Evaluating the Predicted Local Extinction of a Once-Common Mouse

OLIVER R.W. PERGAMS* AND DENNIS W. NYBERG†

Department of Biological Sciences, University of Illinois at Chicago, 845 West Taylor Street, Chicago, IL 60607-7060, U.S.A.

Abstract: *In an earlier paper (Pergams & Nyberg 2001) we found that the proportion of the prairie deer mouse (*Peromyscus maniculatus bairdii*), among all local* Peromyscus *museum specimens collected in the Chicago region, had significantly declined over time. This proportion changed from about 50% before 1900 to <10% in the last 25 years. Based on this proportion a regression model predicted the local extinction of the prairie deer mouse in 2009. To evaluate that prediction, we estimated current deer mouse abundance by live trapping small mammals at 15 preserves in Cook and Lake counties, Illinois (USA) at which prairie deer mice had previously been caught or that still contained their preferred open habitat. In 1900 trap nights, 477 mammals were caught, including 251 white-footed mice (*P. leucopus*), but only one prairie deer mouse. The observed proportion of* Peromyscus *that were prairie deer mice, 0.4%, was even lower than the 4.5% predicted for 2000. Here we also introduce a simple, new community proportions model, which for any given geographic region compares the proportions of species recently caught with the proportions of species in museums. We compared proportions of seven species collected in Cook and Lake counties and examined by Hoffmeister (1989) with proportions of these species that we caught. Ten percent of the museum community was prairie deer mice, but only 0.2% of our catch was. The current local scarcity of the prairie deer mouse is consistent with the regression-based prediction of its eminent local extinction. More conservation attention should be paid to changes in relative abundance of once-common species.*

Key Words: extinction prediction, Chicago, decline of common species, *Peromyscus leucopus*, *Peromyscus maniculatus bairdii*

Evaluación del Pronóstico de la Extinción Local de un Ratón Anteriormente Común

Resumen: *En un artículo previo (Pergams & Nyberg 2001) encontramos que la proporción de* Peromyscus maniculatus bairdii*, entre todos los especimenes de museo de Peromyscus recolectados en la región de Chicago, había declinado significativamente. Esta proporción cambió de 50% antes de 1900 a <10% en los últimos 25 años. Con base en esta proporción, un modelo de regresión pronosticó la extinción local de P. m. bairdii en 2009. Para evaluar esa predicción, estimamos la abundancia actual de* P. m. bairdii *mediante el trampeo de mamíferos pequeños en 25 reservas en los condados Cook y Lake, Illinois (E.U.A.) en las que se había capturado a* P. m. bairdii *previamente o que aun contenían su hábitat abierto preferido. En 1900 noches-trampa, capturamos a 477 mamíferos, incluyendo a 251* P. leucopus *pero solo a un* P. m. bairdii. *La proporción observada de* P. m. bairdii, *0.4%, fue menor a 4.5% pronosticado para 2000. Aquí también introducimos un modelo, nuevo y sencillo, de proporciones de la comunidad que compara, para cualquier región geográfica, las proporciones de especies recientemente capturadas con la proporciones de especies en los museos. Comparamos las proporciones de siete especies recolectadas en los condados Cook y Lake y examinadas por Hoffmeister (1989) con las proporciones de especies que capturamos. Diez por ciento de la comunidad de museos era* P. m. bairdii, *pero solo 0.2% de nuestra muestra lo fue. La actual escasez local de* P. m. bairdii *es consistente con*

**email pergams@uic.edu*

†Current address: Department of Biological Sciences 4120, Illinois State University, Normal, IL 61790-4120, U.S.A.

Paper submitted May 13, 2004; revised manuscript accepted November 18, 2004.

Conservation Biology 1312–1317

DOI: 10.1111/j.1523-1739.2005.00209.x

la predicción de su inminente extinción local con base en la regresión. La conservación debe prestar mayor atención a los cambios en la abundancia relativa de una especie anteriormente común.

Palabras Clave: Chicago, declinación de especies comunes, extinción pronosticada, *Peromyscus leucopus*, *Peromyscus maniculatus bairdii*

Introduction

A variety of models have been developed to predict extinction of a population or species. One type of model projects the future based on genetic, demographic, and ecological processes modeled as stochastic events (Lindenmayer & Lacy 2002; Lindenmayer et al. 2003). Another type of model makes projections based on trends analyzed from empirical records, usually museum specimens (Solow 1993; McCarthy 1998). We developed a variant of the empirical records model that reduces the uncertainty of how much trapping was attempted by comparing two species of the same genus living within the region of interest (Pergams & Nyberg 2001).

The deer mouse is one of the most widespread mammals of North America. The prairie deer mouse (*Peromyscus maniculatus bairdii*) is found in prairies from Ohio to Oklahoma to southern Manitoba. Its range overlaps with that of the northern white-footed mouse (*P. leucopus noveboracensis*), except in its extreme western and northern portions (Osgood 1909). The white-footed mouse is a habitat generalist that usually prefers deciduous woodlands, but it has colonized agricultural areas (Wegner & Merriam 1990). Although most other *P. maniculatus* subspecies occupy woodland habitats, *P. maniculatus bairdii* often nests in burrows and lives in prairie and open, cultivated fields (Baker 1983; Hoffmeister 1989).

Kennicott (1857) reported that the prairie deer mouse was much more abundant in the Chicago region than the white-footed mouse and that in his trapping surveys the deer mouse was strictly an inhabitant of prairies. Other early studies of the two *Peromyscus* species in the Chicago region (Cory 1912; Gregory 1936) confirm the prairie/woodland habitat segregation and the abundance patterns reported by Kennicott (1857).

Using museum collection information, Pergams and Nyberg (2001) regressed the proportion of the prairie species of two genera against time. They reported that the proportion of prairie vole (*Microtus ochrogaster*) (number of specimens of prairie vole/number of specimens of all *Microtus* spp.) had declined 60% in 1850–1900 to <1% in 1980–2000 and was declining at a rate of −0.3%/year. The regression predicted extinction of the prairie vole in 2000, although this prediction was not statistically significant. The proportion of prairie deer mouse declined from 47% of *Peromyscus* in 1850–1900 to 12% in 1980–2000. The regression slope was −0.5% year^{-1} and was statistically significant. The regression model predicted that *P. maniculatus bairdii* would be locally extinct in 2009 (95% CI = 2000 − 2149) and that the prairie deer mouse would be only 4.5% of the local *Peromyscus* in 2000. We undertook a trapping study to determine the current proportions of prairie species in those genera in Cook and Lake counties.

The regression model compared the proportions of sympatric species pairs over time among deposited specimens. By comparing species within a genus we attempted to overcome problems of uneven trapping effort inherent in single-species museum records (Solow 1993; McCarthy 1998). An extension of this idea is to compare species within a community. For any given region, one would compare the proportions of species recently caught with the proportions of species in museums (which could be trapped efficiently). We call this way of assaying change the community proportions model. It does not require the existence of two sympatric species in the region of interest (as does our previous regression model) and thus is much more widely applicable. The proportion of any species in the community could be regressed against time but we did not do this. The community proportions method is a simple way to find changes in the abundance of common species.

Methods

Based on the collection information provided by museums, we identified 10 locations in Cook and Lake counties from which deer mice had been trapped. Six of these locations still had natural areas, and we identified eight spots to trap among the six: Cranberry Slough Nature Preserve, Grand Army of the Republic Woods (GAR), The Grove and Woodworth Prairie, Heller Nature Preserve and Highmoor Nature Preserve, Illinois Beach State Park, and Volo Bog. Those sites were all trapped in 1999. In 2000 we selected some of the best-quality prairies (Burnham, Gensburg-Markham, Glenbrook North High School, Somme, and Wolf Road Prairies) and the largest open fields (Bartel Grassland and Poplar Creek [a restoration contiguous with a prairie Nature Preserve]) for trapping. Except for Bartel, Burnham, GAR, Poplar Creek, and Woodworth, sites are Illinois Nature Preserves. All sites except Bartel (open exotic), GAR (all wooded), and The Grove (all wooded) still had at least some open areas dominated by native vegetation.

Table 1. Results of small-mammal trapping in Cook and Lake counties, Illinois.

Location	*County*	*Location coordinates*	*Date trapped (month/day/year)*	*Trap nights*	*Catch rate (%)**
Bartel Grassland	Cook	41° 33′ N, 87° 46′ W	9/28/00	144	22
Burnham Prairie	Cook	41° 38′ N, 87° 33′ W	8/31/00	144	18
Cranberry Slough Nature Preserve	Cook	41° 42′ N, 87° 51′ W	8/9/99-8/11/99	230	19
G.A.R. Woods	Cook	41° 53′ N, 87° 50′ W	6/15/99-6/17/99	135	15
Gensburg-Markham	Cook	41° 37′ N, 87° 42′ W	10/5/00	144	43
Glenbrook North High School	Cook	42° 06′ N, 87° 50′ W	10/12/00	48	71
Heller Nature Preserve	Lake	42° 13′ N, 87° 52′ W	9/26/99	48	35
Highmoor Nature Preserve	Lake	42° 12′ N, 87° 51′ W	9/26/99	35	46
Illinois Beach State Park	Lake	42° 28′ N, 87° 48′ W	10/4/99	96	19
Poplar Creek	Cook	42° 03′ N, 88° 11′ W	8/14/00	147	16
Somme Prairie	Cook	42° 08′ N, 87° 50′ W	7/31/00	127	35
The Grove	Cook	42° 04′ N, 87° 52′ W	9/13/99	91	22
Volo Bog	Lake	42° 21′ N, 88° 11′ W	8/1/99-8/4/99	283	17
Wolf Road Prairie	Cook	41° 53′ N, 87° 54′ W	8/30/00	144	35
Woodworth Prairie	Cook	42° 03′ N, 87° 50′ W	9/12/99	84	29

**See Methods for calculation of catch rate.*

We used Sherman (Tallahassee, Florida, model SNA [5.1 × 6.4 × 16.5 cm]) live traps baited with peanut butter and rolled oats. The traps were set on the ground without looking for runs. Traps were about 10 m apart except at the smallest site (Glenbrook North High School), where the traps were 5 m apart. Traps that were torn open (presumably by predators) were not included in the trap-night count. Trap nights were approximately proportional to site area and ranged from 35 to 283 per site. We distinguished the two *Peromyscus* species in the field by measuring tail and hind foot length. Ear snips were taken from trapped *Peromyscus*, and field identifications were confirmed by sequencing mtDNA. Other species were identified based on field characteristics and measurements in Hoffmeister (1989). Animals were released after species, weight, and sex were recorded.

To estimate the relative abundance that could be trapped, we made a list of mammal species known from the region that weigh 10–80 g. For each of those seven species we used the number of museum specimens collected in Cook and Lake counties (cited by Hoffmeister [1989], standard local reference) to estimate the proportion of that species in the local community of small mammals. We calculated the expected catch number of each species based on the total number of individuals we caught. Large deviations of the current catch proportions from community proportions based on museums specimens suggest substantial changes in abundance of a species in the local community have occurred.

Results

The 15 sites (Table 1) ranged over almost a degree of latitude (41°33′N to 42°28′N) and longitude (87°33′W to 88°11′W). We caught 477 individuals in 1900 trap nights, for an overall catch rate of 25%. Catch rate among sites ranged from 15 to 71%. Nine species were caught. The number of animals caught of the seven species we expected to be efficiently caught in our traps is given in Table 2. (Four masked shrews [*Sorex cinereus*] and four eastern chipmunks [*Tamias striatus*] we caught are not in Table 2 because they are too small and too big, respectively, to consistently be caught in our traps.) More than half (53%) of the individuals caught were *P. leucopus*, the only species caught at each of the 15 sites. Only a single *P. maniculatus bairdii* was caught. The proportion of *Peromyscus* that were prairie deer mice was 0.4%, which is even lower than the 4.5% predicted by the regression model. The prairie vole was caught 21 times at 5 different sites. It was much less commonly caught than the meadow vole (169 times, 11 sites). The proportion of *Microtus* that were prairie voles was 11%, which was greater than regression prediction of zero but less than the 27% fraction of prairie voles among museum *Microtus* (Table 2).

The community proportions model showed two species, the white-footed mouse (1.94) and the meadow vole (1.80), caught much more frequently by us than numbers in museums predicted (Table 2). Based on proportions in museums one would expect the short-tailed shrew to be the most common small mammal. It was the third most common species in our catch, but we caught only 16% of the number expected based on the community proportion. Also, we caught only 11% of the expected number of meadow jumping mice. The species whose proportion was least compared with expected was the prairie deer mouse (0.02). The prairie vole proportion caught was larger, 0.61, suggesting it is not declining as a member of the small mammal community. Recall that we selected

Table 2. Comparison of our catch with historical trapping abundance (Hoffmeister 1989) of small terrestrial mammals weighing 10-80 g (expected size of animals in our traps) from Cook and Lake counties, Illinois.

Species	*No. specimens examined by Hoffmeister (1989)*	*No. expected to be caught based on* n = *469**	*No. caught during our search for* P. maniculatus bairdii	*Proportion of number caught to expected number in community*
Short-tailed shrew				
Blarina brevicauda	91	135.5	22	0.16
White-footed mouse				
P. leucopus	87	129.5	251	1.94
Meadow vole				
Microtus pennsylvanicus	63	93.8	169	1.80
Prairie deer mouse				
P. maniculatus bairdii	41	61.0	1	0.02
Prairie vole				
Microtus ochrogaster	23	34.2	21	0.61
Meadow jumping mouse				
Zapus hudsonius	6	8.9	1	0.11
House mouse				
Mus musculus	4	6.0	4	0.67
Totals	315	469.0	469	

**See Methods for calculation of expected number.*

trapping areas on the basis of historical presence of prairie deer mice or their preferred habitat. We did trap in some woodland habitats, but the habitats we sampled were biased toward prairie and away from woodland (compared with a random sample).

Discussion

Pergams and Nyberg (2001) predicted the disappearance of two prairie species. Here we found the prairie deer mouse to be even rarer than predicted by the regression, and possibly it will become locally extinct within the near future. The prairie vole's decline, unlike that of the prairie deer mouse, was not statistically significant. The estimated regression slope suggested that the prairie vole would have been completely replaced by the meadow vole in 2000, but the lack of significance could be interpreted as a prediction of constancy of the proportions of the two *Microtus* with time. The observed proportion of prairie voles as a proportion of *Microtus* was 0.11, halfway between the regression prediction and the "no change," which is compatible with the lack of statistical significance. Regression-model predictions based on proportion of museum specimens of species within a genus were quite accurate for *Peromyscus* and less accurate but generally consistent with changes in *Microtus*.

The proportion of prairie deer mice in our collection was low, 0.002, especially considering that 10% of the small mammal museum specimens from these two counties are of this species. The community proportions model suggested the proportion of prairie voles we caught was close to that in museum *Microtus*. For *Microtus* the community model suggests less change than the regression model. The community model would work best if the museum sample were based on proportional sampling of all habitats within the area of interest and if all species in the community were equally likely to be caught with all trapping methods. Neither of these ideal conditions will be true in any historical sample. The habitat selectivity is difficult to assess. The trap selectivity issue has been investigated. Sherman live traps are more effective in catching small mammals than snap traps (Cockrum 1947; Sealander & James 1958; Hansson & Hoffmeyer 1973) (but see Wiener & Smith [1972]). Variation among factors such as locality (e.g., Williams & Braun 1983), season (e.g., Mengak & Guynn 1987), bait, and trap tension may be greater than the variation among live and snap traps when catching similar rodents. In any case, knowing the proportions of species in museums was informative, but its general applicability requires more study.

The decline of the prairie deer mouse as a proportion of *Peromyscus* may be more widespread than the two-county area we studied. Long (1968) used snap traps to study the small mammal community in prairie along railroad right-of-ways in central Illinois. He reported that the white-footed mouse was slightly greater than 70% of the animals trapped, whereas the prairie deer mouse made up only 7.6% of his catch.

Why is *P. maniculatus bairdii* becoming locally rare, while *P. leucopus* is increasing in habitat remnants, even those that are still prairie? The loss of original prairie (Iverson et al. 1989; Anderson 1991) is great but does not explain why *P. maniculatus bairdii* has become very rare or absent in remaining high-quality prairie and large open fields or why *P. leucopus* has taken its place. Thus, the possibilities seem to be a change in the prairie habitat or a change in one or more of the species involved. The Chicago region, like many others, has had a long history of fire suppression (e.g., Stevens 1995). The beneficial effects of fire and the detrimental effects of lack of fire for the deer mouse have been documented over time. In the years following burning, *Peromyscus* species abundance shifted to favor *P. maniculatus* (Cook 1959; Lawrence 1966). There were significantly higher proportions of *P. maniculatus bairdii* in burned habitat (Ahlgren 1966; Beck & Vogl 1972), and burning improved prairie deer mouse habitat and food conditions (Tester 1965). These findings support the habitat change hypothesis.

Some new facts draw attention to the change-within-species hypothesis. A mitochondrial COX2 haplotype *M* that was uncommon (<25%) in the Chicago region before 1920 currently has a frequency of 94% (Pergams et al. 2003). More recent work shows complete replacement of mitochondrial D-loop haplotypes within the last 30 years (O.R.W.P. & R. C. Lacy, unpublished data). The rapidity of these genetic replacements within the white-footed mouse suggests a selective advantage of *P. leucopus* with the modern haplotypes. The new type of *P. leucopus* could not only provide a competitive advantage within its own species but could also allow the white-footed mouse to displace the prairie deer mouse. Although speculative, the already known genetic changes emphasize that species, and therefore competitive relationships, are not static.

Our results has show how expectations of local abundance generated in two ways from museum records can be compared with current information to document abundance changes in common species. Conservation effort focused on *species* that were always globally rare is appropriate if one values species outside the context of their community. Conservation effort focused on *communities* should consider changes in abundance of common species. At the least our work points out the possibility that many species assumed to be abundant may no longer be so. The prairie deer mouse was the most abundant mouse in the Chicago region only 150 years ago; now it is seldom found even in the most appropriate remaining habitat. It and other species that have undergone dramatic local declines deserve greater conservation attention.

Acknowledgments

We thank the Illinois Nature Preserves Commission, Forest Preserve District of Cook County, Illinois Department of Natural Resources, Lake County Forest Preserve District, Park District of Highland Park, and Glenbrook North High School for permission to trap; the University of Illinois at Chicago for useful improvements to our animal protocol; C. Long, an anonymous reviewer, and K. Paige for useful comments; and J. Norton, G. Alaks, A. Walsh, A. Pergams, the late D. Petro, J. Marzalik, S. Breedlove, and C. O'Leary for assistance in trapping. Brookfield Zoo loaned Sherman traps. Funding was provided by two Restoration Research Grants from the Forest Preserve District of Cook County in conjunction with The Nature Conservancy, a grant (to D. N.) from the University of Illinois at Chicago Campus Research Board, a Conservation Research Grant from Brookfield Zoo, a Grant-in-Aid of Research (to O. P.) from the American Society of Mammalogists, a STAR Fellowship (to O. P.) from the U.S. Environmental Protection Agency, a Dean's Scholar Award Fellowship (to O. P.) from the University of Illinois at Chicago, and a David H. Smith Conservation Research Postdoctoral Fellowship (to O. P.) from The Nature Conservancy.

Literature Cited

Ahlgren, C. E. 1966. Small mammals and reforestation following prescribed burning. Journal of Forestry **64:**614–618.

Anderson, R. C. 1991. Illinois prairies: a historical perspective. In L. M. Page and M. R. Jeffords, editors. Our living heritage: the biological resources of Illinois. Illinois Natural History Survey Bulletin **34:**384–391.

Baker, R. H. 1983. Michigan mammals. Michigan State University Press, East Lansing.

Beck, A. M., and R. J. Vogl. 1972. The effects of spring burning on rodent populations in a brush prairie savanna. Journal of Mammalogy **53:**336–346.

Cockrum, E. L. 1947. Effectiveness of live traps versus snap traps. Journal of Mammalogy **28:**186.

Cook, S. F. 1959. Effects of fire on a population of small rodents. Ecology **40:**102–108.

Cory, C. B. 1912. The mammals of Illinois and Wisconsin. Zoological series. Volume XI. The Field Museum of Natural History, Chicago.

Gregory, T. 1936. Mammals of the Chicago region. Program of Activities of the Chicago Academy of Sciences **7:**15–75.

Hansson, L., and I. Hoffmeyer. 1973. Snap and live trap efficiency for small mammals. Oikos **24:**477–478.

Hoffmeister, D. F. 1989. Mammals of Illinois. University of Illinois Press, Urbana.

Iverson, I. R., R. L. Oliver, D. P. Tucker, P. G. Risser, C. D. Burnett, and R. G. Rayburn. 1989. The forest resources of Illinois: an atlas and analysis of spatial and temporal trends. Special Publication 11. Illinois Natural History Survey, Champaign.

Kennicott, R. 1857. The quadrupeds of Illinois, injurious and beneficial to the farmer. Transactions of the Illinois State Agricultural Society **2:**615–684.

Lawrence, C. E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecology **47:**278–291.

Lindenmayer, D. B., and R. C. Lacy. 2002. Small mammals, habitat patches and PVA models: a field test of model predictive ability. Biological Conservation **103:**247–265.

Lindenmayer, D. B., H. P. Possingham, R. C. Lacy, M. A. McCarthy, and M. L. Pope. 2003. How accurate are population models? Lessons from landscape-scale tests in a fragmented system. Ecology Letters **6:**41–47.

Long, C. A. 1968. Populations of small mammals on railroad right-of-way in prairie of central Illinois. Transactions of the Illinois State Academy of Science **61:**139–145.

McCarthy, M. A. 1998. Identifying declining and threatened species with museum data. Biological Conservation **83:**9–17.

Mengak, M. T., and D. G. Guynn, Jr. 1987. Pitfalls and snap traps for sampling small mammals and amphibians to two trap types and two trap baits in Pacific Northwest [USA] forest. American Midland Naturalist **118:**284–288.

Osgood, W. H. 1909. Revision of the mice of the American genus *Peromyscus*. North American Fauna **28:**65.

Pergams, O. R. W., and D. Nyberg. 2001. Museum collections of mammals corroborate the exceptional decline of prairie habitat in the Chicago region. Journal of Mammalogy **82:**984–992.

Pergams, O. R. W., W. M. Barnes, and D. Nyberg. 2003. Rapid change of mouse mitochondrial DNA. Nature **423:**397.

Sealander, J. A., and D. James. 1958. Relative efficiency of different small mammal traps. Journal of Mammalogy **39:**215–223.

Solow, A. R. 1993. Inferring extinction from sighting data. Ecology **74:**962–964.

Stevens, W. K. 1995. Miracle under the oaks: the revival of nature in America. Pocket Books, New York.

Tester, J. R. 1965. Effects of a controlled burn on small mammals in a Minnesota oak-savanna. American Midland Naturalist **74:**240–243.

Wegner, J., and G. Merriam. 1990. Use of spatial elements in a farmland mosaic by a woodland rodent. Biological Conservation **54:** 263–276.

Wiener, J. G., and M. H. Smith. 1972. Relative efficiencies of four small mammal traps. Journal of Mammalogy **53:**868–873.

Williams, D. F., and S. E. Braun. 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. Journal of Wildlife Management **47:**841–845.