16≡73g	UWSP	9762	X	X	X		
Ryan Stephens	1132	168	8/20/2010	M	9			235-96-33-19≡74g	UWSP	9437	X	X	X		
Ryan Stephens	1447	171	8/19/2010	F		X		232-96-30-18≡58g	UWSP	9793	X	X	X		

Ictidomys tridecemlineatus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	628	36	7/22/2009	M	5			245-97-38-7≡87.5g	UWSP	9614	X	X	X		
Ryan Stephens	649	39	7/25/2009	F		X		241-88-36-8≡102g	UWSP	9913	X	X	X		
Ryan Stephens	629	39	7/22/2009	F		X		275-102-37-7≡108g	NMNH	570953	X	X			
Ryan Stephens	808	47	7/29/2009	M	4			228-85-35-9≡87.59g	UWSP	9651	X	X	X		
Ryan Stephens	662	51	7/28/2009	F		X		252-86-35-8≡152g	UAF	113815	X	X	X		
Ryan Stephens	653	51	7/27/2009	M	8			250-89-38-9≡129g	NMNH	570959	X	X	X		
Ryan Stephens	853	55	8/8/2009	M	3			242-93-37-9≡80.67g	UWSP	9659	X	X			
Ryan Stephens	851	55	8/7/2009	M	3			270-103-38-9≡168g	NMNH	570985	X	X	X		
Ryan Stephens	673	56	8/6/2009	F		X		248-84-34-9≡93.5g	UWSP	9630	X	X	X		
Ryan Stephens	728	76	8/20/2009	F		X		238-86-35-8≡106g	NMNH	570970	X	X	X		
Ryan Stephens	739	76	8/22/2009	M	7			272-86-36-9≡185g	UWSP	9635	X	X	X		
Ryan Stephens	748	77	8/25/2009	F		X		244-85-34-7≡109g	UWSP	9640	X	X	X		
Ryan Stephens	1019	84	6/4/2010	M	9			265-86-36-9≡145g	UWSP	9436	X	X	X		
Sara Wendt	10	141	7/26/2011	M	X			210-70-31-9≡56g	UAF	113814	X	X	X		

Microtus ochrogaster

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	626	38	7/22/2009	F		X		124-23-18-11≡17.25g	UWSP	9612	X	X	X		
Ryan Stephens	625	41	7/22/2009	F		X		85-25-17-10≡9.4g	NMNH	570952	X	X	X		
Ryan Stephens	633	41	7/23/2009	F		X		104-28-18-10≡15.25g	UWSP	9617	X	X	X		
Ryan Stephens	630	41	7/22/2009	F		X		117-26-18-10≡15.75g	NMNH	570954	X	X	X		
Ryan Stephens	632	41	7/22/2009	F		4		121-28-18-12≡32g	UWSP	9616	X	X	X		
Ryan Stephens	624	41	7/22/2009	M	4			108-27-16-10≡11.75g	UWSP	9611	X	X	X		
Ryan Stephens	844	41	7/25/2009	M	11			139-33-18-11≡27.46g	NMNH	570984	X	X	X		
Ryan Stephens	646	42	7/24/2009	F			4	137-32-17-10≡31.5g	UWSP	9623	X	X	X		
Ryan Stephens	832	42	7/25/2009	F			3	150-38-18-15≡37.96g	NMNH	570983	X	X	X		
Ryan Stephens	833	42	7/25/2009	F			4	145-32-16-13≡38.69g	UWSP	9657	X	X	X		
Ryan Stephens	639	42	7/25/2009	M	5			119-27-17-11≡21.5g	UWSP	9620	X	X	X		
Ryan Stephens	834	42	7/25/2009	M	12			145-35-18-13≡39.38g	UWSP	10204			X		
Ryan Stephens	627	43	7/22/2009	F		4		141-29-18-12≡36.5g	UWSP	9613	X	X	X		
Ryan Stephens	731	75	8/21/2009	M	13			156-37-20-14≡40g	UWSP	9633	X	X	X		
Ryan Stephens	1013	87	6/3/2010	F		X		130-32-20-13≡23.5g	UWSP	9666	X	X	X		

Microtus pennsylvanicus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	468	2	6/7/2009	M	17			158-39-20-13≡41.5g	UWSP(T)	10136		X	X		
Ryan Stephens	490	3	6/10/2009	M	12			138-35-20-12≡23.75g	UWSP	9584	X	X	X		
Ryan Stephens	495	3	6/12/2009	M	15			160-42-20-12≡32.5g	UWSP	9585	X	X	X		
Ryan Stephens	475	3	6/7/2009	M	16			152-45-20-14≡44.5g	NMNH	570937	X	X	X		
Ryan Stephens	476	3	6/7/2009	M	15			165-44-21-13≡48g	NMNH	570938	X	X	X		
Ryan Stephens	501	6	6/10/2009	M	11			134-39-19-13≡23.7g	UWSP	9579	X	X	X		
Ryan Stephens	525	9	6/20/2009	F		X		138-43-20-12≡19g	UWSP	10024			X	X	X
Ryan Stephens	520	11	6/19/2009	M	12			136-37-19-12≡23g	UWSP	10022			X	X	X
Ryan Stephens	510	12	6/19/2009	F		X		130-35-28-13≡26.5g	UWSP	10020			X	X	X
Ryan Stephens	508	12	6/19/2009	M	14			128-40-20-11≡29.5g	UWSP	10018			X	X	X
Ryan Stephens	511	13	6/19/2009	M	X			114-30-18-11≡13.75g	UWSP	10021			X	X	X
Ryan Stephens	524	14	6/20/2009	M	14			136-42-20-11≡23g	UWSP	9582	X	X	X		
Ryan Stephens	516	14	6/19/2009	M	12			147-42-21-15≡28.25g	UWSP	9580	X	X	X		
Ryan Stephens	569	24	7/3/2009	M	6			110-37-26-11≡11.75g	UWSP	9601	X	X	X		
Ryan Stephens	610	33	7/10/2009	F		X		132-34-20-11≡22g	UWSP	10055			X	X	X
Ryan Stephens	609	33	7/10/2009	F		6		155-44-22-13≡36.5g	UWSP	10054			X	X	X
Ryan Stephens	608	33	7/10/2009	F		12		160-43-21-12≡42.5g	UWSP	10053			X	X	X
Ryan Stephens	611	33	7/10/2009	M	12			156-40-20-13≡31.5g	UWSP	10056			X	X	X
Ryan Stephens	594	33	7/8/2009	M	16			150-39-20-16≡43g	UWSP	10046			X	X	X
Ryan Stephens	593	33	7/8/2009	M	16			167-45-20-12≡46.5g	UWSP	10147			X	X	X
Ryan Stephens	607	33	7/10/2009	M	13			173-43-22-13≡48g	UWSP	10052			X	X	X
Ryan Stephens	631	40	7/22/2009	F			4	158-46-19-12≡28.75g	UWSP	9615	X	X	X		
Ryan Stephens	638	42	7/23/2009	F		3		146-49-21-12≡27.75g	NMNH	570956	X	X	X		
Ryan Stephens	664	45	7/28/2009	F		X		143-40-19-13≡26g	UWSP	9627	X	X	X		
Ryan Stephens	812	45	7/30/2009	M	7			145-35-19-12≡28g	UWSP	9652	X	X			

Microtus pennsylvanicus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	811	45	7/30/2009	M	13			150-36-20-15≡41g	NMNH	570980	X	X			
Ryan Stephens	663	45	7/28/2009	M	17			157-41-20-14≡48g	UWSP	9625	X	X	X		
Ryan Stephens	813	47	7/28/2009	F		6		126-33-19-13≡26.58g	UWSP	9653	X	X			
Ryan Stephens	789	48	7/28/2009	F		X		125-38-19-11≡21.5g	UWSP	9648	X	X			
Ryan Stephens	807	49	7/29/2009	F		X		142-40-19-12≡27.86g	UAF	113792	X	X	X		
Ryan Stephens	806	49	7/29/2009	F		X		140-39-20-12≡28.89g	UWSP	9650	X	X	X		
Ryan Stephens	659	49	7/28/2009	M	16			158-44-20-12≡41.5g	NMNH	570960	X	X	X		
Ryan Stephens	790	50	7/28/2009	M	14			165-45-20-12≡35.5g	UWSP	9649	X	X			
Ryan Stephens	847	53	8/6/2009	F		6		133-36-19-12≡31.13g	UAF	113793	X	X	X		
Ryan Stephens	848	54	8/8/2009	M	14			143-42-20-12≡27.38g	UWSP	9719	X	X	X		
Ryan Stephens	850	56	8/5/2009	F		X		161-48-20-12≡35.58g	UAF	113791	X	X	X		
Scott Churchill	1	57	8/8/2009	F		X		137-32-22-11≡25g	UWSP	9921	X	X	X		
Tim Neuman	1	57	8/8/2009	M	13			172-46-20-15≡44g	UWSP	9948	X	X	X		
Ryan Stephens	855	59	8/5/2009	F		X		144-42-19-11≡26.4g	UWSP	9722	X	X	X		
Ryan Stephens	703	59	8/9/2009	M	4			102-39-12-6≡5g	UWSP	10073			X	X	X
Ryan Stephens	704	59	8/9/2009	M	17			102-29-19-9≡11.5g	UWSP	10074			X	X	X
Luke Williamson	1	59	8/6/2009	M	14			149-38-20-12≡33g	UWSP	9902	X	X	X		
Sara Wendt	2	62	8/6/2009	F			6	141-41-20-12≡30.3g	UWSP	10199	X				
Ryan Stephens	1145	75	8/21/2009	F		X		147-42-20-13≡24.5g	NMNH	600016	X	X	X		
Ryan Stephens	736	75	8/21/2009	M	3			143-42-20-13≡23.75g	UWSP	9714	X	X			
Jake Zimmerman	1	75	8/21/2009	M	15			174-47-21-15≡51g	UWSP	9871	X	X	X		
Ryan Stephens	732	75	8/21/2009	M	17			179-45-22-13≡54g	NMNH	570972	X	X	X		
Mark Cufaude	2	76	8/20/2009	M	X			160-47-20-14≡43.5g	UWSP	9905	X	X	X		
Heather Heimann	2	78	8/28/2009	F		5		132-35-18-10≡21g	UWSP	10107	X	X			
Scott Firkus	2	78	8/28/2009	F		X		140-32-20-13≡26g	UWSP	9863	X	X			

Microtus pennsylvanicus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Andrew Gilbert	2	78	8/28/2009	F		X		142-42-18-12≡29g	UWSP	9867	X	X	X		
Ryan Stephens	1148	78	8/28/2009	F			5	155-112-19-12≡32g	UWSP	10161		X	X		
Kevin Brecka	1	78	8/28/2009	F		3		156-42-18-15≡38g	UWSP	9901	X	X	X		
Kim Cooley	1	78	8/25/2009	F		X		151-50-40-10≡43g	UWSP	9903	X	X	X		
Adam Nickel	1	78	8/25/2009	M	2			160-45-20-19≡42g	UWSP	9883	X		X	X	
Jaclyn Schmitz	1	79	8/27/2009	M	14			164-42-17-11≡31g	UWSP	9937	X	X	X		
Dan McElwee	2	79	8/27/2009	M	X			155-41-19-14≡78g	UWSP	9907	X	X	X		
Kat Dickerson	2	81	8/26/2009	F		6		147-38-15-12≡42g	UWSP	9944	X	X	X		
Amy Munes	1	82	8/27/2009	F		X		142-30-18-10≡22g	UWSP	9933	X	X	X		
Ryan Stephens	747	82	8/25/2009	M	15			160-44-19-12≡46.5g	UAF	113787	X	X	X		
Amy Munes	2	83	8/26/2009	M	13			165-49-20-13≡40g	UWSP	9961	X	X			
Ryan Stephens	453	PS1	5/27/2009	F		4		137-36-19-11≡30.15g	UWSP	9568	X	X	X		
Ryan Stephens	447	PS1	5/25/2009	F		7		142-39-19-12≡35.91g	UWSP	9567	X	X	X		
Ryan Stephens	446	PS1	5/25/2009	M	16			154-39-20-13≡40.6g	UWSP	9560	X	X	X		
Tyler Hasheider	2	78	8/28/2010	M	15			150-50-20-10≡40g	UWSP	9860	X	X	X		
Ryan Stephens	1014	87	6/4/2010	M	13			139-31-19-12≡29g	UWSP	9482	X	X	X		
Ryan Stephens	1017	92	6/4/2010	F		5		142-42-19-13≡27.5g	UWSP	9484	X	X	X		
Matthew Flintrop	1	95	6/11/2010	F			6	159-45-18-12≡35g	UWSP	9924	X	X	X		
Jake Loore	1	95	6/11/2010	F		5		147-40-18-13≡43.5g	UWSP	9881	X	X	X		
Troy Olson	1	95	6/11/2010	M	16			154-47-38-11≡47g	UWSP	9935	X	X	X		
Ryan Stephens	1024	95	6/8/2010	M	15			160-38-20-14≡50g	NMNH	570991	X	X	X		
Ryan Stephens	1035	97	6/10/2010	F		X		103-28-19-10≡8.7g	UWSP	9489	X	X	X		
Arik Wallace	2	98	6/9/2010	F		X		120-40-15-10≡27g	UWSP	9859	X		X	X	
Ryan Stephens	1190	98	6/11/2010	M	1			109-29-16-6≡12g	UWSP	10172		X	X		
Ryan Stephens	1189	98	6/11/2010	M	5			111-29-19-6≡12.5g	UWSP	10171		X	X		

Microtus pennsylvanicus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Mark Worth	2	98	6/9/2010	M	4			149-39-18-X≡13g	UWSP	9861	X	X	X		
Chadd Nelson	2	98	6/7/2010	M	16			159-48-43-15≡36.1g	UWSP	9966	X	X	X		
Nate Huck	4	100	6/9/2010	F		5		167-43-20-12≡48g	UWSP	9942	X	X			
Kali King	2	100	6/9/2010	M	2.5			165-71-30-11≡25g	UWSP	9875	X	X	X		
Kali Cotteleer	3	104	6/17/2010	F			4	128-40-17-10≡45g	UWSP	9985	X	X	X		
Ryan Stephens	1053	104	6/19/2010	M	18			117-46-19-14≡53.5g	UWSP	9494	X	X	X		
Ryan Stephens	1057	106	6/20/2010	F		X		171-47-20-12≡28g	UWSP	9496	X	X	X		
Patrick Bula	2	112	6/22/2010	F		X		134-38-16-10≡42g	UWSP	9986	X	X	X		
Ryan Stephens	1070	128	7/13/2010	M	20			165-48-20-13≡57.5g	UWSP	9513	X	X	X		
Ryan Stephens	1141	129	7/12/2010	F			8	158-40-21-11≡37.5g	UWSP	9830		X	X		
Andy Schantz	1	129	7/12/2010	F		X		126-43-37-12≡51g	UWSP	10100	X	X	X		
Justine Doty	2	129	7/15/2010	M	16			150-X-17-15≡56g	UWSP	9844	X		X	X	
Ryan Stephens	1143	130	7/15/2010	M	17			176-40-21-14≡60g	UWSP	9512	X	X	X		
Ryan Stephens	1142	132	7/12/2010	F		X		136-43-15-11≡20g	UWSP	9785		X	X		
Ryan Stephens	1140	132	7/15/2010	M	11			140-39-20-11≡24g	UWSP	9784		X	X		
Amanda Zalewski	6	134	7/21/2010	M	15			173-39-20-15≡47g	UWSP	113857		X	X		
Matthew Styka	2	134	7/21/2010	M	15			170-40-20-12≡47.5g	UWSP	9900	X	X	X		
Sara Wendt	8	135	7/21/2010	M	9			173-49-21-15≡47g	UWSP	10129	X		X	X	
Alexa Cushman	1	139	7/23/2010	F		4	5	140-38-19-15≡30g	UWSP	10106	X	X	X		
Kelsey Musser	1	143	7/28/2010	M	15			145-33-20-12≡30.5g	UWSP	9938	X	X	X		
Ryan Stephens	1179	147	7/26/2010	F		3		145-40-19-12≡25.5g	UWSP	9514	X	X	X		
Matthew Thayer	1	147	7/26/2010	M	13			142-28-20-13≡29g	UWSP	10118	X	X	X		
Tim Neuman	2	147	7/26/2010	M	8			141-35-18-11≡29g	UWSP	9947	X	X	X		
Mari Shirley	1	147	7/27/2010	M	12			155-40-20-15≡40g	UWSP	10001	X	X	X		
Ryan Stephens	1262	153	8/8/2010	F		X		137-35-20-13≡19g	UWSP	9689	X	X	X		

Microtus pennsylvanicus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1259	155	8/6/2010	F		4		158-42-19-14≡42g	UWSP	9524	X	X	X		
Ryan Stephens	1437	166	8/21/2010	F			5	150-42-20-11≡30g	UWSP	9822		X	X		
Kali Cotteleer	4	166	8/22/2010	M	13			138-20-38-12≡36g	UWSP	10122	X	X	X		
Ryan Stephens	1438	166	8/21/2010	M	15			161-48-20-13≡37.5g	UWSP	9821		X	X		
Rob Prinsen	1	175	8/26/2010	F		X		120-40-20-10≡16g	UWSP	9866	X	X	X		
Dillon Fedro	3	175	8/26/2010	F			2	12-3.5-2-X≡17.5g	UWSP	10203	X	X	X		
Ryan Stephens	1104	175	8/25/2010	F		4		150-40-19-11≡29.5g	UWSP	9515	X	X	X		
Ryan Stephens	1276	T11	5/30/2011	M	15			155-39-19-13≡34.5g	UWSP	9734	X	X	X		
Gerrid Greenwood	1	T37	6/26/2011	F		6		158-49-17-12≡40.5g	UWSP	10116	X	X	X		
Ryan Stephens	1271	T6	5/26/2011	M	12			150-44-19-12≡31g	UWSP	9733	X	X	X		
Ryan Stephens	1267	T6	5/25/2011	M	15			161-39-20-12≡45g	UWSP	9731	X	X	X		

Mustela erminea

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	467	2	6/7/2009	F		X		242-62-30-15≡61g	NMNH	570936	X	X	X		
Ryan Stephens	480	2	6/9/2009	M	16			301-83-39-17≡151g	UWSP(T)	10140		X	X		
Ryan Stephens	1071	131	7/13/2010	F		X		225-56-31-15≡53g	NMNH	571000	X	X	X		
Ryan Stephens	1078	139	7/22/2010	F		X		234-62-30-15≡64.5g	UWSP	9468	X	X	X		
Ryan Stephens	1088	145	7/27/2010	F			3	240-60-31-15≡63g	UWSP	9469	X	X	X		
Ryan Stephens	1124	145	7/26/2010	F			2	228-65-31-15≡67.5g	UWSP	9467	X	X	X		
Ryan Stephens	1182	145	7/26/2010	M	6			305-79-41-16≡139g	UWSP	9461	X	X	X		
Ryan Stephens	1168	145	7/27/2010	M	4			311-89-44-19≡143g	NMNH	600018	X	X	X		
Ryan Stephens	1181	147	7/26/2010	F		X		255-66-31-15≡63.5g	UWSP	9516	X	X			
Ryan Stephens	1198	148	7/26/2010	F		X		243-62-31-15≡84.5g	UWSP	9464	X	X	X		
Ryan Stephens	1116	148	7/28/2010	M	5			314-89-43-20≡152g	UWSP	9462	X	X	X		
Ryan Stephens	1234	149	8/8/2010	F		X		235-57-31-17≡69g	UWSP	9525	X	X	X		
Ryan Stephens	1358	169	8/20/2010	M	6			294-74-40-18≡122g	UWSP	9771	X	X	X		
Ryan Stephens	1436	171	8/22/2010	M	6			301-80-40-18≡108g	UWSP	9795	X	X	X		
Ryan Stephens	1426	172	8/20/2010	M	4			301-86-39-14≡105g	UWSP	9763	X	X	X		
Ryan Stephens	1319	T44	6/30/2011	F			2	240-57-31-15≡66.5g	UWSP	9769	X	X	X		

Mustela frenata

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1094	158	8/11/2010	F		X		372-117-40-19≡153g	UWSP	9463	X	X	X		

Myodes gapperi

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	472	5	6/8/2009	F		X		117-31-18-14≡16.5g	UWSP	9573	X	X	X		
Ryan Stephens	469	7	6/7/2009	M	10			123-33-17-15≡20g	UWSP	9572	X	X	X		
Ryan Stephens	466	8	6/7/2009	M	12			140-38-19-13≡24.5g	UWSP(T)	10135		X	X		
Ryan Stephens	478	8	6/9/2009	M	12			142-42-20-15≡26g	NMNH	570939	X	X	X		
Ryan Stephens	527	11	6/20/2009	F		X		114-30-18-12≡13g	UWSP	10026			X	X	X
Ryan Stephens	515	15	6/19/2009	F		6		143-40-18-15≡28g	UAF	113808	X	X	X		
Ryan Stephens	540	15	6/22/2009	M	7			108-26-18-14≡13.5g	UWSP	10029			X	X	X
Ryan Stephens	809	46	7/28/2009	F		5		148-42-18-15≡26.75g	NMNH	570978	X	X			
Ryan Stephens	651	46	7/27/2009	M	8			112-30-17-11≡17.25g	UAF	113811	X	X	X		
Ryan Stephens	660	46	7/28/2009	M	9			124-34-18-14≡24.5g	NMNH	570961	X	X	X		
Ryan Stephens	816	51	7/28/2009	M	7			119-32-29-12≡16.09g	UWSP	9718	X	X	X		
Ryan Stephens	701	52	8/9/2009	F		X		119-30-19-14≡17g	UWSP	10071			X	X	X
Kali King	1	52	8/6/2009	F		7		126-35-32-13≡19g	UWSP	9940	X	X	X		
Ryan Stephens	674	52	8/6/2009	F		4		136-36-27-13≡23.5g	UWSP	9705	X	X	X		
Ryan Stephens	682	52	8/7/2009	F		6		141-39-17-12≡24.5g	UAF	113809	X	X	X		
Ryan Stephens	862	52	8/8/2009	F			9	138-35-18-14≡27.66g	UWSP	9727	X	X	X		
Ryan Stephens	861	52	8/8/2009	F		7		141-34-18-13≡29.53g	UWSP	9726	X	X	X		
Ryan Stephens	872	52	8/8/2009	M	13			113-30-19-13≡15.07g	UWSP	9730	X	X			
Ryan Stephens	864	52	8/8/2009	M	1			116-30-18-12≡15.71g	UWSP	9729	X	X			
Ryan Stephens	863	52	8/8/2009	M	2			118-34-18-14≡17.14g	UWSP	9728	X	X			
Ryan Stephens	860	52	8/8/2009	M	10			132-34-19-12≡21.94g	UWSP	9725	X	X	X		
Chadd Nelson	1	58	8/6/2009	F		3		150-40-19-20≡20g	UWSP	9891	X	X	X		
Andy Kramer	2	59	8/8/2009	M	5			117-32-19-8≡16.5g	UWSP	9934	X	X	X		
Christine Burns	2	61	8/11/2009	F		6		135-40-15-11≡20g	UWSP	9855	X	X	X		
Ryan Stephens	717	61	8/12/2009	M	4			111-32-18-13≡12.5g	UWSP	10077			X	X	X

Myodes gapperi continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Rob Prinsen	2	61	8/11/2009	M	10			112-30-10-15≡23g	UWSP	9846	X	X	X		
Ryan Stephens	719	63	8/13/2009	F			3	135-36-28-14≡19.75g	UWSP	10079			X	X	X
Ryan Stephens	711	66	8/12/2009	M	10			137-35-19-12≡22g	NMNH	570966	X	X	X		
Ryan Stephens	1156	67	8/14/2009	F		X		115-30-17-13≡16g	UWSP	9787		X	X		
Arik Wallace	1	67	8/14/2009	M	9			120-35-15-10≡21g	UWSP	9885	X	X	X		
Ryan Stephens	448	PS1	5/25/2009	F		5		123-34-17-14≡17.69g	UWSP	9569	X	X	X		
Ryan Stephens	449	PS4	5/23/2009	M	12			133-37-18-14≡22.87g	UWSP	9570	X	X	X		
Ryan Stephens	443	PS4	5/22/2009	M	13			124-32-18-13≡23.85g	UWSP	9566	X	X			
Matthew Flintrop	2	98	6/11/2010	F		X		115-30-17-10≡14g	UWSP	9970	X	X	X		
Cody Scholfield	2	98	6/11/2010	F		X		110-30-19-10≡16g	UWSP	9886	X	X	X		
Nate Huck	5	98	6/10/2010	F		5		129-35-18-14≡22g	UWSP	9950	X	X			
Ryan Stephens	1033	98	6/10/2010	F		5		130-38-18-15≡25g	UWSP	9488	X	X	X		
Ryan Stephens	1026	100	6/8/2010	M	11			115-30-17-13≡19g	NMNH	570992	X	X	X		
Lisa McCabe	2	100	6/9/2010	M	5			125-30-20-10≡23g	UWSP	9851	X	X	X		
Ryan Stephens	1464	125	7/8/2010	F		X		115-32-18-12≡12.5g	UWSP	9991	X	X	X		
Jennifer LaMontagne	1	125	7/10/2010	F		6		148-45-29-22≡24g	UWSP	9908	X	X	X		
Tanya Wolf	1	125	7/10/2010	M	13			120-28-18-11≡20g	UWSP	9853	X	X	X		
Ryan Stephens	1064	125	7/7/2010	M	12			116-28-18-13≡21g	UWSP	9671	X	X	X		
Michael Manel	1	125	7/7/2010	M	10			125-34-19-14≡21g	UWSP	9926	X	X	X		
Maureen Panka	2	126	7/12/2010	F		5		125-30-15-11≡27g	UWSP	9941	X	X	X		
Eric Wiederhoeft	2	126	7/12/2010	M	7			152-54-14-11≡20g	UWSP	9959	X	X	X		
Caitlin Enright	2	126	7/12/2010	M	10			122-33-15-12≡24g	UWSP	9850	X	X	X		
Justine Doty	1	126	7/12/2010	M	12			125-31-17-13≡24g	UWSP	9878	X	X	X		
Matthew Styka	1	129	7/15/2010	F		5		110-42-20-X≡37g	UWSP	9869	X	X	X		
Andy Stetter	2	129	7/15/2010	M	4			122-38-19-11≡13g	UWSP	9868	X	X	X		

Myodes gapperi continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Natasha Siegel	2	129	7/15/2010	M	10			124-31-20-7≡22g	UWSP	9971	X	X	X		
Sara Wendt	7	137	7/23/2010	F		X		117-33-17-13≡16g	NMNH	600232	X	X	X		
Ryan Stephens	1171	137	7/23/2010	F		X		120-34-18-12≡17g	UWSP	9518	X	X	X		
Alexa Cushman	3	137	7/24/2010	F			11	139-29-38-14≡30g	UWSP	10123	X	X	X		
Amanda Zalewski	4	137	7/23/2010	M	4			140-37-20-12≡18g	UWSP	9862	X	X	X		
Amanda Zalewski	3	137	7/23/2010	M	8			120-36-17-14≡21g	NMNH	600235	X	X	X		
Ryan Stephens	1147	138	7/23/2010	F		4		145-40-17-14≡35g	UWSP	9577	X	X	X		
Ryan Stephens	1194	138	7/24/2010	M	3			115-31-17-12≡13.5g	UWSP	9677	X	X	X		
Kelsey Musser	2	138	7/22/2010	M	10			125-37-17-12≡25g	UWSP	10117	X	X	X		
Sara Wendt	5	140	7/22/2010	F			6	141-35-17-15≡21.5g	NMNH	600230	X	X			
Ryan Stephens	1454	142	7/28/2010	F		2		137-36-17-15≡33g	UWSP	9992	X	X	X		
Kali Cotteleer	1	144	7/26/2010	F			4	130-37-15-13≡19g	UWSP	10003	X	X	X		
Sara Wendt	13A	146	7/28/2010	F		X		115-35-18-13≡15.5g	UWSP	9600	X	X	X		
Ryan Stephens	1220	146	7/28/2010	F			12	146-46-18-15≡23g	UWSP	9684	X	X	X		
Ryan Stephens	1235	149	8/5/2010	F			3	142-37-18-15≡21g	UWSP	9535	X	X	X		
Ryan Stephens	1236	149	8/5/2010	M	4			122-34-18-12≡13g	UWSP	10178		X	X		
Ryan Stephens	1225	149	8/7/2010	M	10			122-38-19-15≡17g	UWSP	9533	X	X	X		
Ryan Stephens	1246	152	8/8/2010	F		X		127-36-18-15≡18.5g	UWSP	9538	X	X	X		
Ryan Stephens	1216	152	8/6/2010	F			9	137-37-18-12≡21.5g	UWSP	9519	X	X	X		
Ryan Stephens	1245	152	8/8/2010	F		3	3	135-35-19-15≡23.5g	UWSP	9526	X	X	X		
Ryan Stephens	1247	152	8/8/2010	F		4	6	139-41-20-15≡26.5g	UWSP	9808		X	X		
Ryan Stephens	1242	152	8/8/2010	F			13	132-39-18-15≡30.5g	UWSP	9686	X	X	X		
Ryan Stephens	1244	152	8/8/2010	M	X			137-39-19-14≡24.5g	UWSP	9836		X	X		
Ryan Stephens	1217	152	8/6/2010	M	13			143-39-19-14≡25.5g	UWSP	9520	X	X	X		
Ryan Stephens	1261	153	8/8/2010	F		X		126-31-19-13≡20.25g	UWSP	9527	X	X	X		

Myodes gapperi continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Sara Wendt	14	153	8/5/2010	F			4	136-41-17-19≡23.5g	NMNH	600233	X	X	X		
Jessica Plante	1	156	8/6/2010	M	12			121-37-15-12≡18.2g	UWSP	9854	X	X	X		
Sara Wendt	13B	156	7/28/2010	M	11			131-36-18-19≡29g	UAF	113810	X	X	X		
Katelyn Brauner	2	158	8/11/2010	F		X		112-36-14-6≡14g	UWSP	9845	X	X	X		
Eric Alexander	2	158	8/10/2010	F		X		110-30-16-11≡15.5g	UWSP	9849	X	X	X		
Richard Breunig	1	158	8/13/2010	F		X		128-32-16-10≡24g	UWSP	9929	X	X	X		
Melissa Boehmer	2	158	8/11/2010	F		5		144-42-22-19≡31g	UWSP	9884	X	X	X		
Kim Cooley	2	160	8/18/2010	F		X		130-40-20-10≡30g	UWSP	9847	X	X	X		
Alix Godar	2	160	8/11/2010	M	12			123-33-17-16≡27g	UWSP	9852	X	X	X		
Ryan Freidel	2	160	8/11/2010	M	X			135-37-16-14≡29g	UWSP	9848	X	X	X		
Patrick Bula	1	164	8/11/2010	F			11	130-29-18-12≡26.5g	UWSP	10103	X	X			
Ryan Stephens	1096	164	8/12/2010	M	13			142-39-19-15≡30g	NMNH	600005	X	X	X		
Ben Cate	1	168	8/20/2010	M	X			105-25-26-11≡13g	UWSP	9909	X	X	X		
Ryan Stephens	1356	169	8/20/2010	F		X		118-31-19-15≡19.5g	UWSP	9770	X	X	X		
Lucy Hatfield	2	172	8/20/2010	F		5	4	125-29-17-14≡19.5g	UWSP	9995	X	X	X		
Ryan Stephens	1106	180	8/25/2010	F			9	130-36-18-14≡19.5g	UWSP	9517	X	X	X		
Ryan Stephens	1296	T20	6/11/2011	F			5	139-40-13-14≡24.5g	UWSP	9837		X	X		

Peromyscus leucopus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	822	42	7/24/2009	M	11			170-74-21-15≡27.97g	UWSP	9977	X	X			
Christine Burns	1	16	6/27/2009	M	4			64-27-8-6≡22g	UWSP	9889	X	X	X		
Jacob Heidemann	2	22	6/27/2009	M	11			165-72-20-13≡23g	UWSP	9945	X	X	X		
Ryan Stephens	581	24	7/5/2009	F		3		160-74-22-15≡21.25g	NMNH	570946	X	X	X		
Ryan Stephens	579	24	7/5/2009	F			10	150-54-22-16≡29g	UWSP	9596	X	X	X		
Ryan Stephens	571	27	7/3/2009	M	14			164-74-21-16≡23g	UWSP	9593	X	X	X		
Ryan Stephens	578	28	7/5/2009	M	16			181-84-22-16≡30.25g	UWSP	9595	X	X	X		
Ryan Stephens	570	29	7/3/2009	M	17			179-80-21-16≡27.5g	NMNH	570945	X	X	X		
Ryan Stephens	574	29	7/4/2009	M	15			176-80-22-16≡32.5g	UWSP	9594	X	X	X		
Ryan Stephens	612	30	7/10/2009	F		X		159-69-20-15≡15.5g	UWSP	10057			X	X	X
Adam Nickel	2	30	7/11/2009	F		X		150-71-20-12≡16g	UWSP	9953	X	X	X		
Kevin Brecka	2	30	7/11/2009	M	8.5			132-66-18-9≡16g	UWSP	9888	X	X	X		
Ryan Stephens	613	30	7/10/2009	M	8			153-69-20-15≡17g	UWSP	10058			X	X	X
Ryan Stephens	590	31	7/8/2009	F		X		153-70-20-14≡16.25g	UWSP	10049			X	X	X
Ryan Stephens	589	31	7/8/2009	M	9			156-77-21-16≡20g	UWSP	10050			X	X	X
Ryan Stephens	588	32	7/8/2009	M	15			173-81-21-16≡27.25g	UAF	113818	X	X	X		
Ryan Stephens	595	33	7/8/2009	M	4			134-60-20-16≡13.25g	UWSP	10015			X	X	X
Ryan Stephens	599	33	7/9/2009	M	6			157-71-22-15≡17.5g	UWSP	10148			X	X	X
Ryan Stephens	1165	33	7/11/2009	M	5			167-74-21-15≡20.5g	UWSP	10167		X	X		
Alix Godar	1	33	7/11/2009	M	12			174-79-21-15≡31g	UWSP	9917	X	X	X		
Jaclyn Schmitz	2	34	7/11/2009	M	10			146-71-20-14≡18.5g	UWSP	9894	X	X	X		
Ryan Stephens	586	34	7/8/2009	M	12			170-85-23-16≡26g	UWSP	9598	X	X	X		
Ryan Stephens	623	41	7/22/2009	M	13			174-80-21-15≡21g	UWSP	9610	X	X	X		
Ryan Stephens	840	42	7/22/2009	F		X		145-66-20-14≡14.63g	UAF	113763	X	X	X		
Ryan Stephens	839	42	7/22/2009	F		3		171-77-21-16≡32.65g	UAF	113762	X	X	X		

Peromyscus leucopus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	841	42	7/22/2009	M	4			141-63-20-15≡14.57g	UAF	113761	X	X	X		
Ryan Stephens	824	42	7/24/2009	M	9			150-74-21-15≡15.75g	UWSP	9655	X	X	X		
Ryan Stephens	838	42	7/22/2009	M	10			151-68-21-16≡19.6g	UAF	113772	X	X	X		
Ryan Stephens	823	42	7/24/2009	M	13			167-79-20-16≡22.41g	NMNH	570981	X	X			
Ryan Stephens	826	43	7/24/2009	F		X		145-66-22-16≡14.5g	UWSP	9656	X	X	X		
Ryan Stephens	641	43	7/22/2009	F			7	159-70-19-15≡18.25g	UWSP	9592	X	X			
Ryan Stephens	828	43	7/24/2009	M	2			140-66-20-15≡10.75g	UAF	113765	X	X	X		
Ryan Stephens	827	43	7/24/2009	M	9			152-70-21-15≡16g	UAF	113766	X	X	X		
Ryan Stephens	640	43	7/22/2009	M	10			157-71-21-16≡19g	UWSP	9621	X	X	X		
Ryan Stephens	825	43	7/24/2009	M	12			171-80-21-15≡24g	NMNH	570982	X	X	X		
Ryan Stephens	810	46	7/28/2009	F		5		182-85-21-16≡29.5g	NMNH	570979	X	X			
Ryan Stephens	787	46	7/27/2009	M	12			147-65-20-14≡21.7g	UWSP	9646	X	X	X		
Ryan Stephens	788	46	7/27/2009	M	12			167-80-21-16≡22.1g	UWSP	9647	X	X	X		
Ryan Stephens	669	46	7/29/2009	M	11			161-75-22-16≡23.75g	UWSP	9628	X	X	X		
Ryan Stephens	670	46	7/29/2009	M	13			163-74-21-15≡24g	UWSP	9629	X	X	X		
Ryan Stephens	782	46	7/30/2009	M	13			174-75-21-17≡28.72g	UWSP	9644	X	X	X		
Ryan Stephens	652	46	7/27/2009	M	15			165-76-22-17≡29.5g	NMNH	570958	X	X	X		
Melissa Boehmer	1	52	8/6/2009	F		5		169-82-19-15≡21g	UWSP	9916	X	X	X		
Kat Dickerson	1	52	8/6/2009	M	19			165-75-19-13≡27g	UWSP	9962	X	X	X		
Ryan Stephens	871	52	8/8/2009	M	13			180-82-21-16≡28.32g	UWSP	9658	X	X	X		
Ryan Stephens	856	53	8/8/2009	M	3			166-78-23-15≡19.98g	UWSP	9723	X	X			
Ryan Stephens	852	55	8/8/2009	M	4			146-65-20-15≡17.79g	UAF	113764	X	X	X		
Ryan Stephens	854	56	8/7/2009	M	8			152-71-21-16≡14.5g	UWSP	9721	X	X			
Ryan Stephens	1175	58	8/8/2009	M	8			155-73-21-14≡16g	UWSP	9799		X	X		
Ryan Stephens	1174	58	8/8/2009	M	6			162-71-21-15≡20g	UWSP	9832		X	X		

Peromyscus leucopus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	700	60	8/9/2009	M	4			152-69-21-15≡17g	UWSP	10070			X	X	X
Amanda Zalewski	2	61	8/11/2009	F			14	168-83-20-16≡25g	NMNH	600234	X	X	X		
Maggie Mann	1	62	8/14/2009	M	12			144-65-18-15≡16g	UWSP	9893	X	X	X		
Ryan Stephens	720	63	8/13/2009	M	6			143-67-19-16≡17.75g	UWSP	10014			X	X	X
Eric Alexander	1	67	8/14/2009	F		X		129-59-15-12≡14.5g	UWSP	9897	X	X	X		
Ryan Stephens	710	67	8/12/2009	F		6		179-80-21-16≡27.25g	UAF	113771	X	X	X		
Ryan Stephens	709	67	8/11/2009	M	15			171-82-21-17≡26.75g	UAF	113773	X	X	X		
Ryan Stephens	718	68	8/13/2009	M	12			161-67-21-16≡17g	UWSP	10078			X	X	X
Kyle Lakey	1	71	8/21/2009	M	16			163-72-21-16≡25.5g	UWSP	9969	X	X	X		
Ryan Stephens	737	74	8/22/2009	M	11			165-79-21-15≡26.75g	NMNH	570973	X	X	X		
Ryan Stephens	1146	75	8/21/2009	M	5			178-83-21-15≡20.5g	UWSP	10160		X	X		
Kurt Miedtke	2	78	8/25/2009	M	11			172-77-21-12≡28g	UWSP	9899	X	X	X		
Ryan Stephens	750	79	8/25/2009	M	10			160-70-20.5-15≡18.25g	UAF	113768	X	X	X		
Ryan Stephens	751	80	8/26/2009	M	10			168-77-22-15≡24.5g	UAF	113767	X	X	X		
Ryan Stephens	433	PS1	5/20/2009	M	13			165-77-20-13≡26.88g	UWSP	9564	X	X			
Ryan Stephens	454	PS1	5/27/2009	M	14			176-82-22-16≡27.65g	NMNH	570933	X	X	X		
Ryan Stephens	1022	88	6/5/2010	M	12			173-88-21-16≡25g	UWSP	9667	X	X	X		
Nate Huck	2	91	6/4/2010	M	10			166-86-21-17≡26g	UWSP	9943	X	X			
Kyle Lakey	2	98	6/11/2010	M	12			X-74-21-15≡23g	UWSP	9956	X	X	X		
Naryssa Christensen	2	99	6/8/2010	M	7			142-63-20-11≡19g	UWSP	9955	X	X	X		
Ryan Stephens	1027	100	6/8/2010	M	9			150-71-21-15≡16.5g	UWSP	9668	X	X	X		
Jake Toben	1	105	6/19/2010	M	10			153-76-22-14≡27g	UWSP	9989	X	X	X		
Nate Huck	7	106	6/18/2010	M	7			125-58-18-12≡14.5g	UWSP	9865	X	X	X		
Kali Cotteleer	5	115	6/6/2010	F		6		160-76-19-14≡23g	UWSP	10115	X	X	X		
Ryan Stephens	1065	125	7/7/2010	M	14			185-85-23-17≡30g	UWSP	9978	X	X	X		

Peromyscus leucopus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Maureen Panka	1	127	7/15/2010	F		X		141-65-20-11≡13g	UWSP	10108	X	X	X		
Alexa Cushman	2	127	7/15/2010	F		X		132-60-31-14≡15.5g	UWSP	10105	X	X	X		
Scott Firkus	1	127	7/15/2010	F		2		171-69-20-16≡23g	UWSP	9896	X	X	X		
Kali Cotteleer	2	127	7/15/2010	F			6	165-76-20-13≡29g	UWSP	10104	X	X	X		
Ben Doty	1	127	7/15/2010	M	10			170-77-22-16≡28g	UWSP	9951	X	X	X		
Courtney Blumberg	1	127	7/15/2010	M	14			179-82-21-15≡29g	UWSP	9972	X	X	X		
Amanda Zalewski	1	129	7/15/2010	M	5			148-63-21-15≡16g	UWSP	113856		X	X		
Ben Cate	2	129	7/15/2010	M	11			153-76-18-12≡22g	UWSP	9954	X	X	X		
Brennen Rausch	2	129	7/15/2010	M	14			170-70-20-13≡23g	UWSP	9973	X	X	X		
Sam Jones	1	132	7/15/2010	F		X		141-62-19-14≡12g	UWSP	9892	X	X	X		
Mark Worth	1	132	7/15/2010	F		X		151-70-20-15≡15g	UWSP	9895	X	X	X		
Brittany Ruttenberg	1	132	7/12/2010	F		X		165-82-19-15≡24g	UWSP	10102	X	X	X		
Heather Heimann	1	132	7/15/2010	F			10	176-80-20-17≡28g	UWSP	9919	X	X	X		
Tyler Hasheider	1	132	7/15/2010	M	X			150-68-20-13≡19g	UWSP	9890	X	X	X		
Wesley Ellarson	2	132	7/15/2010	M	14			172-81-19-16≡28g	UWSP	9898	X	X	X		
Ryan Stephens	1195	137	7/24/2010	M	3			140-66-21-15≡11.5g	UWSP	10175		X	X		
Ryan Stephens	1186	138	7/22/2010	F		11		180-84-20-16≡24.5g	UWSP	9679	X	X	X		
Leah McSherry	1	147	7/29/2010	M	10			145-68-18-16≡17g	UWSP	10202	X	X	X		
Ryan Stephens	1201	150	8/8/2010	F		4		173-77-21-15≡29.5g	NMNH	600022	X	X	X		
Ryan Stephens	1202	150	8/8/2010	M	X			154-70-20-15≡16g	UWSP	9680	X	X	X		
Ryan Stephens	1257	154	8/8/2010	M	3			166-75-20-15≡20g	UWSP	9688	X	X	X		
Ryan Stephens	1250	155	8/8/2010	M	3			176-84-21-16≡19.5g	UWSP	9687	X	X	X		
Sara Wendt	15	156	8/8/2010	F		X		157-77-20-15≡16.5g	UWSP	9843		X	X		
Matthew Thayer	2	158	8/11/2010	F		X		150-70-12-13≡22g	UWSP	9958	X	X	X		
Scott Churchill	2	158	8/11/2010	M	1.5			150-59-21-16≡21g	UWSP	9887	X	X	X		

Peromyscus leucopus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Richard Breunig	2	159	8/13/2010	F		3		168-75-20-15≡27g	UWSP	9906	X	X	X		
Phil Vogrinc	1	173	8/26/2010	F		6		185-75-20-15≡20g	UWSP	9946	X	X	X		
Ryan Stephens	1407	T10	5/31/2011	F		X		149-70-20-14≡16g	UWSP	9828		X	X		
Ryan Stephens	1383	T10	6/1/2011	F		6	7	186-87-20-16≡23.5g	UAF	113769	X	X	X		
Ryan Stephens	1364	T11	5/31/2011	M	11			167-77-21-16≡24.5g	UWSP	9773	X	X	X		
Ryan Stephens	1362	T13	6/1/2011	M	6			149-72-20-15≡14.5g	UWSP	9772	X	X	X		
Ryan Stephens	1389	T15	6/1/2011	F		X		151-71-21-15≡17g	UAF	113770	X	X	X		
Ryan Stephens	1402	T2	5/27/2011	M	11			170-79-21-15≡25g	UWSP	9757	X	X	X		
Ryan Stephens	1392	T27	6/13/2011	M	9			150-68-21-15≡16.5g	UWSP	9841		X	X		
Ryan Stephens	1380	T32	6/24/2011	F		7		185-87-21-16≡35.5g	UAF	113774	X	X	X		
Ryan Stephens	1365	T35	6/24/2011	M	10			157-73-20-15≡20g	UWSP	9774	X	X	X		
Ryan Stephens	1382	T4	5/26/2011	F		5		174-82-20-16≡29g	UWSP	9839		X	X		
Ryan Stephens	1363	T4	5/27/2011	M	13			181-88-20-15≡24g	UWSP	9840		X			
Ryan Stephens	1390	T45	6/30/2011	M	4			152-78-21-15≡19.5g	UWSP	9752	X	X	X		
Ryan Stephens	1393	T45	6/28/2011	M	14			168-83-20.5-15≡26g	UWSP	9753	X	X	X		
Ryan Stephens	1391	T5	5/27/2011	F		X		121-52-19-14≡11.5g	UWSP	9826		X	X		
Ryan Stephens	1361	T6	5/27/2011	M	6			142-61-20-15≡16g	UWSP	9838		X	X		
Ryan Stephens	1384	T7	5/27/2011	M	10			165-82-20-15.5≡21.5g	UWSP	9776	X	X	X		
Ryan Stephens	1404	T8	5/27/2011	F		X		180-84-21-15.5≡22.5g	UWSP	9825		X	X		
Ryan Stephens	1381	T8	5/27/2011	M	11			178-83-21.5-15≡23.5g	UWSP	9775	X	X	X		
Ryan Stephens	1406	T9	5/27/2011	F		X		127-57-19-13≡11.5g	UWSP	9827		X	X		

Peromyscus maniculatus bairdii

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	597	32	7/9/2009	F			8	157-61-18-15≡19g	UWSP	9599	X	X	X		
Ryan Stephens	587	32	7/8/2009	M	9			137-54-18-15≡17g	NMNH	570948	X	X	X		
Ryan Stephens	620	36	7/22/2009	M	10			125-54-18-13≡15g	UWSP	9607	X	X	X		
Ryan Stephens	843	36	7/25/2009	M	8			124-53-17-13≡15g	UWSP	10130	X		X		
Ryan Stephens	647	36	7/24/2009	M	9			132-56-17-14≡18.5g	UWSP	9975	X	X	X		
Ryan Stephens	634	39	7/23/2009	F			6	121-46-17-13≡16g	NMNH	570955	X	X	X		
Ryan Stephens	635	39	7/23/2009	F			5	135-52-17-15≡17.5g	UWSP	9974	X	X	X		
Ryan Stephens	644	39	7/24/2009	M	9			121-50-18-14≡12.5g	UWSP	9622	X	X	X		
Ryan Stephens	621	39	7/22/2009	M	11			132-58-18-14≡14.75g	UWSP	9608	X	X	X		
Ryan Stephens	642	39	7/24/2009	M	9			132-58-19-15≡16g	NMNH	570957	X	X	X		
Ryan Stephens	820	39	7/25/2009	M	9			129-52-18-14≡16.6g	UWSP	9976	X	X	X		
Ryan Stephens	821	39	7/25/2009	M	9			130-58-18-14≡17.75g	UWSP	9654	X	X	X		
Ryan Stephens	643	39	7/24/2009	M	10			130-54-19-14≡18g	UWSP(D)	10149		X	X		
Ryan Stephens	741	73	8/23/2009	M	9			136-56-18-14≡17.5g	UWSP	9636	X	X	X		
Ryan Stephens	727	73	8/20/2009	M	10			144-55-19-15≡19.57g	NMNH	570969	X	X	X		
Ryan Stephens	744	77	8/25/2009	M	11			135-54-18-13.5≡16.75g	UWSP	9638	X	X	X		
Ryan Stephens	752	81	8/26/2009	F		1		153-57-19-14≡22g	UWSP	9641	X	X	X		
Ryan Stephens	746	81	8/25/2009	M	7			125-54-18-14≡12g	NMNH	570974	X	X	X		
Ryan Stephens	1173	81	8/26/2009	M	7			132-55-17-14≡16g	UWSP	9988	X	X	X		
Ryan Stephens	745	81	8/25/2009	M	10			140-62-19-15≡18.75g	UWSP	9639	X	X	X		
Ryan Stephens	1011	84	6/3/2010	M	7			138-55-19-15≡15g	UWSP	9665	X	X	X		
Ryan Stephens	1496	106	6/20/2010	F		X		115-51-19-14≡12g	UWSP	10110	X	X	X		
Ryan Stephens	1041	107	6/17/2010	M	9			131-51-16-13≡16.5g	UWSP	9670	X	X	X		
Ryan Stephens	1040	107	6/17/2010	M	10			141-58-18-14≡18.5g	UWSP	9669	X	X	X		

Peromyscus maniculatus gracilis

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	496	5	6/12/2009	M	6			149-68-21-17≡14.5g	UWSP	9481	X	X	X		
Ryan Stephens	497	6	6/12/2009	M	6			130-63-19-16≡9.4g	UWSP	9912	X	X	X		
Ryan Stephens	494	7	6/12/2009	F		6		162-81-21-19≡23.25g	UWSP	9911	X	X	X		
Ryan Stephens	514	14	6/19/2009	M	17			184-88-21-17≡26.75g	UWSP(T)	10145		X	X		
Ryan Stephens	1127	16	6/25/2009	F			6	164-81-21-19≡20.5g	UWSP	9979	X	X	X		
Cody Scholfield	1	19	6/25/2009	F		5		175-75-20-16≡30g	UWSP	9963	X	X	X		
Dillon Fedro	2	137	7/24/2010	F		X		150-74-20-18≡12g	UWSP	10121	X	X	X		
Ryan Stephens	1445	137	7/22/2010	F		X		174-89-21-19≡18g	UWSP	9765	X	X	X		
Ryan Stephens	1080	137	7/22/2010	F		5		180-91-21-19≡22.5g	UWSP(D)	10156		X	X		
Ryan Stephens	1193	137	7/24/2010	F		5		185-90-20-20≡24.5g	UWSP	9981	X	X	X		
Ryan Stephens	1481	137	7/24/2010	M	12			175-83-21-19≡25g	UWSP	10099	X	X	X		
Ryan Stephens	1157	148	7/29/2010	M	4			155-72-20-18≡16g	UWSP	9676	X	X	X		
Ryan Stephens	1200	150	8/8/2010	F			8	192-92-21-20≡21g	UWSP	9982	X	X	X		
Ryan Stephens	1241	152	8/8/2010	F			4	165-80-21-16≡16g	UWSP	9529	X	X	X		
Ryan Stephens	1243	152	8/8/2010	M	X			177-88-21-19≡21g	UWSP	9835		X	X		
Ryan Stephens	1213	156	8/8/2010	M	5			166-73-21-17≡22.5g	UWSP	9682	X	X	X		
Ryan Stephens	1397	165	8/22/2010	F		X		167-91-20-18.5≡18g	UWSP	9756	X	X	X		
Ryan Stephens	1424	168	8/22/2010	F			6	184-91-21-20≡21.5g	UWSP	9761	X	X	X		
Ryan Stephens	1428	168	8/20/2010	M	12			180-90-22-20≡24g	UWSP	9755	X	X	X		

Reithrodontomys megalotis

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1010	87	6/3/2010	M	10			134-66-16-13≡10.5g	UWSP	9817		X	X		

Sorex arcticus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	463	2	6/7/2009	F		9		119-41-15-7≡14.5g	UWSP(D)	10133		X	X		
Ryan Stephens	486	2	6/10/2009	M	1			115-45-14-7≡6.4g	UWSP	9692	X	X			
Ryan Stephens	485	2	6/10/2009	M	3			115-44-15-5≡7.2g	UWSP	9691	X	X	X		
Ryan Stephens	465	2	6/7/2009	M	2			114-45-15-7≡7.5g	UWSP	9480	X	X	X		
Ryan Stephens	464	2	6/7/2009	M	7			127-45-15-6≡11.5g	UWSP(T)	10134		X	X		
Ryan Stephens	481	3	6/9/2009	F		8		116-41-15-6≡9.5g	UWSP	9479	X	X	X		
Ryan Stephens	484	3	6/10/2009	M	5			108-43-13-7≡7g	UWSP	9459	X	X	X		
Ryan Stephens	499	8	6/12/2009	M	3			114-42-15-7≡6.8g	UWSP(T)	10143		X	X		
Ryan Stephens	531	10	6/21/2009	M	2			112-44-14-6≡6.25g	UWSP	9458	X	X	X		
Ryan Stephens	528	10	6/21/2009	M	6			121-42-15-6≡9g	NMNH	570943	X	X	X		
Ryan Stephens	509	11	6/19/2009	M	2			100-38-13-7≡6.6g	UWSP	10019			X	X	X
Ryan Stephens	522	11	6/20/2009	M	3			120-52-15-7≡8.8g	UWSP	9925	X	X	X		
Ryan Stephens	544	11	6/22/2009	M	X			114-39-15-6≡9.3g	UWSP	10033			X	X	X
Ryan Stephens	512	13	6/19/2009	F		8		120-41-14-7≡11.5g	NMNH	570941	X	X	X		
Ryan Stephens	541	13	6/22/2009	M	2			120-46-15-7≡7.25g	UWSP	10030			X	X	X
Ryan Stephens	504	13	6/19/2009	M	2			113-43-13-6≡9.4g	UWSP	10009			X	X	X
Ryan Stephens	542	14	6/22/2009	F		6		114-42-14.5-7≡10.5g	UWSP	10031			X	X	X
Ryan Stephens	543	14	6/22/2009	M	1			113-42-14-6≡8.4g	UWSP	10032			X	X	X
Ryan Stephens	758	49	7/30/2009	M	3			114-41-15-7≡7.19g	NMNH	570975	X	X	X		
Ryan Stephens	657	49	7/28/2009	M	X			112-41-14-7≡8g	UWSP	9700	X	X	X		
Ryan Stephens	759	50	7/30/2009	M	7			113-41-15-7≡9.25g	UAF	113782	X	X	X		
Ryan Stephens	705	59	8/9/2009	F		X		108-40-14-7≡6g	UWSP	9709	X	X	X		
Ryan Stephens	691	59	8/8/2009	M	1.5			107-41-15-7≡6g	UWSP	10061			X	X	X
Ryan Stephens	680	59	8/7/2009	M	2			100-40-14-6≡6.2g	UWSP	9706	X	X	X		
Ryan Stephens	687	59	8/8/2009	M	2			111-39-16-7≡7.8g	UWSP	9707	X	X	X		

Sorex arcticus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	688	59	8/8/2009	M	1			109-38-14-7≡7.8g	UWSP	9708	X	X	X		
Ryan Stephens	686	59	8/8/2009	M	1			117-43-15-7≡8.4g	NMNH	570964	X	X	X		
Ryan Stephens	693	60	8/9/2009	M	X			111-40-13-7≡8g	UWSP	10063			X	X	X
Ryan Stephens	722	65	8/13/2009	F		X		107-42-14-7≡7g	UWSP	9711	X	X	X		
Ryan Stephens	1031	96	6/9/2010	M	3			111-39-14-8≡6.3g	UWSP	9446	X	X	X		
Ryan Stephens	1034	97	6/10/2010	M	2			111-40-14-7≡7.1g	UWSP	9445	X	X	X		
Ryan Stephens	1055	103	6/20/2010	M	1			111-42-15-8≡6.2g	UWSP	9443	X	X	X		
Ryan Stephens	1044	103	6/18/2010	M	1			107-40-14-8≡7g	UWSP	9444	X	X	X		
Ryan Stephens	1039	103	6/17/2010	M	8			114-38-14-7≡8.9g	UWSP	9439	X	X	X		
Ryan Stephens	1052	105	6/19/2010	F		X		115-42-15-7≡7.1g	NMNH	570997	X	X	X		
Ryan Stephens	1042	105	6/18/2010	M	2			116-43-15-8≡7.1g	UWSP	9442	X	X	X		
Ryan Stephens	1038	107	6/17/2010	M	3			106-40-14-8≡5.3g	UWSP	9441	X	X	X		
Ryan Stephens	1072	129	7/14/2010	F		8		116-38-13-7≡13.5g	UWSP	9440	X	X	X		
Ryan Stephens	1074	129	7/14/2010	M	3			110-39-14-8≡7.5g	UWSP	9448	X	X	X		
Ryan Stephens	1073	129	7/14/2010	M	6			111-37-13-7≡9.3g	NMNH	600001	X	X	X		
Ryan Stephens	1206	134	7/24/2010	M	1			111-46-15-7≡6.25g	UWSP	9801		X	X		
Ryan Stephens	1113	139	7/24/2010	F		X		108-39-14-7≡6.8g	UWSP	9454	X	X	X		
Ryan Stephens	1077	139	7/21/2010	M	2			109-41-14-7≡5.9g	UWSP	9449	X	X	X		
Ryan Stephens	1076	139	7/21/2010	M	2			109-43-14-7≡7.1g	UWSP	9447	X	X	X		
Ryan Stephens	1111	139	7/24/2010	M	6			116-38-14-7≡9.4g	NMNH	600009	X	X	X		
Ryan Stephens	1110	139	7/24/2010	X				116-38-14-7≡9.4g	UWSP	9778		X	X		
Ryan Stephens	1167	145	7/27/2010	M	3			111-48-15-8≡7.6g	UWSP	9455	X	X	X		
Ryan Stephens	1199	147	7/29/2010	F		Lac.		111-40-14-7≡13.2g	UWSP	9438	X	X	X		
Ryan Stephens	1452	148	7/26/2010	M	3			117-43-15-6≡8.5g	UWSP	9810		X	X		
Ryan Stephens	1224	149	8/7/2010	F		5		109-39-13-7≡9.7g	UWSP	9531	X	X	X		

Sorex arcticus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1184	163	8/11/2010	F		X		112-42-14-6≡8.6g	UWSP	9456	X	X	X		
Ryan Stephens	1183	163	8/11/2010	M	1			114-42-15-8≡8.2g	UWSP	9457	X	X	X		
Ryan Stephens	1429	166	8/22/2010	F		X		112-41-13-7≡8.1g	UWSP	9754	X	X	X		
Ryan Stephens	1485	166	6/11/2010	M	1			109-39-14-6≡8.6g	UWSP	10186	X	X	X		
Ryan Stephens	1434	167	8/19/2010	F		X		112-39-14-7≡9.5g	UWSP	9823		X	X		
Ryan Stephens	1433	167	8/19/2010	M	1			114-40-14-7≡8g	UWSP	9760	X	X	X		
Ryan Stephens	1100	171	8/21/2010	F		X		114-43-14-8≡8g	UWSP	9450	X	X	X		
Ryan Stephens	1444	171	8/19/2010	M	1			103-40-14-5≡6.8g	UWSP	9764	X	X	X		
Ryan Stephens	1443	171	8/19/2010	M	1			111-42-14-6≡7.1g	UWSP	9983	X		X	X	
Ryan Stephens	1109	174	8/26/2010	M	1			111-43-14-8≡6.7g	NMNH	600008	X	X	X		
Ryan Stephens	1105	174	8/25/2010	M	1			111-43-14-8≡6.8g	UWSP	9453	X	X	X		
Ryan Stephens	1102	174	8/24/2010	M	2			107-39-13-7≡8.2g	UWSP	9452	X	X	X		
Ryan Stephens	1103	175	8/25/2010	F		X		105-44-14-8≡5.9g	UWSP	9451	X	X	X		
Ryan Stephens	1486	176	8/24/2010	M	5			114-39-14-6≡8.6g	UWSP	10096	X	X	X		
Ryan Stephens	1483	T17	6/11/2011	F		X		112-40-13-7≡8.4g	UWSP	10184	X	X	X		
Ryan Stephens	1289	T17	6/10/2011	F		X		124-43-15-8≡11g	UWSP	9739	X	X	X		
Ryan Stephens	1482	T17	6/11/2011	M	1			107-40-13-7≡7.2g	UWSP	10098	X	X	X		
Ryan Stephens	1294	T17	6/10/2011	M	2			111-43-15-7≡7.8g	UWSP	9741	X	X	X		
Ryan Stephens	1282	T17	6/8/2011	M	2			120-45-14-7≡8g	UWSP	9737	X	X	X		
Ryan Stephens	1281	T17	6/8/2011	M	2			105-40-14-7≡8.1g	UWSP	9736	X	X	X		
Ryan Stephens	1484	T21	6/8/2011	F		X		111-42-13-8≡7.6g	UWSP	10185	X	X	X		
Ryan Stephens	1291	T21	6/10/2011	F		7		123-41-15-7≡12.4g	UAF	113802	X	X	X		
Ryan Stephens	1285	T21	6/9/2011	M	2			108-42-15-7≡7.1g	UWSP	9738	X	X	X		
Ryan Stephens	1279	T21	6/8/2011	M	1			109-40-15-7≡8.2g	UWSP	9735	X	X	X		
Ryan Stephens	1280	T21	6/8/2011	M	7			115-41-14-7≡10.5g	UAF	113835	X	X	X		

Sorex arcticus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1298	T27	6/13/2011	M	1			103-38-13-6≡5.9g	UWSP	9743	X	X	X		
Ryan Stephens	1308	T27	6/15/2011	M	2			111-42-15-7≡7.5g	UWSP	9746	X	X	X		
Ryan Stephens	1297	T27	6/13/2011	M	8			108-40-14-7≡9.5g	UAF	113837	X	X	X		
Ryan Stephens	1307	T27	6/15/2011	M	7			115-41-14-8≡9.9g	UAF	113839	X	X	X		
Ryan Stephens	1305	T29	6/15/2011	M	2			112-43-15-8≡7.3g	UWSP	9745	X	X	X		
Ryan Stephens	1500	T32	6/23/2011	F		X		110-41-14-7≡7.7g	UWSP	10191		X	X		
Ryan Stephens	1498	T32	6/23/2011	M	1			110-40-15-7≡7.7g	UWSP	10112	X	X	X		
Ryan Stephens	1494	T33	6/25/2011	F		X		110-42-14-6≡7.5g	UWSP	10094	X	X	X		
Ryan Stephens	1309	T33	6/23/2011	F		6		104-40-15-7≡11.5g	UAF	113803	X	X	X		
Ryan Stephens	1487	T37	6/26/2011	M	2			103-40-14-6≡7.3g	UWSP	10097	X	X	X		
Ryan Stephens	1311	T38	6/24/2011	F		7		115-38-14-7≡10.5g	UAF	113789	X	X	X		
Ryan Stephens	1502	T38	6/25/2011	M	2			111-41-13-6≡6.3g	UWSP	10193		X	X		
Ryan Stephens	1501	T38	6/25/2011	M	1			111-40-14-7≡6.5g	UWSP	10192		X	X		
Ryan Stephens	1503	T39	6/23/2011	F		X		113-40-14-7≡8g	UWSP	10194		X	X		
Ryan Stephens	1491	T39	6/24/2011	M	1			101-38-14-6≡5.3g	UWSP	10188	X	X	X		
Ryan Stephens	1490	T39	6/24/2011	M	1			110-43-14-6≡5.4g	UWSP	10187	X	X	X		
Ryan Stephens	1488	T39	6/24/2011	M	7			115-39-15-7≡10.5g	UWSP	10095	X	X	X		
Ryan Stephens	1489	T39	6/24/2011	M	6			121-43-15-7≡11g	UWSP	10093	X	X	X		
Ryan Stephens	1313	T42	6/29/2011	F			8	113-40-14-7≡9.9g	UAF	113801	X	X	X		
Ryan Stephens	1314	T42	6/29/2011	F		X		117-41-14-7≡10.5g	UAF	113777	X	X	X		
Ryan Stephens	1316	T44	6/30/2011	F		X		115-41-13-7≡9.8g	UWSP	9767	X	X	X		
Ryan Stephens	1317	T44	6/30/2011	M	2			109-44-15-6≡7.5g	UWSP	9768	X	X	X		
Ryan Stephens	1318	T44	6/30/2011	M	2			108-39-15-7≡7.6g	UAF	113836	X	X	X		
Ryan Stephens	1497	T47	6/29/2011	M	2			109-41-14-7≡8g	UWSP	10111	X	X	X		

Sorex cinereus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	482	1	6/9/2009	M	6			95-40-12-6≡4.8g	NMNH	570940	X	X			
Ryan Stephens	487	4	6/10/2009	F		5		102-39-13-6≡5.6g	UWSP	9476	X	X	X		
Ryan Stephens	488	4	6/10/2009	F		6		97-41-12-6≡5.9g	UWSP	9478	X	X	X		
Ryan Stephens	483	4	6/7/2009	F		6		90-35-11-6≡6.6g	UWSP	9474	X	X	X		
Ryan Stephens	473	4	6/7/2009	M	6			94-36-7-6≡4.5g	UWSP(T)	10137		X	X		
Ryan Stephens	498	7	6/12/2009	M	5			97-37-12-6≡5.1g	UWSP	9475	X	X	X		
Ryan Stephens	505	9	6/19/2009	F		X		91-39-11-5≡3.4g	UWSP	10016			X	X	X
Ryan Stephens	546	9	6/22/2009	M	1			88-40-12-7≡3.2g	UWSP	10038			X	X	X
Ryan Stephens	545	9	6/22/2009	M	6			96-38-12-5≡4.8g	UWSP	10039			X	X	X
Ryan Stephens	534	9	6/21/2009	M	5			99-39-13-6≡5g	UWSP	10023			X	X	X
Ryan Stephens	547	10	6/22/2009	M	1			95-39-13-7≡3.8g	UWSP	10037			X	X	X
Ryan Stephens	548	10	6/22/2009	M	X			91-40-12-6≡3.8g	UWSP	10036			X	X	X
Ryan Stephens	535	11	6/21/2009	M	2			90-41-12-6≡3.2g	UWSP	10010			X	X	X
Ryan Stephens	521	12	6/20/2009	M	5			99-39-12-6≡4.8g	UWSP	9581	X	X	X		
Ryan Stephens	507	15	6/19/2009	F		X		90-40-11-6≡3.2g	UWSP	10017			X	X	X
Ryan Stephens	539	15	6/22/2009	M	X			88-38-12-6≡3.6g	UWSP	10028			X	X	X
Ryan Stephens	533	15	6/21/2009	M	1			99-39-13-6≡5g	UWSP	10027			X	X	X
Ryan Stephens	552	15	6/22/2009	M	5			99-38-12-7≡5.2g	UWSP	10007			X	X	X
Ryan Stephens	556	17	6/24/2009	M	4			98-38-11-6≡3.8g	UWSP	9588	X	X	X		
Ryan Stephens	1495	18	6/25/2009	F		X		87-35-12-7≡3.22g	UWSP	10190		X			
Ryan Stephens	566	18	6/26/2009	F		X		101-40-13-7≡4.5g	UWSP	10045			X	X	X
Ryan Stephens	568	24	7/3/2009	M	4			95-35-11.5-6≡3.8g	UWSP	9591	X	X	X		
Ryan Stephens	572	25	7/4/2009	M	2			75-33-12-6≡3.2g	UWSP	9693	X	X	X		
Ryan Stephens	573	25	7/4/2009	M	1.5			83-35-12-6≡3.2g	UWSP	9695	X	X	X		
Ryan Stephens	576	27	7/4/2009	F		X		87-35-11.5-7≡4.4g	UAF	113783	X	X	X		

Sorex cinereus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	575	27	7/4/2009	M	5			88-38-12.5-6≡4.2g	UWSP	9696	X	X	X		
Ryan Stephens	582	27	7/5/2009	M	4.5			87-36-11-7≡4.6g	UWSP	9697	X	X	X		
Ryan Stephens	1166	31	7/11/2009	F		X		92-38-12-6≡4.2g	UWSP	10168		X	X		
Ryan Stephens	601	31	7/10/2009	M	5			91-35-12-7≡4.2g	NMNH	570950	X	X	X		
Ryan Stephens	1508	33	7/8/2009	M	5			92-39-12-7≡3.6g	UWSP	10087			X	X	X
Ryan Stephens	1163	33	7/11/2009	M	6			89-32-11-7≡4.4g	UWSP	9792		X	X		
Ryan Stephens	1164	33	7/11/2009	M	5			90-34-10-7≡4.6g	UWSP	9796		X	X		
Ryan Stephens	592	33	7/8/2009	M	4			88-37-11-7≡4.8g	UWSP	10047			X	X	X
Ryan Stephens	598	35	7/9/2009	M	5			98-36-13-7≡4.6g	UWSP	9698	X	X	X		
Ryan Stephens	650	40	7/24/2009	F		X		87-36-12-6≡3.6g	UWSP	9624	X	X	X		
Ryan Stephens	636	42	7/23/2009	M	5			89-38-12-6≡3.6g	UWSP	9618	X	X	X		
Ryan Stephens	792	44	7/30/2009	F		X		91-37-12-6≡4.07g	UAF	113800	X	X	X		
Ryan Stephens	794	44	7/29/2009	M	3			88-38-11-6≡3.53g	UWSP	9717	X	X	X		
Ryan Stephens	791	44	7/30/2009	M	5			71-15-12-7≡4.8g	UAF	113830	X	X	X		
Ryan Stephens	793	45	7/29/2009	M	5			95-38-12-6≡5.09g	NMNH	570977	X	X	X		
Ryan Stephens	786	45	7/28/2009	M	5			98-37-12-7≡5.1g	UAF	113778	X	X	X		
Ryan Stephens	814	47	7/28/2009	M	5			94-38-11-7≡4.66g	UAF	113838	X	X	X		
Ryan Stephens	815	47	7/28/2009	M	6			95-37-12-6≡4.7g	UAF	113821	X	X	X		
Ryan Stephens	668	48	7/29/2009	F		X		100-42-12-6≡3.8g	UAF	113786	X	X	X		
Ryan Stephens	667	48	7/29/2009	F		6		99-39-12-6≡5.6g	UAF	113784	X	X	X		
Ryan Stephens	655	48	7/27/2009	M	6			93-39-12-7≡4.2g	UAF	113844	X	X	X		
Ryan Stephens	656	48	7/27/2009	M	5			95-39-12-6≡4.6g	UAF	113820	X	X	X		
Ryan Stephens	654	48	7/27/2009	M	5			96-40-12-7≡4.8g	UWSP	9699	X	X	X		
Ryan Stephens	658	49	7/28/2009	M	1			91-39-12-7≡3.6g	UWSP	9701	X	X	X		
Ryan Stephens	756	49	7/30/2009	M	2			95-39-12-6≡3.6g	UWSP	9715	X	X	X		

Sorex cinereus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	757	49	7/30/2009	M	3			97-42-12-7≡3.8g	UWSP	9716	X	X	X		
Ryan Stephens	817	50	7/27/2009	F		Lac.		92-34-12-7≡5.3g	UWSP	9809		X			
Ryan Stephens	665	50	7/28/2009	M	1			94-39-11-6≡6.2g	UWSP	9702	X	X	X		
Ryan Stephens	695	52	8/9/2009	F		X		94-38-12-6≡3.4g	UWSP	10065			X	X	X
Ryan Stephens	675	52	8/6/2009	F		X		89-38-11-6≡3.8g	UAF	113797	X	X	X		
Ryan Stephens	724	52	8/13/2009	M	2			87-35-11-6≡3g	UWSP	9713	X	X	X		
Ryan Stephens	697	54	8/9/2009	F		X		91-39-12-7≡3.4g	UWSP	10067			X	X	X
Ryan Stephens	696	54	8/9/2009	M	1.5			89-38-12-6≡3.4g	UWSP	10066			X	X	X
Ryan Stephens	956	56	8/6/2009	M	4			90-35-11-7≡2.85g	UWSP(D)	10154		X			
Ryan Stephens	849	56	8/5/2009	M	2			94-39-11-7≡3.35g	UWSP	9720	X	X	X		
Ryan Stephens	694	56	8/9/2009	M	1.5			89-36-12-7≡3.6g	UWSP	10064			X	X	X
Ryan Stephens	679	57	8/7/2009	M	5			88-40-12-7≡4.1g	UAF	113833	X	X	X		
Ryan Stephens	858	58	8/6/2009	F		X		86-38-12-7≡3g	UAF	113799	X	X	X		
Ryan Stephens	857	58	8/6/2009	M	3			80-34-12-6≡3.06g	UWSP	9724	X	X	X		
Ryan Stephens	677	58	8/6/2009	X				90-38-11-6≡Xg	UWSP	10060			X	X	X
Ryan Stephens	702	59	8/9/2009	F		X		95-39-12-6≡5g	UWSP	10072			X	X	X
Ryan Stephens	699	60	8/9/2009	F		X		89-38-11-6≡4g	UWSP	10069			X	X	X
Ryan Stephens	698	60	8/9/2009	M	1			111-45-12-6≡4.2g	UWSP	10068			X	X	X
Sara Wendt	6	61	8/11/2009	F		X		90-38-11-7≡2.8g	NMNH	600231	X	X	X		
Ryan Stephens	716	61	8/12/2009	M	1			83-39-11-6≡3.5g	UWSP	10076			X	X	X
Ryan Stephens	721	65	8/13/2009	M	1			88-39-11-6≡2.5g	UWSP	10080			X	X	X
Ryan Stephens	723	65	8/13/2009	M	1			88-39-11-6≡2.9g	UWSP	10081			X	X	X
Ryan Stephens	715	65	8/12/2009	M	5			91-38-11-6≡3.8g	UWSP	10075			X	X	X
Ryan Stephens	713	66	8/12/2009	F		X		96-38-11-6≡4.2g	NMNH	570967	X	X	X		
Ryan Stephens	1154	67	8/14/2009	F		X		95-40-12-6≡2.6g	UWSP	9786		X	X		

Sorex cinereus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1155	67	8/14/2009	M	1			93-38-12-7≡2.4g	UWSP	10166		X	X		
Ryan Stephens	729	69	8/20/2009	F		X		91-38-12-6≡3.4g	UWSP	10083			X	X	X
Ryan Stephens	730	69	8/20/2009	F		X		99-37-11-6≡5g	NMNH	570971	X	X	X		
Ryan Stephens	743	74	8/23/2009	M	4			95-39-12-6≡4.5g	UWSP	10082			X	X	X
Ryan Stephens	734	75	8/21/2009	M	1			96-39-12-7≡3.6g	UWSP	9634	X	X	X		
Ryan Stephens	742	76	8/23/2009	M	4			94-36-12-6≡4g	UWSP	9637	X	X	X		
Ryan Stephens	1152	78	8/28/2009	F		X		95-41-12-6≡3.3g	UWSP	10165		X	X		
Ryan Stephens	1158	78	8/27/2009	M	1			92-37-11-6≡2.4g	UWSP	9788		X	X		
Ryan Stephens	1159	78	8/27/2009	M	1			87-37-11-7≡2.5g	UWSP	9789		X	X		
Ryan Stephens	1150	78	8/28/2009	M	3			88-36-12-6≡3.4g	UWSP	10163		X	X		
Ryan Stephens	753	81	8/26/2009	F		X		89-35-11-7≡3.4g	UWSP	9642	X	X	X		
Ryan Stephens	755	82	8/27/2009	F		X		93-37-12-7≡3.8g	UWSP	9643	X	X	X		
Ryan Stephens	432	PS3	5/19/2009	F		X		90-47-12-8≡4.76g	UWSP	9563	X	X			
Ryan Stephens	431	PS4	5/20/2009	F		Lac.		102-39-12-8≡7.21g	UWSP	9562	X	X			
Ryan Stephens	430	PS3	5/20/2009	M	5			93-37-12-6≡4.2g	UWSP	9561	X	X			
Ryan Stephens	435	PS2	5/29/2009	M	3			95-36-12-5≡4.4g	UWSP	9777		X			
Ryan Stephens	1015	87	6/4/2010	M	5			91-36-11-6≡3.2g	NMNH	570990	X	X	X		
Ryan Stephens	1016	89	6/4/2010	M	2			85-34-11-7≡1.9g	UWSP	9483	X	X	X		
Ryan Stephens	1018	92	6/4/2010	M	5			97-37-12-7≡5g	UWSP	9485	X	X	X		
Ryan Stephens	1025	98	6/8/2010	F		6		93-39-12-7≡3.3g	UWSP	9486	X	X	X		
Ryan Stephens	1191	98	6/11/2010	F		X		95-38-11-6≡4g	UWSP	10173		X	X		
Amanda Zalewski	9	100	6/9/2010	M	X			86-38-11-5≡3.2g	NMNH	600237	X	X	X		
Ryan Stephens	1048	102	6/18/2010	M	5			90-37-11-6≡3.8g	UWSP	9493	X	X	X		
Ryan Stephens	1047	102	6/18/2010	M	6			96-36-11-6≡4g	UWSP	9492	X	X	X		
Ryan Stephens	1051	105	6/18/2010	F		X		88-38-12-6≡2.9g	UWSP	9477	X	X	X		

Sorex cinereus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1135	126	7/12/2010	M	5			100-40-13-6≡3.6g	UWSP	9781		X			
Ryan Stephens	1136	126	7/12/2010	M	5			93-33-12-6≡3.8g	UWSP	9782		X	X		
Ryan Stephens	1107	127	8/25/2010	M	1			99-39-11-6≡3g	NMNH	600007	X	X	X		
Amanda Zalewski	7	137	7/24/2010	F		X		84-34-10-3≡2g	UWSP	10120	X	X	X		
Ryan Stephens	1196	137	7/22/2010	F		X		94-39-11-7≡2.9g	UWSP	9747	X	X	X		
Ryan Stephens	1169	137	7/23/2010	F		X		97-42-11-6≡3.2g	UWSP	9797		X	X		
Ryan Stephens	1112	139	7/24/2010	M	1			92-37-11-6≡2.8g	NMNH	600010	X	X	X		
Ryan Stephens	1205	141	7/26/2010	F		X		94-39-12-6≡2.8g	UWSP	9800		X	X		
Ryan Stephens	1125	141	7/28/2010	M	1			92-40-12-7≡2.1g	UWSP	9542	X	X	X		
Ryan Stephens	1221	146	7/27/2010	F		X		89-40-12-6≡2.9g	UWSP	9685	X	X	X		
Ryan Stephens	1223	146	7/27/2010	M	1			89-39-12-7≡3g	UWSP	9806		X	X		
Ryan Stephens	1222	146	7/27/2010	M	X			90-39-12-7≡3.1g	UWSP	9805		X	X		
Ryan Stephens	1207	147	7/29/2010	F		X		96-40-12-6≡3.4g	UWSP	9802		X	X		
Ryan Stephens	1180	147	7/26/2010	M	0.5			92-43-11-7≡2.9g	NMNH	600021	X	X	X		
Ryan Stephens	1451	148	6/26/2010	F		X		94-38-11-6≡3.5g	UWSP	9749	X	X	X		
Ryan Stephens	1232	149	8/5/2010	F		X		95-39-12-6≡3.2g	UWSP	10177		X	X		
Ryan Stephens	1230	149	8/8/2010	F		X		94-42-12-7≡3.2g	UWSP	10176		X	X		
Ryan Stephens	1237	149	8/5/2010	F		X		90-38-11-7≡13g	UWSP	10179		X	X		
Ryan Stephens	1231	149	8/5/2010	M	2			92-39-11-6≡2.8g	UWSP	9536	X	X	X		
Ryan Stephens	1212	149	8/8/2010	M	1			85-36-11-6≡2.8g	UWSP	9804		X	X		
Ryan Stephens	1229	149	8/8/2010	M	3			87-35-11-6≡3.3g	UWSP	9532	X	X	X		
Ryan Stephens	1238	149	8/6/2010	M	1			92-40-12-6≡3.4g	UWSP	9530	X	X	X		
Ryan Stephens	1239	152	8/8/2010	F		X		93-39-12-7≡3.4g	UWSP	9807		X	X		
Ryan Stephens	1215	152	8/6/2010	M	1			85-38-11-6≡2.5g	UWSP	9543	X	X	X		
Ryan Stephens	1255	154	8/8/2010	F		X		91-36-12-7≡3.6g	UWSP	9528	X	X	X		

Sorex cinereus continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1260	155	8/5/2010	F		X		88-38-11-6≡3.3g	UAF	113796	X	X	X		
Ryan Stephens	1260	155	8/5/2010	F		X		88-38-11-6≡3.3g	UWSP	9813		X	X		
Ryan Stephens	1248	155	8/8/2010	M	1			89-35-12-7≡2.9g	UWSP	9537	X	X	X		
Ryan Stephens	1256	155	8/7/2010	M	2			93-39-12-7≡3.2g	UWSP	9811		X	X		
Ryan Stephens	1263	155	8/7/2010	M	2			93-39-12-7≡3.2g	UWSP	10180		X	X		
Ryan Stephens	1192	161	8/10/2010	F		X		96-39-10-7≡2.8g	UWSP	10174		X	X		
Ryan Stephens	1097	164	8/12/2010	F		X		96-40-12-7≡3.4g	UWSP	9546	X	X	X		
Ryan Stephens	1137	168	8/20/2010	M	1			100-44-13-6≡2.2g	UWSP	9783		X	X		
Ryan Stephens	1435	171	7/22/2010	F		X		94-39-11-7≡2.9g	UWSP	9747	X	X	X		
Ryan Stephens	1394	172	8/19/2010	M	3			94-43-12-7≡4.1g	UWSP	9928	X	X			
Ryan Stephens	1274	T11	5/30/2011	F		7		93-35-11-6≡5.6g	UAF	113785	X	X	X		
Ryan Stephens	1275	T11	5/30/2011	M	5			93-35-11-6≡5.6g	UAF	113832	X	X	X		
Ryan Stephens	1278	T12	6/1/2011	M	5			94-36-11-6≡4.2g	UAF	113831	X	X	X		
Ryan Stephens	1277	T12	5/30/2011	M	6			98-48-11-6≡4.9g	UAF	113834	X	X	X		
Ryan Stephens	1287	T20	6/9/2011	F		9		102-43-11-6≡5.7g	UAF	113798	X	X	X		
Ryan Stephens	1270	T6	5/27/2011	M	1			88-35-11-6≡2.9g	UWSP	9732	X	X	X		

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Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	479	7	6/9/2009	M	3			88-30-11-5≡4.75g	UWSP(T)	10139		X	X		
Ryan Stephens	559	19	6/26/2009	F		4		80-30-11-6≡3.4g	UWSP	9590	X	X	X		
Ryan Stephens	554	19	6/24/2009	M	5			90-32-11-6≡3.6g	UWSP	9587	X	X	X		
Ryan Stephens	560	20	6/26/2009	F		X		79-29-11-6≡2.1g	NMNH	570944	X	X	X		
Ryan Stephens	557	20	6/22/2009	F		3		94-33-11-6≡4.5g	UWSP	9589	X	X	X		
Ryan Stephens	622	38	7/22/2009	M	4			80-32-11-6≡3.8g	UWSP	9609	X	X	X		
Ryan Stephens	637	42	7/23/2009	M	2			84-30-10.5-5≡3g	UWSP	9619	X	X	X		
Ryan Stephens	692	53	8/9/2009	M	1			89-33-11-6≡3.4g	UWSP	10062			X	X	X
Ryan Stephens	678	58	8/6/2009	M	1			82-30-11-6≡2.5g	NMNH	570962	X	X	X		
Ryan Stephens	676	58	8/6/2009	M	X			83-30-10-4≡Xg	UWSP	10059			X	X	X
Ryan Stephens	706	64	8/11/2009	F		X		87-32-10-5≡4.2g	UAF	113805	X	X	X		
Ryan Stephens	707	64	8/11/2009	M	2			75-29-10-5≡2.5g	UWSP	9710	X	X	X		
Ryan Stephens	440	PS2	5/22/2009	M	3			84-30-11-6≡4.06g	UWSP	9555	X	X			
Ryan Stephens	1028	93	6/9/2010	M	4			83-31-11-6≡2.9g	UWSP	9487	X	X	X		
Ryan Stephens	1037	100	6/11/2010	M	4			86-29-10-6≡3.4g	NMNH	570995	X	X	X		
Ryan Stephens	1063	102	6/20/2010	F		X		80-29-11-6≡2.3g	UWSP	9829		X	X		
Ryan Stephens	1043	102	6/18/2010	M	1			93-30-11-7≡3.8g	UWSP	9490	X	X	X		
Ryan Stephens	1046	103	6/18/2010	M	4			95-31-11-7≡3.9g	UWSP	9491	X	X	X		
Ryan Stephens	1045	103	6/18/2010	M	4			88-29-11-7≡4.2g	NMNH	570996	X	X	X		
Ryan Stephens	1056	107	6/20/2010	M	3			89-30-10-6≡3.6g	UWSP	9495	X	X	X		
Ryan Stephens	1059	111	6/22/2010	F		X		87-31-11-6≡2.6g	UWSP	9497	X	X	X		
Ryan Stephens	1062	111	6/24/2010	M	4			98-34-11-7≡4.5g	NMNH	570999	X	X	X		
Ryan Stephens	1068	130	7/12/2010	F		X		87-32-10-6≡3.4g	UWSP	9980	X	X	X		
Ryan Stephens	1066	130	7/12/2010	M	5			95-31-11-7≡4.1g	UWSP	9498	X	X	X		
Ryan Stephens	1067	130	7/12/2010	M	4			91-33-10-6≡4.4g	UWSP	9548	X	X	X		

Sorex hoyi continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1075	135	7/21/2010	F		X		90-33-10-6≡3.4g	UWSP	9547	X	X	X		
Ryan Stephens	1087	142	7/26/2010	F		X		83-28-11-5≡2.5g	UWSP	9541	X	X	X		
Ryan Stephens	1219	146	7/28/2010	M	1			89-30-11-6≡2.8g	UWSP	9683	X	X	X		
Ryan Stephens	1450	148	7/26/2010	M	1			92-32-11-6≡3.6g	UWSP	9819		X	X		
Ryan Stephens	1090	149	8/5/2010	M	1			83-31-10-6≡3.2g	UWSP	9545	X	X	X		
Ryan Stephens	1396	165	8/22/2010	F		X		81-30-11-6≡3.6g	UAF	113806	X	X	X		
Ryan Stephens	1098	171	8/19/2010	F		X		82-32-11-7≡2.7g	UWSP	9544	X	X	X		
Ryan Stephens	1101	171	8/21/2010	F		X		89-31-11-6≡3.2g	NMNH	600006	X	X	X		
Ryan Stephens	1290	T22	6/10/2011	M	5			90-31-11-7≡4.9g	UWSP	9740	X	X	X		
Ryan Stephens	1303	T28	6/15/2011	M	4			85-32-11-7≡5.1g	UWSP	9744	X	X	X		
Ryan Stephens	1306	T29	6/15/2011	M	5			89-31-10-7≡3.9g	UAF	113840	X	X	X		
Ryan Stephens	1299	T31	6/13/2011	M	5			86-33-11-6≡4.5g	UAF	113841	X	X	X		

Sorex palustris

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1036	97	6/11/2010	F		X		137-60-19-7≡7.5g	UWSP	9473	X	X	X		
Ryan Stephens	1086	145	7/26/2010	F		X		130-59-19-9≡8.2g	NMNH	600003	X	X	X		
Ryan Stephens	1288	T17	6/9/2011	M	7			145-69-19-7≡15g	UAF	113845	X	X	X		
Ryan Stephens	1295	T20	6/11/2011	F		X		136-61-17-7≡10.6g	UWSP	9742	X	X	X		

Synaptomys cooperi

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	502	1	6/13/2009	M	6			111-17-17-15≡22.28g	UWSP(T)	10144		X	X		
Ryan Stephens	845	4	6/8/2009	M	1			74-14-16-9≡8.13g	UWSP	9602	X	X	X		
Ryan Stephens	500	4	6/9/2009	M	2			81-17-17-11≡8.5g	UWSP	9578	X	X	X		
Ryan Stephens	474	6	6/7/2009	F		4		114-19-18-12≡26.5g	UWSP	9583	X	X	X		
Ryan Stephens	461	8	6/7/2009	M	6			116-18-18-11≡20g	NMNH	570934	X	X	X		
Ryan Stephens	532	9	6/21/2009	M	5			118-15-18-13≡28g	UWSP	9574	X	X	X		
Ryan Stephens	536	15	6/22/2009	F		3		111-17-18-13≡19.25g	UWSP	10005			X	X	X
Ryan Stephens	523	15	6/20/2009	M	5			120-17-19-12≡29g	NMNH	570942	X	X	X		
Ryan Stephens	555	17	6/24/2009	F		5		114-15-18-12≡22g	UWSP	9540	X	X	X		
Ryan Stephens	685	56	8/7/2009	F		X		85-15-17-11≡9.1g	UAF	113813	X	X	X		
Ryan Stephens	452	PS1	5/27/2009	F		X		100-15-18-12≡18.61g	UWSP	9571	X	X	X		
Ryan Stephens	434	PS1	5/21/2009	F		X		100-15-17-11≡19.45g	UWSP	9576	X	X			
Ryan Stephens	1083	137	7/24/2010	M	6			117-20-19-13≡22.5g	UWSP	9673	X	X	X		
Ryan Stephens	1081	137	7/23/2010	M	7			110-17-17-12≡24.5g	UWSP	9672	X	X	X		
Ryan Stephens	1203	141	7/26/2010	F		3		124-18-17-11≡31g	UWSP	9681	X	X	X		
Ryan Stephens	1204	141	7/26/2010	M	8			114-19-19-11≡24.5g	UWSP	9834		X	X		
Ryan Stephens	1085	141	7/26/2010	M	7			112-17-18-11≡25g	UWSP	9674	X	X	X		
Ryan Stephens	1449	146	7/26/2010	M	5			98-16-17-11.5≡15g	UWSP	9818		X	X		
Ryan Stephens	1123	148	7/26/2010	M	7			109-17-17-13≡19.8g	UWSP	9675	X	X	X		
Ryan Stephens	1211	149	8/5/2010	F		2		120-16-18-12≡30.5g	UWSP	9803		X	X		
Ryan Stephens	1446	149	8/5/2010	M	5			113-16-17-12≡24g	UWSP	9766	X	X	X		
Ryan Stephens	1091	149	8/5/2010	M	7			125-18-19-14≡33g	UAF	113788	X	X	X		
Ryan Stephens	1240	152	8/8/2010	F		X		95-17-18-11≡15.5g	UWSP	9815		X	X		
Ryan Stephens	1092	155	8/5/2010	F		X		99-15-18-9≡13g	UWSP(D)	10157		X	X		
Ryan Stephens	1448	155	8/7/2010	M	6			105-15.5-16-12≡22g	UWSP	9820		X	X		

Synaptomys cooperi continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1249	155	8/8/2010	M	4			112-17-18-11≡23g	UWSP	9539	X	X	X		
Ryan Stephens	1093	155	8/6/2010	M	6			109-17-17-12≡24g	UWSP(D)	10158		X	X		
Ryan Stephens	1185	163	8/11/2010	M	7			125-15-19-12≡30.5g	UWSP	9678	X	X	X		
Ryan Stephens	1099	165	8/20/2010	F		X		112-20-17-11≡20g	UWSP	9664	X	X	X		
Ryan Stephens	1398	170	8/19/2010	M	6			110-17-17-12≡20g	UAF	113843	X	X	X		
Ryan Stephens	1395	172	8/19/2010	F			6	107-17-16-13≡19g	UAF	113812	X	X	X		

Tamias striatus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Mark Cufaude	1	18	7/24/2009	F		X		210-80-29-15≡53g	UWSP	9939	X	X			
Ryan Stephens	583	29	7/5/2009	F		X		211-85-36-17≡65g	UWSP	9597	X	X	X		
Ryan Stephens	784	46	7/29/2009	F		X		244-99-36-17≡88.94g	UWSP	9645	X	X	X		
Ryan Stephens	1153	60	8/6/2009	F		X		248-96-37-19≡99g	UWSP	9465	X	X	X		
Ryan Stephens	1023	89	6/5/2010	F		X		197-76-35-17≡55g	UWSP	9466	X	X	X		
Nate Huck	3	90	6/5/2010	F		X		192-80-33-16≡43g	UWSP	9915	X	X			
Mari Shirley	3	108	6/19/2010	F		X		214-75-32-11≡86g	UWSP	9984	X	X	X		
Leah McSherry	2	115	6/6/2010	F		X		267-107-35-13≡122g	UWSP	10113	X	X	X		

Tamiasciurus hudsonicus

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1176	63	8/11/2009	M	5			312-118-49-24≡159g	NMNH	600019	X	X	X		
Ryan Stephens	1119	154	8/8/2010	F			5	322-134-50-25≡285g	NMNH	600013	X	X	X		
Ryan Stephens	1439	171	8/23/2010	F		X		296-122-45-23≡148g	UWSP	9794	X	X	X		

Zapus hudsonius

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	471	2	6/8/2009	M	5			193-121-29-12≡14.25g	UWSP	9471	X	X	X		
Ryan Stephens	489	3	6/11/2009	M	6			202-126-29-12≡12.5g	UWSP	9472	X	X	X		
Ryan Stephens	470	8	6/8/2009	F			4	205-126-30-14≡16.75g	UWSP	9470	X	X	X		
Ryan Stephens	462	8	6/7/2009	M	6			119-121-28-15≡15g	NMNH	570935	X	X	X		
Ryan Stephens	530	14	6/21/2009	F		6		213-126-29-15≡22g	UWSP	9550	X	X	X		
Ryan Stephens	529	14	6/21/2009	M	6			219-141-30-14≡17.75g	UWSP	9559	X	X	X		
Ryan Stephens	549	15	6/22/2009	F		5		213-130-30-14≡18.5g	UWSP	10035			X	X	X
Ryan Stephens	551	15	6/22/2009	M	2			205-122-29-15≡16.5g	UWSP	10012			X	X	X
Ryan Stephens	550	15	6/22/2009	M	5			215-126-30-15≡18.5g	UWSP	10034			X	X	X
Ryan Stephens	580	24	7/5/2009	F		X		175-110-29-12≡8.5g	UWSP	9661	X	X	X		
Ryan Stephens	584	27	7/6/2009	M	2			173-115-29-10≡7.5g	UWSP	9662	X	X	X		
Ryan Stephens	577	27	7/5/2009	M	4			188-121-29-13≡9.75g	UWSP	9660	X	X	X		
Ryan Stephens	600	31	7/10/2009	F		X		189-114-28-13≡10.75g	UWSP	9663	X	X	X		
Ryan Stephens	585	31	7/8/2009	M	5			179-113-27-13≡11g	NMNH	570947	X	X	X		
Ryan Stephens	606	33	7/10/2009	F		X		191-113-28-13≡13.5g	UWSP	9606	X	X	X		
Ryan Stephens	605	33	7/10/2009	F		X		193-120-28-13≡14.25g	UWSP	9605	X	X	X		
Ryan Stephens	591	33	7/8/2009	M	5			182-118-30-12≡9.2g	UWSP	10048			X	X	X
Ryan Stephens	596	33	7/9/2009	M	5			204-125-29-14≡13g	NMNH	570949	X	X	X		
Ryan Stephens	602	35	7/10/2009	F		X		197-121-29-13≡12.25g	UWSP	9603	X	X	X		
Ryan Stephens	604	35	7/10/2009	F		X		202-122-29-13≡15g	NMNH	570951	X	X	X		
Ryan Stephens	1160	35	7/11/2009	M	2			200-121-31-12≡12.5g	NMNH	600017	X	X	X		
Ryan Stephens	603	35	7/10/2009	M	5			202-122-30-14≡15g	UWSP	9604	X	X	X		
Ryan Stephens	661	47	7/28/2009	F		X		195-118-28-14≡11.5g	UWSP	9626	X	X	X		
Ryan Stephens	690	52	8/8/2009	M	4			201-118-39-14≡18.5g	NMNH	570965	X	X	X		
Ryan Stephens	689	53	8/8/2009	M	4			211-125-30-15≡16.75g	UWSP	9632	X	X	X		

Zapus hudsonius continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	684	59	8/7/2009	F		X		194-117-28-14≡13.25g	UWSP	9631	X	X	X		
Sara Wendt	3	63	8/14/2009	M	X			186-115-27-11≡13.5g	NMNH	600229	X	X			
Ryan Stephens	726	70	8/20/2009	F		X		189-114-29-12≡12g	UAF	113790	X	X	X		
Ryan Stephens	725	70	8/20/2009	M	5			190-115-27-13≡13g	NMNH	570968	X	X	X		
Ryan Stephens	740	76	8/23/2009	M	5			200-123-28-13≡14g	UAF	113807	X	X	X		
Ryan Stephens	802	79	8/28/2009	F		X		165-102-27-10≡8g	UWSP(D)	10151		X	X		
Ryan Stephens	798	83	8/27/2009	M	3			164-105-27-10≡6.6g	UAF	113842	X	X	X		
Ryan Stephens	445	PS1	5/25/2009	F			5	210-125-29-14≡16.53g	UWSP	9553	X	X	X		
Ryan Stephens	455	PS1	5/26/2009	F			3	209-121-29-13≡17.02g	UWSP	9551	X	X	X		
Ryan Stephens	442	PS1	5/25/2009	M	6			190-114-27-13≡14.8g	UWSP	9552	X	X	X		
Ryan Stephens	444	PS1	5/25/2009	M	6			212-127-30-13≡15.93g	UWSP	9554	X	X	X		
Ryan Stephens	1012	85	6/3/2010	F		4		200-114-29-14≡17g	UWSP	9506	X	X	X		
Ryan Stephens	1020	92	6/5/2010	F		X		211-134-29-13≡18.5g	UWSP	9505	X	X	X		
Ryan Stephens	1021	92	6/5/2010	F		3		217-128-29-14≡24g	UWSP	9504	X	X	X		
Ryan Stephens	1029	96	6/9/2010	F		4		210-122-29-15≡18.5g	NMNH	570993	X	X	X		
Ryan Stephens	1049	102	6/18/2010	F		5		200-115-26-14≡19g	UWSP	9503	X	X	X		
Ryan Stephens	1050	105	6/18/2010	F			4	199-116-27-14≡21g	UWSP	9502	X	X	X		
Alexa Cushman	4	115	6/25/2010	F			4	222-131-46-15≡25g	UWSP	10114	X	X	X		
Ryan Stephens	1058	115	6/22/2010	M	7			209-122-30-14≡19.5g	NMNH	570998	X	X	X		
Ryan Stephens	1465	125	7/8/2010	F		X		184-115-27-12≡10.5g	UWSP	10183		X	X		
Ryan Stephens	1463	125	7/8/2010	F			5	209-125-28-14≡20.5g	UWSP	9994	X	X	X		
Dillon Fedro	1	125	7/8/2010	M	9			200-115-27-11≡16g	UWSP	9990	X	X	X		
Ryan Stephens	1455	126	7/12/2010	M	6			188-115-29-12≡14g	UWSP	9999	X	X	X		
Ryan Stephens	1459	127	7/15/2010	F		X		200-121-27-13≡14.5g	UWSP	9998	X	X	X		
Ryan Stephens	1458	127	7/15/2010	M	4			185-112-27-12≡12.5g	UWSP	9997	X	X	X		

Zapus hudsonius continued

Preparator	Field #	ID	M/D/Y	Sex	Tes.	EMB	P scar.	Measurements	Museum	Cat. #	Skin	Skel	Tis	Skull	Fluid
Ryan Stephens	1069	128	7/13/2010	F		4		209-121-28-14≡20.5g	UWSP	9501	X	X	X		
Ryan Stephens	1138	129	7/12/2010	F		X		192-118-29-16≡12.5g	UWSP	9508	X	X	X		
Ryan Stephens	1170	137	7/23/2010	M	2			191-115-28-12≡10.5g	UWSP	9798		X	X		
Ryan Stephens	1115	139	7/24/2010	M	6			213-125-30-13≡18g	NMNH	600011	X	X	X		
Ryan Stephens	1084	139	7/24/2010	M	5			197-117-28-14≡18g	UWSP	9500	X	X	X		
Ryan Stephens	1114	139	7/24/2010	M	6			223-134-32-14≡20.5g	UWSP	9509	X	X	X		
Ryan Stephens	1126	141	7/28/2010	M	4			216-122-32-16≡21g	UWSP	9507	X	X	X		
Sara Wendt	11	142	7/27/2010	M	5			190-121-28-11≡13g	UWSP	9864	X	X	X		
Amanda Zalewski	5	143	7/26/2010	M	X			208-123-30-11≡19g	NMNH	600236	X	X	X		
Ryan Stephens	1272	T7	5/26/2011	F		X		210-124-27-13≡17g	UAF	113779	X	X	X		