

Spatial Scales of Trapping in Small-mammal Research

JEFF BOWMAN^{1,3}, CRISTINE V. CORKUM², and GRAHAM J. FORBES¹

¹New Brunswick Cooperative Fish and Wildlife Research Unit, P.O. Box 44555, University of New Brunswick, Fredericton, New Brunswick E3B 6C2 Canada

²Department of Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E9 Canada

³Present address: Wildlife Research and Development Section, Ontario Ministry of Natural Resources, 300 Water Street, 3rd Floor North, Peterborough, Ontario K9J 8M5 Canada, e-mail: jbowman@canada.com

Bowman, Jeff, Cristine V. Corkum, and Graham J. Forbes. 2001. Spatial scales of trapping in small-mammal research. *Canadian Field-Naturalist* 115(3): 472–475.

We surveyed 127 published small-mammal trapping studies (of either *Peromyscus maniculatus* or *Clethrionomys gapperi*) to assess the range of sizes used in the design of trap arrays. The distribution of trap spacings was bimodal, with peaks at 10 and 15 m. The mean extent of trapping arrays was 1.8 ha for grids and 358 m for transects. Only seven manuscripts mentioned prebaiting. The results suggest that many small-mammal studies are designed in a similar way, at small spatial scales. Larger-scale patterns and processes may occur undetected without larger-scale sampling designs. We present and discuss some recent examples from the literature.

Key Words: *Clethrionomys*, dispersal, landscape context, *Peromyscus*, prebaiting, sampling, scale, small mammal, spatial autocorrelation, synchrony, trapping, winter mortality.

Ecological research has often been carried out over a narrow range of relatively small spatial scales (Kareiva and Anderson 1989; Brown and Roughgarden 1990). This broad observation also may apply to small-mammal research. One consequence of working at small spatial scales is that larger-scale patterns and processes can be overlooked or misinterpreted (Wiens et al. 1993). For example, Wegner and Merriam (1990) showed that White-footed Mice, *Peromyscus leucopus*, use agricultural fields adjacent to forest fragments; a phenomenon that could have been overlooked without considering landscape context. Empirical small-mammal field studies commonly employ grid or transect arrays of traps, the design of which often establishes the spatial scale of the study. We surveyed the literature to assess the range of trapping array sizes, and thus spatial scales, used in small-mammal research.

Methods

We surveyed 127 studies published in five journals (*American Midland Naturalist*, *The Canadian Field-Naturalist*, *Canadian Journal of Zoology*, *Ecology*, and *Journal of Mammalogy*) between 1960 and 1998. We selected only field-based studies of two common species: the Red-backed Vole, *Clethrionomys gapperi*, and the Deer Mouse, *Peromyscus maniculatus*. From each published manuscript, we tabulated information on trap spacing, spatial extent of grid or transect, total trap nights of the study, length of trapping period, length of prebait period, and the number of grid or transect replicates. Replication was a difficult issue to evaluate as authors often did not clearly discuss assumptions about the spatial independence of sampling sites.

Grids or transects were assumed to be replicated if multiple sites were sampled within a single study, whether or not these sites were truly independent in the statistical sense. This included the few studies where large-scale questions were addressed by the spatially-explicit juxtaposition of small replicates (e.g., Morris 1996). Areal units were converted to ha and length was converted to m. Some authors published multiple manuscripts from one field study, and in these cases we only included one sample. When multiple designs (e.g., transect and grid) were used in one study they were considered as separate samples. We carried out an exploratory analysis of the tabulated data.

Results and Discussion

The majority of studies in our survey (N = 80; Table 1) employed trapping grids rather than transects. The mean extent of the grids was 1.8 ha while the mean extent of transects was 358 m (Figure 1; Table 1). More than 50% of transects were < 300 m, and more than 50% of grids were 1 ha or smaller (Figure 1).

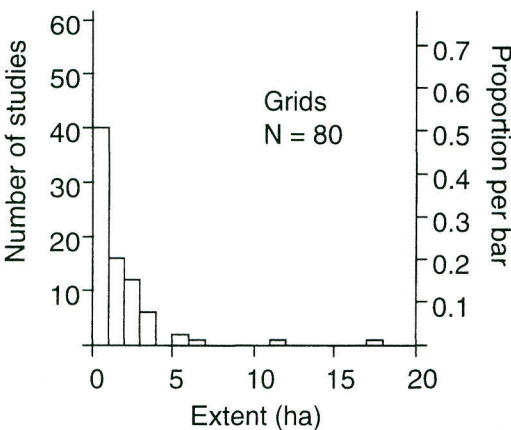
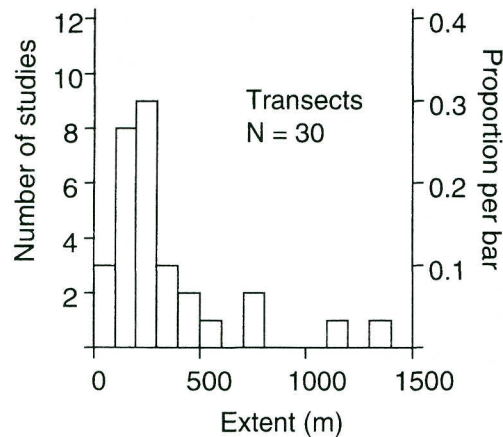
Although the mean trap spacing was 14 m, the distribution of spacings was bimodal, with peaks at 10 and 15 m (Figure 2; Table 1). The convention of using 10- or 15-m trap spacing seems to be based in part on papers by Burt (1940), Calhoun (1948), Kikkawa (1964) and Smith et al. (1975). Calhoun (1948) presented a standardized protocol for the "North American Census of Small Mammals", which used trap stations spaced 20, 50, or 100 ft apart. Note that 50 ft is approximately 15 m. Kikkawa (1964) suggested a 10-m spacing in a deciduous woodland, while Smith et al. (1975) indicated that 15 m is a good

TABLE 1. Descriptive statistics of small-mammal trapping designs published between 1960 and 1998 in five journals*.

Variable	N	Mean	Median	SE	Min	Max
Trap spacing (m)	114	14	15	0.6	2	45
Extent (grid; ha)	80	1.8	1.0	0.3	< 0.1	18
Extent (transect; m)	30	358	294	55.3	16	1309
Number of replicates	116	24	6	4.6	1	429
Length of trapping period (# nights)	68	4	3	0.3	2	14
Length of prebait period (# nights)	121	0.1	0.0	< 0.1	0	5
Total trap nights	112	11238	5346	1403	154	90000

*Field studies of *Peromyscus maniculatus* and/or *Clethrionomys gapperi* published in *American Midland Naturalist*, *Canadian Field-Naturalist*, *Canadian Journal of Zoology*, *Ecology*, or *Journal of Mammalogy*.

compromise distance for studying a range of species. However, we agree with Tew et al. (1994) that there should be no a priori standard distance between traps.



The selection of a trap spacing should be based on the question of interest and on the site-specific biology of the study species. For example, a spacing might be selected so that each individual has a trap within its home range. This is balanced against the extent of the trapping design and the number of traps logistically feasible. In practice, the extent of the trapping unit (grid or transect) and the spacing of traps are chosen as a compromise between wanting a large area covered in traps and wanting adequate coverage of that area. For example, Tew et al. (1994) demonstrated that a 10-ha grid with a 24-m spacing was an efficient way to sample a low density, widely dispersed Wood Mouse (*Apodemus sylvaticus*) population.

We were surprised at how rarely prebaiting has been practised by small-mammal researchers. Only 7 of 127 studies indicated that traps were prebaited. Other authors either did not mention prebaiting or specifically indicated that it did not take place.

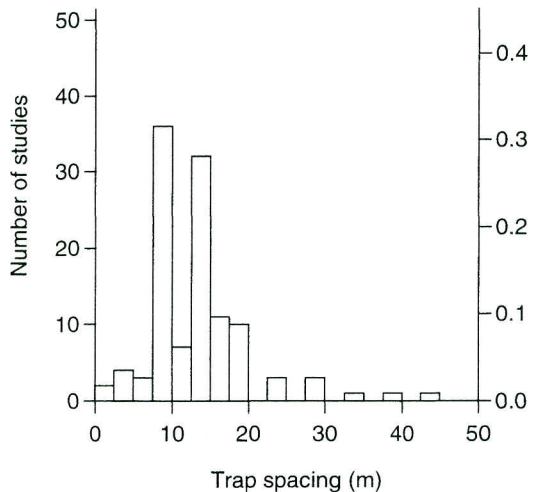


Figure 1. Spatial extent of trapping arrays used in studies of *Clethrionomys gapperi* and/or *Peromyscus maniculatus* published in five journals (*American Midland Naturalist*, *Canadian Field-Naturalist*, *Canadian Journal of Zoology*, *Ecology*, and *Journal of Mammalogy*) between 1960 and 1998.

Figure 2. Trap spacing used in studies of *Clethrionomys gapperi* and/or *Peromyscus maniculatus* published in five journals (*American Midland Naturalist*, *Canadian Field-Naturalist*, *Canadian Journal of Zoology*, *Ecology*, and *Journal of Mammalogy*) between 1960 and 1998.

Chitty and Kempson (1949) suggested that prebaiting could be an important method for avoiding the "new object reaction" by rodents. Though there is limited evidence that more animals can be captured during a given trapping period by employing this technique (Chitty and Kempson 1949) it seems that prebaiting is not widely used, or at least not widely reported, in small-mammal studies.

Our survey revealed that between 1960 and 1998 most empirical studies of *C. gapperi* or *P. maniculatus* used similar, small-scale designs. Trapping grids were mostly < 2 ha in extent (or transects < 500 m), and traps were spaced 10- or 15-m apart. Replicate trapping grids often were used (mean number of replicates = 24.0; median = 6; Table 1). These replicates usually were considered to be spatially independent and were used to generate variance estimates. It is apparent that few of the studies in our review have been designed to address questions about large-scale spatial processes. There is, however, a need for such questions since we cannot assume that population processes are restricted to small areas.

This last point has been empirically demonstrated in recent years, by the few studies that have been designed to look at large-scale spatial processes in small-mammal populations. For example, Morris (1992) and Knight and Morris (1996) have used the spatially-explicit juxtaposition of small, replicate trapping grids to measure density-dependent habitat selection. This approach is different from many others in that the replicate grids are not considered as independent samples. Rather, their juxtaposition in space is used to measure spatial processes. Bowman et al. (2001a,b) also used explicitly juxtaposed replicates. They have demonstrated dynamic temporal and spatial structure in *Clethrionomys* and *Peromyscus* populations over a spatial scale that corresponds to dispersal distance and they have hypothesized that winter extinctions and spring recolonizations play an important role in the spatial dynamics of these populations. Finally, a number of authors have used very large, spatially-explicit grid or transect designs to measure regional synchrony in small-mammal population dynamics (e.g., Steen et al. 1996; Bjornstad et al. 1999; Mackinnon et al. 2001).

A common feature of these recent studies is that they use sampling designs that measure space over relatively large areas as a surrogate for spatial population processes. This is either done by using a systematic design that controls the distance between replicates (e.g., Morris 1992) or by varying the spatial extent of environmental samples taken around replicates (e.g., calculating landscape metrics over buffers of varying radii; Bowman et al. 2001c). A major challenge currently facing small-mammal ecologists is to link these relatively large-scale processes with the kind of well-studied, local popula-

tion dynamics that have long been sampled using the traditional methods described in our literature review.

Acknowledgments

The authors acknowledge the Sustainable Forest Management Network (SFMN) for financial support. JB and GF received additional funding from Fraser Papers Inc., and the Sir James Dunn Wildlife Research Centre. JB received scholarship funding from NSERC and the University of New Brunswick, and CC received support from the University of Alberta. John Bissonette, Tony Diamond, Tim Dilworth, Doug Morris, Roger Powell, Marc-André Villard, and two anonymous reviewers commented on the manuscript and Jan Murie gave some welcome assistance with the literature search.

Literature Cited

- Bjornstad, O. N., N. C. Stenseth, and T. Saitoh.** 1999. Synchrony and scaling of mice in northern Japan. *Ecology* 80: 622–637.
- Bowman, J., G. J. Forbes, and T. G. Dilworth.** 2001a. The spatial component of variation in small-mammal abundance measured at three scales. *Canadian Journal of Zoology* 79: 137–144.
- Bowman, J., G. J. Forbes, and T. G. Dilworth.** 2001b. Spatial and temporal patterns of an irrupting population of deer mice. *Journal of Mammalogy* 82: 567–572.
- Bowman, J., G. J. Forbes, and T. G. Dilworth.** 2001c. Landscape context and small-mammal abundance in a managed forest. *Forest Ecology and Management* 140: 249–255.
- Brown, J. H., and J. Roughgarden.** 1990. Ecology for a changing Earth. *Bulletin of the Ecological Society of America* 71: 173–188.
- Burt, W. H.** 1940. Territorial behavior and populations of some small mammals in southern Michigan. *Miscellaneous Publications of the Museum of Zoology, University of Michigan* Number 45.
- Calhoun, J. B.** 1948. North American Census of Small Mammals. Release No. 1, Announcement of Program. Rodent Ecology Project, John Hopkins University, Baltimore, Maryland.
- Chitty, D. A., and D. A. Kempson.** 1949. Prebaiting small mammals and a new design of live trap. *Ecology* 30: 536–542.
- Kareiva, P. M., and M. Anderson.** 1989. Spatial aspects of species interactions: the wedding of models and experiments. Pages 35–50 in *Community ecology. Lecture notes in biomathematics 77*. Edited by A. S. Hastings. Springer, Berlin.
- Kikkawa, J.** 1964. Movement, activity and distribution of the small rodents *Clethrionomys glareolus* and *Apodemus sylvaticus*. *Journal of Animal Ecology* 33: 259–299.
- Knight, T. W., and D. W. Morris.** 1996. How many habitats do landscapes contain? *Ecology* 77: 1756–1764.
- Mackinnon, J. L., S. J. Petty, D. A. Elston, C. J. Thomas, T. N. Sherratt, and X. Lambin.** 2001. Scale invariant spatio-temporal patterns of field vole density. *Journal of Animal Ecology* 70: 101–111.

- Morris, D. W.** 1992. Scales and costs of habitat selection in heterogeneous landscapes. *Evolutionary Ecology* 6: 412–432.
- Morris, D. W.** 1996. Coexistence of specialist and generalist rodents via habitat selection. *Ecology* 77: 2352–2364.
- Smith, M. H., R. H. Gardner, J. B. Gentry, D. W. Kaufman, and M. H. O'Farrell.** 1975. Density estimations of small mammal populations. Pages 25–33 in *Small mammals: their productivity and population dynamics*. Edited by F. B. Golley, K. Petruszewicz, and L. Ryszkowski. Cambridge University Press, London.
- Steen, H., R. A. Ims, and G. A. Sonerud.** 1996. Spatial and temporal patterns of small-rodent population dynamics at a regional scale. *Ecology* 77: 2365–2372.
- Tew, T. E., I. A. Todd, and D. W. MacDonald.** 1994. The effects of trap spacing on population estimates of small mammals. *Journal of Zoology, London* 233: 340–344.
- Wegner, J., and H. G. Merriam.** 1990. The use of spatial elements in a farmland mosaic by a woodland rodent. *Biological Conservation* 54: 263–276.
- Wiens, J. A., N. C. Stenseth, B. Van Horne, and R. A. Ims.** 1993. Ecological mechanisms and landscape ecology. *Oikos* 66: 369–380.

Received 19 March 2000

Accepted 21 August 2001