AN ABSTRACT OF THE THESIS OF

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Signature redacted for privacy.

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Habitat availability and use by an urban population of opossums were studied with radio telemetry in Corvallis, Oregon in 1981 and 1982. For non-den observations, residential neighborhood types were used about in the proportion available, agricultural/park/riverfront neighborhood types were used in higher proportion than available, and commercial/industrial neighborhood types were used in lower proportion than available. Surface types were also used in proportions different than available within home ranges. Structures and paved surfaces were used less than available, while unpaved surfaces were used in greater proportion than available. Dens were primarily located in man-made structures (76%) and in residential neighborhood types (79%). Unpaved surfaces accounted for 24% of dens, and no dens were found on paved surfaces. Home ranges were more stable and smaller than those reported in rural environments (means; male = 32.36 ha, female = 9.01 ha). Distances moved per night were also shorter than previously reported. Year-round availability of food, abundant den sites, and relative freedom from competitors and predators were proposed as reasons for the stable, small home ranges and success of opossums in an urban habitat.

# Habitat Use by Opossums in an Urban Environment

by

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# HABITAT USE BY OPOSSUMS IN AN URBAN ENVIRONMENT

## INTRODUCTION

Wildlife ecology has evolved from the study of game animals (Dasmann 1981), to a broader study of wildlife associated with human activities ranging from hunting to photography. Since the 1960's interest in studying and managing urban wildlife has grown (Davey 1967, Leedy et al. 1978, Stearns 1967, Thomas and DeGraaf 1973). As cities expand, decreasing wildlife habitat is paralleled by decreasing access of urban dwellers to natural or wilderness areas (Tucker 1968, Washington 1978). In spite of this, people often have favorable attitudes toward urban wildlife (Szot 1975) and may have a psychological need for contact with nature (Gill and Bonnett 1973, Stainbrook 1968). Cities supporting wildlife may be of higher quality for humans as well (Davey 1967, Gill and Bonnett 1973, Leedy et al. 1978, Szot 1975). To manage urban wildlife for the benefit of animals and people, we must have information on the habitat availability and requirements of urban wildlife species.

### Previous Research

Most of the limited research on urban wildlife focused on pest species (Solman 1968, 1973). Studies emphasizing ecology of urban wildlife usually featured diurnal and highly visible birds, which are favorably regarded by the public (Szot 1975). Research on urban mammals was less common, perhaps because they are nocturnal and more difficult to study. Mammals studied included free-roaming dogs (Beck

1973), raccoons (Procyon lotor) (Chapman and Sherfy 1978, Hoffman and Gottschang 1977, Schinner 1969, Schinner and Cauley 1973), chipmunks (Tamias striatus) (Ryan 1974), coyotes (Canis latrans) (Gill 1965), and deer (Odocoileus hemionus columbianus) (Happe 1982). Urban mammals tended to exhibit higher population densities, smaller home ranges, and shorter movements than their rural counterparts. The authors attributed these characteristics to man's influence in creating an abundance of food and water sources, den sites, and lower natural mortality.

Gill and Bonnett (1973) hypothesized that animals best suited to the urban environment would be small, nocturnal, and capable of high productivity. The Virginia opossum (Didelphis virginiana) matches these attributes. The opossum was introduced to Oregon in the early 1900's (Jewett and Dobyns 1929) and has become well-established in both urban and rural habitats. Hopkins and Forbes (1979, 1980) and Hopkins (1980) investigated food habits, parasites, and reproductive status of urban opossums in Oregon using road-killed animals.

Opossums have been studied in wooded, riparian, and agricultural habitats in a variety of locations from Texas to Illinois (Lay 1942, Reynolds 1942, Sandidge 1953, Verts 1963, Wiseman and Hendrickson 1950). Their opportunistic, omnivorous feeding habits (Hopkins and Forbes 1980, Hunsaker 1977) and high reproductive rates (Hartman 1923, Reynolds 1942) contributed to their successful establishment in new habitats.

The objective of this study was to characterize the opossum's use of the urban environment through an analysis of movement patterns, home range characteristics, and habitat use.

## Study Area

The study was conducted within the city limits of Corvallis, Oregon (Benton County), population 41,000 (1980). Corvallis is largely residential with a university campus and clusters of commercial and industrial areas. Open or unbuilt areas include the Willamette River banks, parks, playgrounds, pastures and undeveloped wooded subdivisions. Topography is generally flat (elevation 62 m) with hills to the north and west rising to 152 m.

During the 12 months of the study, rain totaled 140 cm with an additional 14.7 cm of snow, and temperatures ranged from -4 to 38 C.

## MATERIALS AND METHODS

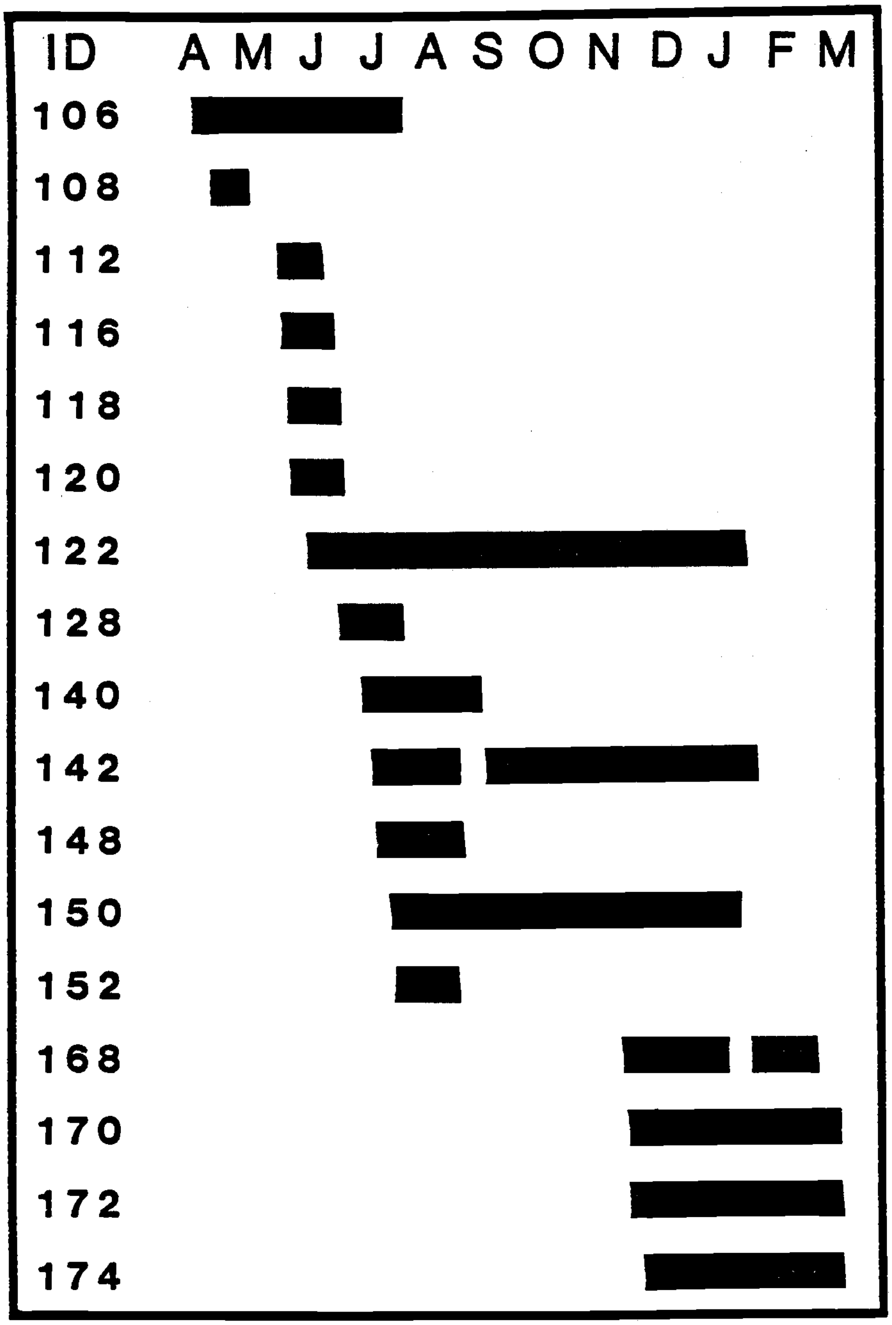
The study was conducted from April 1981 to March 1982. Opossums were livetrapped with 1 and 2 door live traps (23 x 23 x 58 or 81 cm, National Live Trap) baited with fruit or sardines. Traps were placed in locations where opossums had been recently sighted, or in promising habitat. An attempt was made to spatially distribute traps and radio-collared animals in representative sections of the city.

Trapped animals were sexed, weighed, and ear-tagged. A numbered, size 1 fingerling tag (National Band and Tag Co.) was placed in each ear. Radio transmitters on collars were attached to animals over 125 gms. Opossums were released at the capture site.

Opossums were trapped throughout the year as necessary to maintain 6 radio collared animals (Fig. 1). Radio tracking began an hour before dark and concluded after dawn. Every radio-collared animal was located in its den on the first (presunset) observation. Four more evenly spaced observations (after dark, middle of the night, before dawn, and after dawn) were taken on each of 6 opossums followed during a tracking period. Frequency of observations ranged from every 2 hours in mid-summer, to every 3.5 hours in mid-winter. Animal locations were determined by triangulation within 30-300 m of the animal. Visual confirmation was occasionally possible, but close proximity of the investigator affected opossum behavior, so continuous visual observations were not frequently attempted. Locations were noted to the nearest 5 m on a map (1 cm = 24m).

Figure 1. Schedule of radio-tracking of opossums in Corvallis, Oregon, 1981-82.

Figure 1.


ID
A M J J A S O N D J F M
106
108
112
116
118
120
122
128
140
142
148
150
152
168
170
172
174

Weather data were recorded at the time of each observation, and daily summaries were obtained from Hyslop Field (Oregon State Univ. Dept. of Atmospheric Science), located 11 km east of Corvallis. Every animal location was coded for neighborhood type and surface type.

An opossum's active period was defined as beginning when an animal left a den, and ending when the animal returned to a den. Because precise times were not recorded, time of leaving a den was established as the midpoint of the interval between the last observation in the den, and first observation out of the den. Time of returning to a den was similarly established. Active periods were averaged for each opossum every month.

Distance moved per night was an index of activity calculated by adding the straight line distance between successive locations of individual animals each night, beginning and ending at a den. Distances were averaged for each opossum every month.

Home ranges were determined by the minimum convex polygon method (Hayne 1949, Mohr 1947). The 100% home ranges included all observations of a single animal, and frequently encompassed large areas where no observations were recorded. In order to reduce these areas with low or no use, 95% home ranges were determined. The 95% home range encompassed a core area of intensive animal use (Harestad 1981) and eliminated unusual or infrequent observations on the edges of home ranges. Only points with less than or equal to 5% of observations were considered for removal, and points resulting in the greatest reduction in area were excluded in a step-wise manner (Appendix I).

When opossums were followed over more than one season, home range size was measured separately for each season. Seasons were defined as breeding and first litter (Feb-May), breeding and second litter (Jun-Sep), and a non-reproductive period (Oct-Jan). Precise seasonal dates for each animal were determined, when possible, on the basis of known reproductive status, or by extrapolation from shifts in home ranges. Animals which overlapped more than one season were assigned to the period in which they were followed for over 11 days, or separate seasonal home ranges were plotted. The 100% and 95% minimum convex polygon home range areas were compared between males and females, adults and juveniles, and between seasons with the nonparametric Wilcoxon Rank Sum or Signed-Rank tests (Steel and Torrie 1980).

Circular and elliptical home ranges were calculated in order to compare my estimates with previous studies of opossums in rural habitats. Longest distance between observations (Fitch and Sandidge 1953) was used as the diameter of the circular home range, and as the long axis of the ellipse. Length/width was used as an index of linearity of the home range (Verts 1963).

A den site was defined as a cluster of observations located in a discrete structure or area. For example, observations at different corners of a single building were considered a single den site. Den sites which received over 25% of all den use by a single animal were termed main dens. Shifts in home ranges were determined by discontinued use of a main den, concurrent with establishment of a new main den. Home range shifts were not necessarily to entirely new areas, thus determination of home range shifts was somewhat subjective.

Two levels of description were used to evaluate habitat availability and use by opossums. Seven neighborhood types within the study area were recognized on the basis of the City of Corvallis land development plan (1982): low, medium, and high density residential areas, commercial, industrial, riverfront, and agricultural/park areas. Three surface types were recognized: structures, paved, and unpaved. Structures were measured as the areas covered by buildings. Paved surface included streets, sidewalks, parking lots, and playgrounds. Unpaved surface included all area not included in the other categories, such as woods and pastures, vegetative landscaping, and median strips. Percent of neighborhood types available in the study area and within each opossum's home range was determined by overlaying a systematic dot grid (2.4 dots/cm) on the Corvallis land development plan (1cm = 72m, 1982). The dot grid was oriented to avoid paralleling linear map elements (such as streets). The number of dots falling in each neighborhood type were counted and converted to percentiles. Percent of surface types available within the home ranges was similarly sampled from a topographic map of Corvallis (1cm = 24m, dot grid = 5 dots/cm).

Percent neighborhood and surface types used by individual opossums were determined from the radio telemetry locations. Den and non-den locations were analyzed separately.

Use of neighborhood and surface types in proportion to their availability was tested with a Chi-square goodness of fit test (Steel and Torrie 1980). A habitat use index ($D_{hb}$) was calculated to determine relative preference of neighborhood and surface types within each animal's home range, and grouped over all animals. $D_{hb} = \frac{r-p}{r+p-2rp}$ (Jacobs 1974), where r was the proportion of observations in a neighborhood (or surface) type, and p was the proportion of that type available. $D_{hb}$ values from -1 to 0 indicated use in lower proportion than available, values from 0 to 1 indicated use in greater proportion than available.

# RESULTS

## Activity Patterns

Opossums were nocturnal. Animals left the den 2-3 hours after sunset and returned before dawn (Fig. 2). Length of active period increased as length of night increased, averaging 6 hours (range 3.00-8.75 hours) over the year. Opossums were usually active for a single period during the night, although occasionally an opossum would forage, return to a den for a few hours, and then move to another den before dawn.

Mean time of leaving the den appeared to follow the time of sunset in April through July. The remainder of the year, opossums left the den at a fairly uniform time (2100-2200) except in January. There were 10 nights in January with minimum temperatures $<$ 3 C when opossums did not leave the den. Inactivity on those nights may have been the reason opossums began foraging earlier than usual on subsequent nights.

On 28 nights that opossums did not leave their dens temperatures averaged 3 C (range -9.4 to 10.6 C). Over 1.3 cm of rain in 24 hours with temperatures below 7 C also resulted in no observed movement from dens.

Average distance moved by all opossums appeared to correlate with the minimum temperature ($r = 0.65$) (Fig. 3). April and May had small sample sizes and large standard deviations due to inclusion of opossums with longer than average movements (#'s 106, 108) (Appendix

Figure 2. Mean period of activity of opossums in Corvallis, Oregon, 1981-82.

Figure 2.

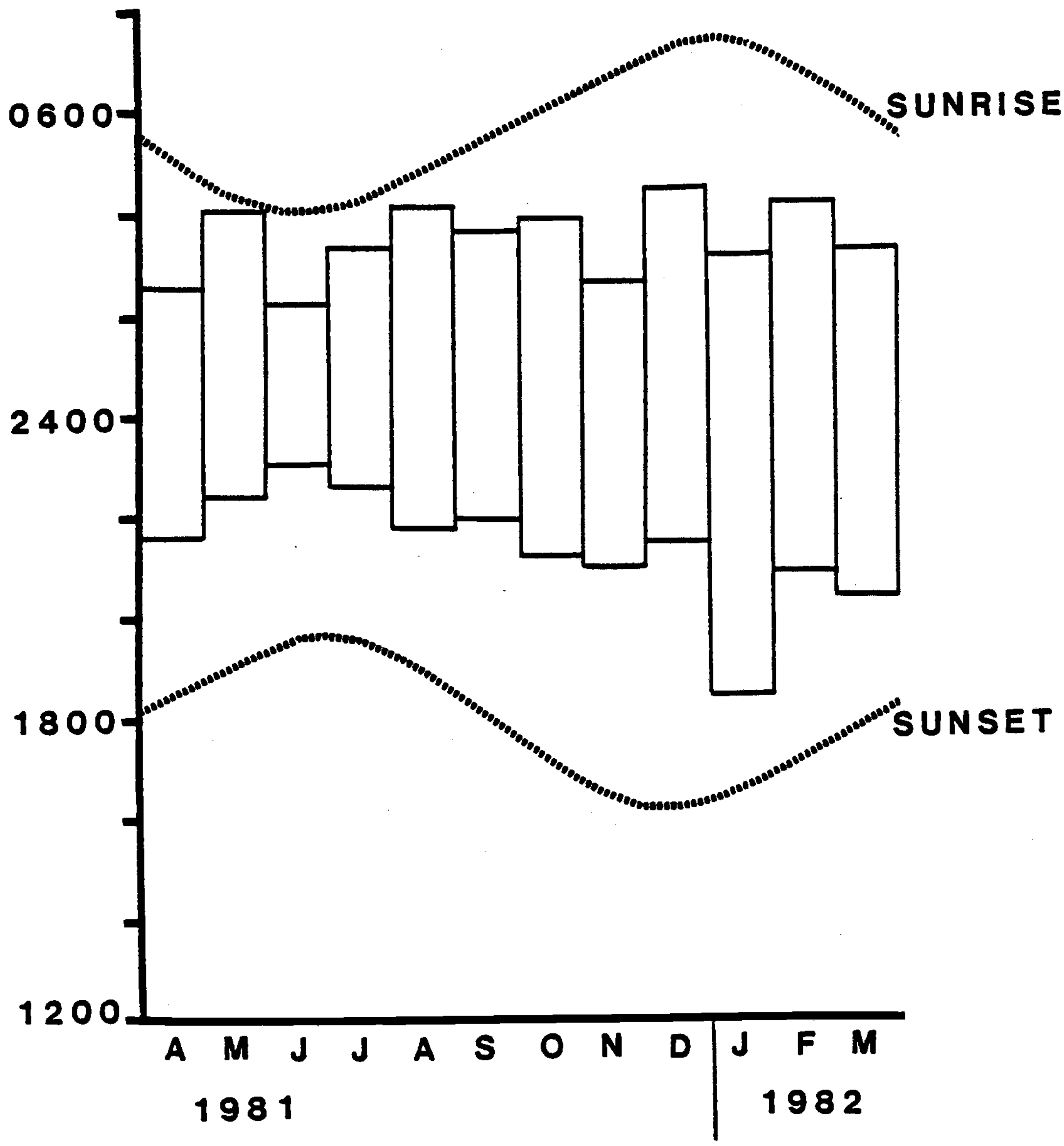
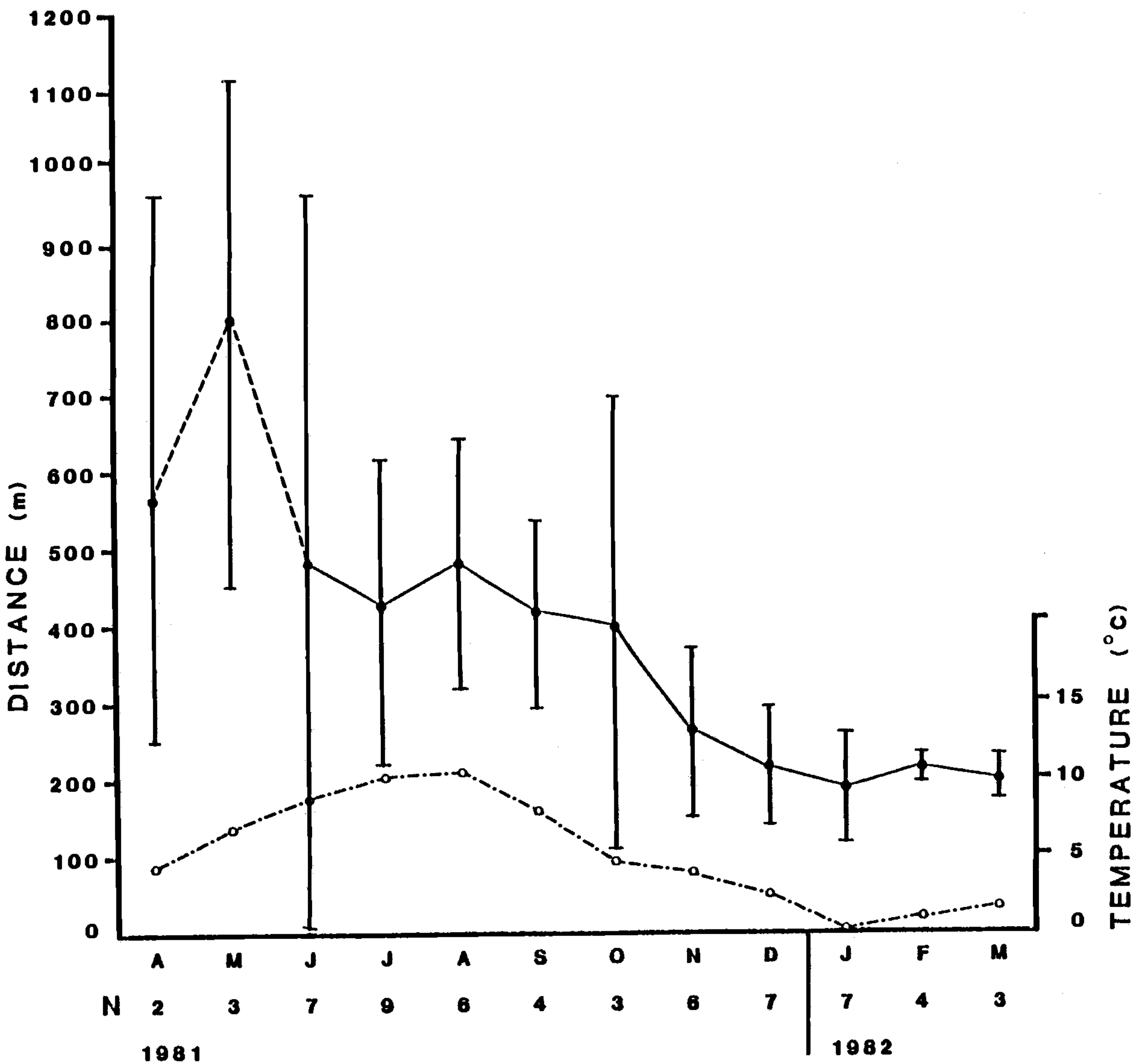


Figure 3. Average distance moved per night (solid line) by opossums, and average daily minimum temperature (dashed line) in Corvallis, Oregon, 1981-82.

Figure 3.



1200
1100
1000
900
800
700
600
500
400
300
200
100
0
DISTANCE (m)
15
10
5
0
TEMPERATURE (°C)
A
M
J
J
A
S
O
N
D
J
F
M
N
2
3
7
9
6
4
3
6
7
7
4
3
1981
1982

II). When these months were removed from the analysis r = 0.94, demonstrating a very close correlation of the activity index with minimum temperature. Precipitation, length of darkness, and date may have also affected the average distance moved, however these variables tend to be intercorrelated, and no attempt was made to sort out their individual effects.

Opossums moved longer distances in April through October than in November through March (Fig. 3). Average for all opossums was 420 m/night in July and 191 m/night in January. Longest distances moved in a single night were 2499 m by a male (#168) and 1591 m by a female (#106). Monthly averages of distance moved per night were not significantly different for males and females ($P > 0.10$) when compared with a Signed Rank test (Appendix II).

Home Range

Of 21 opossums equipped with radio transmitters, 17 were followed long enough to determine home ranges (Fig. 4). Because cumulative home range area of 2 males (#'s 142, 168) and 2 females (#'s 106, 122) leveled off at 11-31 days, or 40-113 observations a minimum of 11 nights or 52 total observations was considered necessary to determine home range (range 52-603, mean = 238 observations). Shifts in home range were clearly demonstrated by jumps in cumulative home range size from a low plateau to a higher one.

The 100% home ranges varied from 2.39 to 19.07 ha for females, and 2.97 to 102.87 ha for males, with a mean for all animals of 18.74 ha (Table 1). The 95% home ranges were 12 to 81% smaller than the 100%

Figure 4. Study area and 100% minimum convex polygon home ranges of 17 opossums in Corvallis, Oregon, 1981-82.

Figure 4.

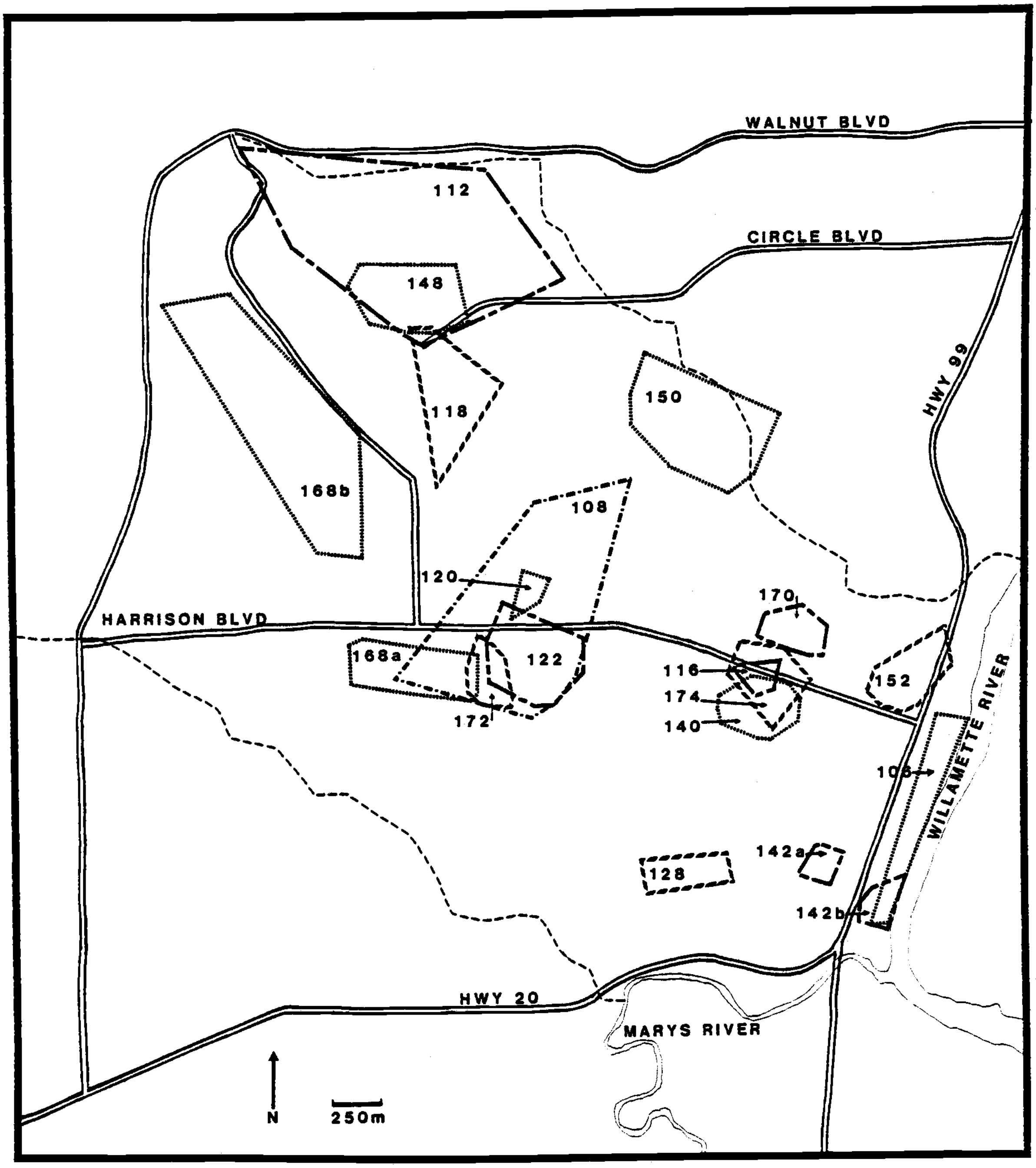

WALNUT BLVD
CIRCLE BLVD
HWY 99
HARRISON BLVD
HWY 20
MARYS RIVER
WILLAMETTE RIVER
112
148
118
168b
150
108
120
170
168a
122
116
174
140
172
152
106
142a
128
142b
N
250m

Table 1. Total and seasonal home range size (ha) of 17 opossums in Corvallis, Oregon, 1981-82. Seasonal home ranges in parentheses.

| Animal | Age | No. obs 100% | Home range (hectares) 100% | Home range (hectares) 95% | 100%-95% Percent Reduction | Dates |
|---|---|---|---|---|---|---|
| Female | | | | | | |
| 106 | Ad | 175 | 10.80 | 2.18 | 80 | 13 Apr - 2 Jun |
| | Ad | 180 | 11.17 | 3.70 | 67 | 3 Jun - 31 Jul |
| 116 | Ad | 87 | 2.62 | 0.68 | 74 | 30 May - 26 Jun |
| 118 | Juv | 52 | 19.07 | 11.38 | 40 | 3 Jun - 26 Jun |
| 120 | Ad | 167 | 2.39 | 0.76 | 68 | 4 Jun - 28 Jul |
| 122 | Ad | 603 | 18.21 | 8.92 | 51 | 10 Jun - 27 Jan |
| | (Ad | 320 | 12.56 | 7.15 | 43 | 10 Jun - 3 Oct) |
| | (Ad | 283 | 17.60 | 9.31 | 47 | 5 Oct - 27 Jan) |
| 128 | Ad | 105 | 5.57 | 4.56 | 18 | 27 Jun - 1 Aug |
| 140 | Ad | 187 | 9.36 | 8.28 | 12 | 9 Jul - 9 Sep |
| 148 | Ad | 126 | 15.73 | 8.63 | 45 | 16 Jul - 31 Aug |
| 170 | Ad | 302 | 6.29 | 3.62 | 42 | 24 Nov - 14 Mar |
| | (Ad | 177 | 4.10 | 2.51 | 39 | 24 Nov - 29 Jan) |
| | (Ad | 125 | 4.62 | 2.23 | 52 | 1 Feb - 14 Mar) |
| 172 | Juv | 302 | 6.11 | 4.15 | 32 | 25 Nov - 14 Mar |
| | (Juv | 163 | 5.42 | 2.87 | 47 | 25 Nov - 25 Jan) |
| | (Ad | 139 | 5.15 | 3.66 | 29 | 27 Jan - 14 Mar) |

Table 1. Continued

| Animal | Age | No. obs 100% | Home range (hectares) 100% | 95% | 100%-95% Percent Reduction | Dates |
|---|---|---|---|---|---|---|
| Male | | | | | | |
| 108 | Ad | 72 | 76.16 | 50.31 | 34 | 22 Apr - 10 May |
| 112 | Ad | 59 | 102.87 | 83.69 | 19 | 28 May - 19 Jun |
| 142a | Juv | 143 | 2.97 | 1.61 | 46 | 15 Jul - 30 Aug |
| 142b | Ad | 378 | 5.14 | 2.38 | 54 | 12 Sep - 2 Feb |
| 150 | Juv | 493 | 29.20 | 6.91 | 76 | 22 Jul - 23 Jan |
| | (Juv | 190 | 24.43 | 7.38 | 70 | 22 Jul - 28 Sep) |
| | (Ad | 303 | 15.82 | 3.06 | 81 | 29 Sep - 23 Jan) |
| 152 | Juv | 109 | 7.92 | 5.14 | 35 | 25 Jul - 28 Aug |
| 168a | Juv | 145 | 14.35 | 11.01 | 23 | 21 Nov - 16 Jan |
| 168b | Ad | 89 | 62.37 | 41.53 | 33 | 29 Jan - 2 Mar |
| 174 | Ad | 280 | 11.59 | 4.47 | 61 | 4 Dec - 14 Mar |
| Mean females[a] | | | 9.01 | 4.85 | 47.2 | |
| SD | | | 5.61 | 3.44 | 20.0 | |
| Mean males[b] | | | 32.36 | 21.06 | 45.6 | |
| SD | | | 35.10 | 28.02 | 20.5 | |
| Mean, all animals[c] | | | 18.74 | 11.60 | 46.5 | |
| SD | | | 25.26 | 19.51 | 19.8 | |

[a] n = 14

[b] n = 10

[c] n = 24

home ranges (mean reduction = 46.5%), and varied from 0.68 to 11.38 ha for females, and 1.61 to 83.69 ha for males, with the mean for all animals of 11.60 ha. There were no apparent differences in percent of reduction seen between different sexes or ages of opossums.

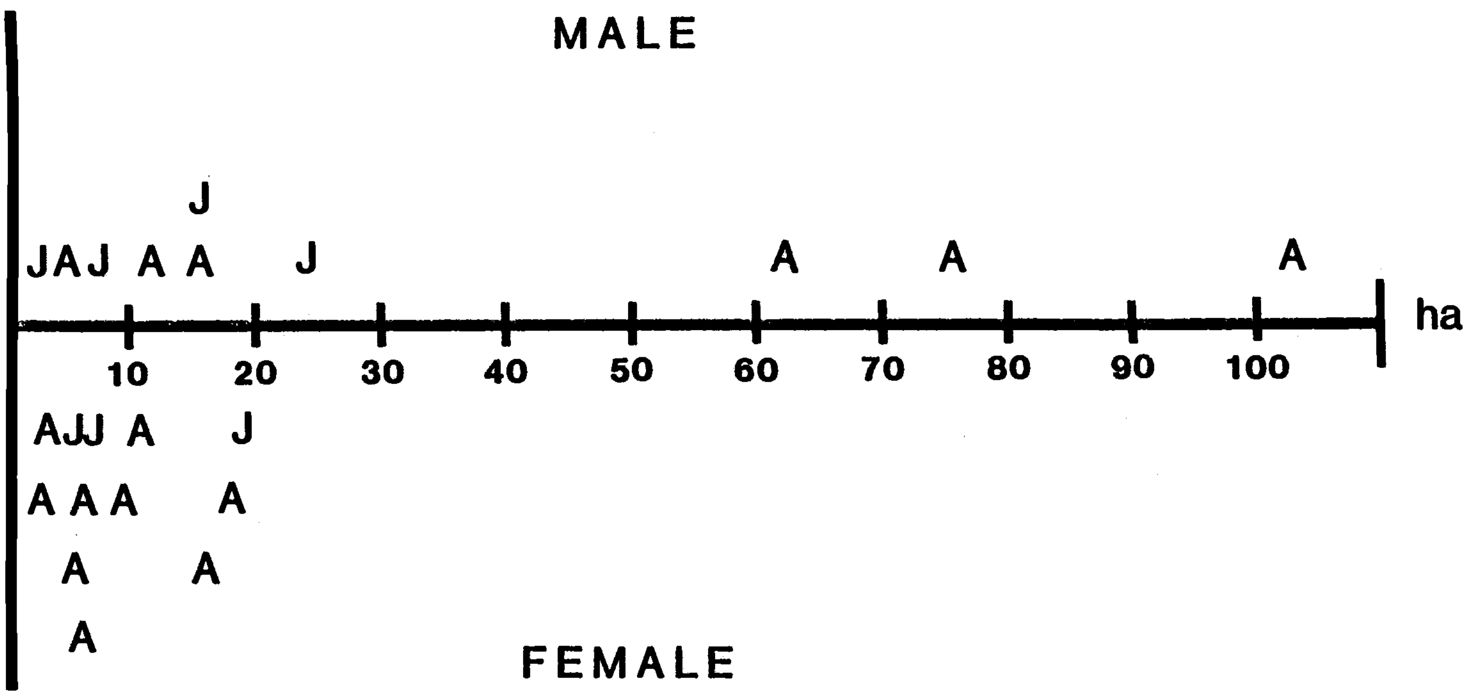
Although home range sizes of males and females overlapped, the larger home ranges consistantly belonged to males (Fig. 5). This apparent tendancy toward larger male home ranges was weakly supported ($P < 0.09$) by the Wilcoxon Rank Sum test in comparisons of male and female 100% minimum convex polygons. Differences between 95% home ranges were not statistically significant ($P > 0.10$) although the trend was still apparent in the data (Table 1).

Home range sizes of adult and juvenile females did not appear different (mean adult female = 4.5 ha; mean juvenile female = 7.1 ha) ($P > 0.10$) (Fig. 5, Appendix III). Although a few adult males had very large home ranges, juvenile male home ranges were similar to home ranges of the remaining adult males and to all females (Fig. 5, Appendix III).

Trends in seasonal changes in home range size were unclear. The largest male home ranges were seen during the first breeding period (Feb-May) (mean = 45.9 ha) but variation in home range size within reproductive and non-reproductive seasons was great (Appendix III). Differences in male home range size between seasons were not statistically significant in the Wilcoxon Rank Sum test ($P > 0.10$). Mean female home ranges were smallest in the first breeding period (Feb-May) (mean = 2.7 ha, SD = 0.8) but variability of size during the second breeding period (Jun-Sep) (mean = 5.6 ha, SD = 3.7) and in the

Figure 5. 100% minimum convex polygon home range size (ha) of opossums in Corvallis, Oregon, 1981-82. J = juvenile, A = adult.

Figure 5.


MALE
J
JAJ A A J A A A
ha
10 20 30 40 50 60 70 80 90 100
AJJ A J
A A A A
A A
A
FEMALE

non-reproductive period (Oct-Jan) (mean = 4.9, SD = 3.8) resulted in no apparent trends or statistical difference ($P > 0.10$) between female reproductive and non-reproductive periods.

Most study animals established well-defined, stable home ranges for several months, then shifted home ranges at times apparently coinciding with reproductive events. Several females shifted main dens at times appearing to coincide with birth or separation from a litter. A few animals used both home ranges, and old and new dens for a brief period. One female (#122) shifted main dens, probably in conjunction with bearing a litter, but stayed in the same home range. At the estimated time of separation from the second litter, she returned to the original den site.

Five males and 3 females gradually shifted home ranges using a den for a few days before moving on to a new one. Dens were used consecutively with some overlap. Such gradual extensions of home range boundaries made their shifts less obvious than most. Home range size for 3 of these males (#'s 108, 112, 168) was 4 to 7 times larger than the average male 100% home range.

Home range shifts by juveniles were considered dispersal movements, as they did not occur during the reproductive season, and were not extensions of the original home range. Two juvenile males (#'s 142, 168) shifted to new home ranges completely separate from their old ones. They were considered juvenile (not reproductively active) while in their first home range, and adult (potentially reproductively active) while in their second home range.

Mean 100% circular home range area was 55.20 ha (SD = 75.55) (Appendix IV). Circles calculated from 95% polygon widths averaged 32.81 ha (SD = 43.56). Mean elliptical home range area was 27.65 ha (SD = 34.57). The index of linearity on 100% polygon home ranges averaged 1.74 (range 1.1 - 3.9), indicating ranges were almost twice as long as wide (Appendix IV).

## Dens

Of all den observations, 79% were in residential neighborhood types, 15% were in agricultural/park or riverfront neighborhood types, and 5% were in commercial or industrial areas. The mean habitat use index ($D_{hb}$) of all opossums showed that use of residential neighborhood types was variable, commercial, industrial, and agricultural/park neighborhood types were used in lower proportion than available, while riverfront was used in higher proportion than available (Table 2). Similarly, 76% of den observations were in or under structures (slightly higher proportion than available), with 24% of den observations on unpaved surfaces (about the same proportion as available). No dens were associated with the paved surface type (Table 3).

Vegetative cover was present near all den sites. Dens in structures in residential neighborhoods included crawl spaces under houses and garages. One animal denned in an attic crawl space. A few dens were in buildings in non-residential neighborhoods. One animal (#142) frequently denned under a coffee roasting and warehouse facility. Another animal (#128) used a seed warehouse and processing

Table 2. Percentage of neighborhood types available and used by opossums for dens (within 100% minimum convex polygon home ranges) in Corvallis, Oregon, 1981-82.

| | Residential | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low Density | | | Medium Density | | | High Density | | | Commercial | | | Industrial | | | Agricultural/Park | | | Riverfront | | |
| Anim | Avail. | Used | $D_{hb}$ [a] | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ |
| 106 | | | | | | | | | | 51 | 0 | -1.00 | | | | | | | 49 | 100 | 1.00 |
| 108 | 52 | 38 | -0.28 | 25 | 0 | -1.00 | 23 | 62 | 0.69 | | | | | | | | | | | | |
| 112 | 92 | 96 | 0.35 | 7 | 0 | -1.00 | | | | | | | | | | 1 | 4 | 0.61 | | | |
| 116 | | | | 34 | 0 | -1.00 | 66 | 100 | 1.00 | | | | | | | | | | | | |
| 118 | 88 | 100 | 1.00 | 1 | 0 | -1.00 | | | | | | | | | | 11 | 0 | -1.00 | | | |
| 120 | 27 | 0 | -1.00 | 65 | 100 | 1.00 | 8 | 0 | -1.00 | | | | | | | | | | | | |
| 122 | 68 | 93 | 0.72 | 5 | 0 | -1.00 | 26 | 7 | -0.65 | | | | | | | | | | | | |
| 128 | | | | | | | 83 | 100 | 1.00 | | | | 17 | 0 | -1.00 | | | | | | |
| 140 | | | | 13 | 0 | -1.00 | 78 | 100 | 1.00 | 9 | 0 | -1.00 | | | | | | | | | |
| 142a | | | | 77 | 68 | -0.22 | | | | 13 | 32 | 0.52 | 10 | 0 | -1.00 | | | | | | |
| 142b | | | | | | | | | | 54 | 25 | -0.56 | | | | | | | 46 | 75 | 0.56 |
| 148 | 97 | 100 | 1.00 | | | | | | | | | | | | | 3 | 0 | -1.00 | | | |
| 150 | 55 | 2 | -0.97 | 38 | 4 | -0.87 | 6 | 93 | 0.99 | 1 | 0 | -1.00 | | | | | | | | | |
| 152 | | | | 7 | 0 | -1.00 | 15 | 0 | -1.00 | 78 | 100 | 1.00 | | | | | | | | | |
| 168a | 64 | 57 | -0.15 | | | | 21 | 43 | 0.48 | | | | | | | 15 | 0 | -1.00 | | | |
| 168b | 27 | 62 | 0.63 | | | | 29 | 21 | -0.21 | | | | | | | 45 | 17 | -0.60 | | | |
| 170 | | | | 100 | 100 | 0.00 | | | | | | | | | | | | | | | |
| 172 | 92 | 40 | -0.89 | 8 | 60 | 0.89 | | | | | | | | | | | | | | | |
| 174 | | | | 57 | 0 | -1.00 | 35 | 100 | 1.00 | 8 | 0 | -1.00 | | | | | | | | | |
| Mean | | | 0.04 | | | -0.55 | | | 0.30 | | | -0.43 | | | -1.00 | | | -0.60 | | | 0.78 |
| SD | | | 0.81 | | | 0.74 | | | 0.85 | | | 0.84 | | | 0.00 | | | 0.70 | | | 0.31 |

[a] $D_{hb}$ = index of habitat use, explained in text. 0 = used in proportion available, + (-) used in higher (lower) proportion than available.

Table 3. Percentages of surface types available and used for den sites in opossum home ranges (100% minimum convex polygon) in Corvallis, Oregon, 1981-82.

| | Unpaved | | | Structures | | | Paved[a] |
|---|---|---|---|---|---|---|---|
| Animal | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | $D_{hb}$ |
| 106 | 22 | 100 | 1.00 | 37 | 0 | -1.00 | |
| 108 | 18 | 78 | 0.88 | 52 | 22 | -0.59 | |
| 112 | 10 | 86 | 0.97 | 74 | 14 | -0.89 | |
| 116 | 20 | 0 | -1.00 | 49 | 100 | 1.00 | |
| 118 | 12 | 100 | 1.00 | 71 | 0 | -1.00 | |
| 120 | 20 | 0 | -1.00 | 52 | 100 | 1.00 | |
| 122 | 19 | 6 | -0.57 | 53 | 94 | 0.87 | |
| 128 | 24 | 48 | 0.49 | 45 | 52 | 0.14 | |
| 140 | 23 | 0 | -1.00 | 41 | 100 | 1.00 | |
| 142a | 24 | 16 | -0.25 | 39 | 84 | 0.78 | |
| 142b | 25 | 60 | 0.64 | 39 | 40 | 0.02 | |
| 148 | 11 | 54 | 0.81 | 69 | 46 | -0.45 | |
| 150 | 12 | 4 | -0.53 | 67 | 96 | 0.84 | |
| 152 | 17 | 20 | 0.10 | 50 | 80 | 0.60 | |
| 168a | 15 | 3 | -0.70 | 68 | 97 | 0.88 | |
| 168b | 6 | 17 | 0.52 | 85 | 83 | -0.07 | |
| 170 | 21 | 0 | -1.00 | 51 | 100 | 1.00 | |
| 172 | 18 | 0 | -1.00 | 59 | 100 | 1.00 | |
| 174 | 21 | 0 | -1.00 | 47 | 100 | 1.00 | |
| Mean | | | -0.09 | | | 0.32 | -1.00 |
| SD | | | 0.83 | | | 0.77 | 0.00 |

[a] Availability of paved surface was 100 - (unpaved + structures). There was no use of paved surface for dens recorded for any animal.

plant. Both warehouses may have provided some food resources as well as den sites.

Dens on unpaved surfaces in residential areas included bushes or dense cover along the side of buildings, and wood piles or other collections of miscellaneous items in back yards. Dens in undeveloped neighborhood types were located in the Willamette River bank, along undeveloped sections of Dixon Creek, and in brush piles in wooded park areas.

Human activity near den sites varied. Dens in undeveloped areas had much lower levels of human activity nearby than those in residential or commercial areas. Human activity decreased at night in all locations, and although people could often approach within a few meters, den entrances were usually inaccessible to humans.

Most opossums used more than one den site (range 1-15), and concentrated denning activity in 4 or 5 main den sites. Over 50% of den use was accounted for by 1.7 dens for females, and 2.7 dens for males (mean = 2.3 dens) (Appendix V). Females used an average of 4.5 dens and males used 7 dens (mean of all animals = 5.9 dens) to account for over 90% of all den use. Males shifted dens more frequently than females and used dens for shorter periods. Some animals used dens sequentially, others used a variety of dens, but returned intermittently to main dens. The longest consecutive use of a den site was by a female (#120) for 46 days.

Few instances of den sharing were observed. On 8 occasions over a 2-week period in November to December, 2 radio-collared opossums shared a den. The animals were a juvenile male (#168) and juvenile female (#172), and were probably litter mates. Initial home ranges overlapped, but after 2 months the male shifted to an area completely separate from the female.

## Habitat Availability and Use

Habitat availability was similar in 100% and 95% home ranges (Tables 4 and 5). Mean differences of proportions of neighborhood types available indicated a small drop in proportion of commercial/industrial types, and small increases in proportions of residential and agricultural/park/riverfront types available in 95% home ranges. Similarly, mean differences showed a small increase in proportion of unpaved surfaces and a drop in proportion of structures and paved surfaces in 95% home ranges. However, these differences were very small, and the Wilcoxon Signed-Rank test showed no significant differences ($P > 0.10$) between habitat availability in the 100% and 95% home ranges.

Opossums included neighborhood types in their 100% home ranges in proportions different than the availability of types in the study area ($\chi^2 = 556$, df = 7, $P < 0.01$) (Table 6). The habitat use index ($D_{hb}$) showed low density residential neighborhoods and riverfront used in higher proportion than available; high density residential, commercial, and industrial neighborhoods used in lower proportion than available; medium density residential and agricultural/park neighborhoods used in about the same proportion as available.

Within individual 100% home ranges, opossums again used neighborhood types in different proportions than available for

Table 4. Percentage of neighborhood types available in 100% and 95% home ranges of opossums in Corvallis, Oregon, 1981-82.

| Anim | Residential | | | Commercial/ Industrial | | | Agricultural/Park Riverfront | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100% home range | 95% home range | 100% minus 95% | 100% home range | 95% home range | 100% minus 95% | 100% home range | 95% home range | 100% minus 95% |
| 106 | | | | 51.0 | 0.0 | 51.0 | 49.0 | 100.0 | -51.0 |
| 108 | 100.0 | 100.0 | 0.0 | | | | | | |
| 112 | 98.7 | 98.4 | 0.3 | | | | 1.3 | 1.6 | -0.3 |
| 116 | 100.0 | 100.0 | 0.0 | | | | | | |
| 118 | 88.9 | 100.0 | -11.1 | | | | 11.1 | 0.0 | 11.1 |
| 120 | 100.0 | 100.0 | 0.0 | | | | | | |
| 122 | 100.0 | 100.0 | 0.0 | | | | | | |
| 128 | 82.8 | 82.4 | 0.4 | 17.2 | 17.7 | -0.5 | | | |
| 140 | 90.9 | 90.0 | 0.9 | 9.1 | 10.0 | -0.9 | | | |
| 142a | 76.9 | 87.5 | -10.6 | 23.1 | 12.5 | 10.6 | | | |
| 142b | | | | 54.1 | 33.3 | 20.8 | 45.9 | 66.7 | -20.8 |
| 148 | 97.2 | 100.0 | -2.8 | | | | 2.8 | 0.0 | 2.8 |
| 150 | 98.8 | 100.0 | -0.2 | 1.2 | 0.0 | 1.2 | | | |
| 152 | 21.6 | 11.9 | 9.7 | 78.4 | 88.1 | -9.7 | | | |
| 168a | 85.4 | 89.7 | -4.3 | | | | 14.6 | 10.3 | 4.3 |
| 168b | 55.4 | 62.6 | -7.2 | | | | 44.6 | 37.4 | 7.2 |
| 170 | 100.0 | 100.0 | 0.0 | | | | | | |
| 172 | 100.0 | 100.0 | 0.0 | | | | | | |
| 174 | 92.3 | 89.4 | 2.9 | 7.7 | 10.6 | -2.9 | | | |
| Mean | 87.6 | 88.9 | -1.3 | 27.3 | 21.5 | 8.7 | 24.2 | 30.9 | -6.7 |
| SD | 20.7 | 22.2 | 4.9 | 28.4 | 28.9 | 19.4 | 21.4 | 39.4 | 22.1 |

Table 5. Percentage of surface types available in 100% and 95% home ranges of opossums in Corvallis, Oregon, 1981-82.

| | Structures | | | Paved | | | Unpaved | | |
|---|---|---|---|---|---|---|---|---|---|
| Anim | 100% home range | 95% home range | 100% minus 95% | 100% home range | 95% home range | 100% minus 95% | 100% home range | 95% home range | 100% minus 95% |
| 106 | 21.9 | 1.8 | 20.1 | 41.1 | 33.2 | 7.9 | 37.0 | 65.1 | -28.1 |
| 108 | 18.1 | 17.0 | 1.1 | 30.0 | 23.4 | 6.6 | 51.9 | 59.7 | -7.8 |
| 112 | 9.9 | 10.7 | -0.8 | 16.4 | 16.5 | -0.1 | 73.8 | 72.8 | 1.0 |
| 116 | 19.8 | 18.4 | 1.4 | 31.5 | 15.8 | 15.7 | 48.8 | 65.8 | -17.0 |
| 118 | 12.3 | 10.3 | 2.0 | 17.0 | 15.4 | 1.6 | 70.7 | 74.3 | -3.6 |
| 120 | 20.2 | 23.3 | -3.1 | 27.6 | 19.6 | 8.0 | 52.2 | 57.1 | -4.9 |
| 122 | 19.1 | 16.9 | 2.2 | 28.5 | 23.6 | 4.9 | 52.4 | 59.5 | -7.1 |
| 128 | 24.4 | 20.8 | 3.6 | 31.4 | 26.0 | 5.4 | 44.2 | 53.3 | -9.1 |
| 140 | 23.2 | 22.0 | 1.2 | 35.8 | 31.2 | 4.6 | 41.0 | 46.9 | -5.9 |
| 142a | 24.2 | 20.4 | 3.8 | 37.4 | 28.9 | 8.5 | 38.5 | 50.8 | -12.3 |
| 142b | 25.3 | 17.0 | 8.3 | 35.9 | 44.1 | -8.2 | 38.8 | 38.8 | 0.0 |
| 148 | 11.2 | 10.2 | 1.0 | 19.7 | 19.0 | 0.7 | 69.1 | 70.9 | -1.8 |
| 150 | 12.1 | 14.2 | -2.1 | 20.5 | 38.8 | -18.3 | 67.4 | 46.9 | 20.5 |
| 152 | 16.8 | 16.6 | 0.2 | 33.3 | 31.7 | 1.6 | 49.9 | 51.8 | -1.9 |
| 168a | 14.7 | 17.0 | -2.3 | 17.1 | 22.8 | -5.7 | 68.2 | 60.2 | 8.0 |
| 168b | 7.8 | 7.3 | 0.5 | 11.1 | 10.1 | 1.0 | 81.1 | 82.6 | -1.5 |
| 170 | 20.7 | 22.0 | -1.3 | 26.6 | 31.2 | -4.6 | 52.7 | 46.9 | 5.9 |
| 172 | 17.6 | 13.5 | 4.1 | 22.9 | 20.5 | 2.4 | 59.5 | 66.1 | -6.6 |
| 174 | 21.5 | 22.2 | -0.7 | 32.1 | 29.7 | 2.4 | 46.4 | 48.1 | -1.7 |
| Mean | 17.9 | 15.3 | 2.1 | 27.2 | 25.3 | 1.8 | 54.9 | 58.8 | -3.9 |
| SD | 5.3 | 6.7 | 5.1 | 8.4 | 8.6 | 7.4 | 13.3 | 11.5 | 10.0 |

Table 6. Percentages of neighborhood types available within the study area, and used by opossums in 17 combined home ranges (100% minimum convex polygon) in Corvallis, Oregon, 1981-82.

| Neighborhood type | Available in study area N | Available in study area % | Used in all home ranges N | Used in all home ranges % | $D_{hb}$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|---|
| Residential | | | | | | |
| low density | 6370 | 40.63 | 2160 | 54.85 | 0.279 | 196.00 |
| medium density | 2060 | 13.14 | 582 | 14.78 | 0.068 | 8.05 |
| high density | 3164 | 20.18 | 548 | 13.92 | -0.220 | 76.58 |
| Commercial | 2380 | 15.18 | 236 | 5.99 | -0.475 | 218.92 |
| Industrial | 205 | 1.31 | 15 | 0.38 | -0.554 | 25.95 |
| Agricultural/Park | 1206 | 7.69 | 277 | 7.03 | -0.048 | 2.20 |
| Riverfront | 295 | 1.88 | 120 | 3.05 | 0.243 | 28.55 |
| Total | 15,680 | | 3,938 | | | 556.25 |

non-denning activities (Table 7). Mean $D_{hb}$ values showed that residential neighborhood types were used about in the proportion available, commercial/industrial types were used in lower proportion than available, and agricultural/park/riverfront types were used in higher proportion than available.

When use of neighborhood types for non-denning activities was analyzed at a finer resolution, relative preference of types was less clear (Table 8). While commercial and industrial types were used in lower proportion than available, and agricultural/park and riverfront types were used in higher proportion than available, relative preference of the 3 residential neighborhood types varied. Standard deviation of use of all types was high. Contributions to this variation probably came from several sources. Because not all opossums had all 7 neighborhood types available in their home ranges, relative preference was partially a function of which types were available. Additional variation may have been caused by opossum's inability to distinguish zoning characteristics established by city administrators. Also, opossums may have been focusing on variables not recognized in this classification scheme.

All but 3 animals showed use of surface types for non-denning activities in proportions significantly different than available within individual 100% home ranges ($P < 0.05$) (Table 9). Although not statistically significant, these 3 animals followed the trends seen in the mean $D_{hb}$, where structures and paved surfaces were used in lower proportion than available, and unpaved surfaces were used in higher proportion than available.

Table 7. Percentages of neighborhood types available and used within opossum home ranges (100% minimum convex polygon) in Corvallis, Oregon, 1981-82. Den sites excluded.

| | Residential | | | Commercial/Industrial | | | Agricultural/ Park/Riverfront | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Anim | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | $\chi^2$ |
| 106 | | | | 51.0 | 8.6 | -0.834 | 49.0 | 91.4 | 0.834 | 41.70** |
| 108 | 100.0 | 100.0 | 0.000 | | | | | | | |
| 112 | 98.7 | 83.3 | -0.875 | | | | 1.3 | 16.7 | 0.875 | 33.79** |
| 116 | 100.0 | 100.0 | 0.000 | | | | | | | |
| 118 | 88.9 | 83.3 | -0.233 | | | | 11.1 | 16.7 | 0.233 | 0.38 |
| 120 | 100.0 | 100.0 | 0.000 | | | | | | | |
| 122 | 100.0 | 100.0 | 0.000 | | | | | | | |
| 128 | 82.8 | 93.1 | 0.474 | 17.2 | 6.9 | -0.474 | | | | 2.16 |
| 140 | 90.9 | 100.0 | 1.000 | 9.1 | 0.0 | -1.000 | | | | 3.70* |
| 142a | 76.9 | 94.1 | 0.655 | 23.1 | 5.9 | -0.655 | | | | 5.67* |
| 142b | | | | 54.1 | 70.0 | 0.329 | 45.9 | 30.0 | -0.329 | 3.05 |
| 148 | 97.2 | 83.3 | -0.752 | | | | 2.8 | 16.7 | 0.752 | 17.27** |
| 150 | 98.8 | 100.0 | 1.000 | 1.2 | 0.0 | -1.000 | | | | 0.89 |
| 152 | 21.6 | 14.8 | -0.225 | 78.4 | 85.2 | 0.225 | | | | 0.73 |
| 168a | 85.4 | 70.0 | -0.431 | | | | 14.6 | 30.0 | 0.431 | 7.61** |
| 168b | 55.4 | 22.2 | -0.626 | | | | 44.6 | 77.8 | 0.626 | 7.86** |
| 170 | 100.0 | 100.0 | 0.000 | | | | | | | |
| 172 | 100.0 | 100.0 | 0.000 | | | | | | | |
| 174 | 92.3 | 100.0 | 1.000 | 7.7 | 0.0 | -1.000 | | | | 11.68** |
| Mean | | | 0.058 | | | -0.551 | | | 0.531 | |
| SD | | | 0.575 | | | 0.545 | | | 0.451 | |

* $P < 0.05$, ** $P < 0.01$

Table 8. Percentage of neighborhood types available and used within opossum home ranges (100% minimum convex polygon) in Corvallis, Oregon, 1981-82. Den sites excluded.

| | Residential | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low Density | | | Medium Density | | | High Density | | | Commercial | | | Industrial | | | Agricultural/Park | | | Riverfront | | |
| Anim | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ |
| 106 | | | | | | | | | | 51 | 8.6 | -0.834 | | | | | | | 49 | 91.4 | 0.834 |
| 108 | 52 | 50.0 | -0.040 | 25 | 16.7 | -0.250 | 23 | 33.3 | 0.252 | | | | | | | | | | | | |
| 112 | 92 | 83.0 | -0.404 | 7 | 0.0 | -1.000 | | | | | | | | | | 1 | 17.0 | 0.906 | | | |
| 116 | | | | 34 | 0.0 | -1.000 | 66 | 100.0 | 1.000 | | | | | | | | | | | | |
| 118 | 88 | 75.0 | -0.419 | 1 | 8.3 | 0.800 | | | | | | | | | | 11 | 16.7 | 0.236 | | | |
| 120 | 27 | 6.3 | -0.695 | 65 | 87.5 | -0.581 | 8 | 6.3 | -0.132 | | | | | | | | | | | | |
| 122 | 68 | 72.0 | 0.095 | 5 | 0.0 | -1.000 | 26 | 28.0 | 0.051 | | | | | | | | | | | | |
| 128 | | | | | | | 83 | 93.0 | 0.463 | | | | 17 | 7.0 | -0.463 | | | | | | |
| 140 | | | | 13 | 0.0 | -1.000 | 78 | 100.0 | 1.000 | 9 | 0.0 | -1.000 | | | | | | | | | |
| 142a | | | | 77 | 94.1 | 0.654 | | | | 13 | 5.9 | -0.410 | 10 | 0.0 | -1.000 | | | | | | |
| 142b | | | | | | | | | | 54 | 70.0 | 0.331 | | | | | | | 46 | 30.0 | -0.331 |
| 148 | 97 | 83.3 | -0.732 | | | | | | | | | | | | | 3 | 16.7 | 0.732 | | | |
| 150 | 55 | 26.0 | -0.553 | 38 | 52.1 | 0.278 | 6 | 21.9 | 0.630 | 1 | 0.0 | -1.000 | | | | | | | | | |
| 152 | | | | 7 | 0.0 | -1.000 | 15 | 14.8 | -0.008 | 78 | 85.2 | 0.237 | | | | | | | | | |
| 168a | 64 | 67.5 | 0.078 | | | | 21 | 2.5 | -0.824 | | | | | | | 15 | 30.0 | 0.417 | | | |
| 168b | 27 | 22.2 | -0.128 | | | | 29 | 0.0 | -1.000 | | | | | | | 45 | 77.8 | 0.621 | | | |
| 170 | | | | 100 | 100.0 | 0.000 | | | | | | | | | | | | | | | |
| 172 | 92 | 100.0 | 1.000 | 8 | 0.0 | -1.000 | | | | | | | | | | | | | | | |
| 174 | | | | 57 | 0.0 | -1.000 | 35 | 100.0 | 1.000 | 8 | 0.0 | -1.000 | | | | | | | | | |
| Mean | | | -0.180 | | | -0.380 | | | 0.221 | | | -0.525 | | | -0.731 | | | 0.582 | | | 0.252 |
| SD | | | 0.514 | | | 0.746 | | | 0.695 | | | 0.591 | | | 0.380 | | | 0.263 | | | 0.823 |

Table 9. Percentages of surface types available and used within opossum home ranges (100% minimum convex polygon) in Corvallis, Oregon, 1981-82. Den sites excluded.

| Anim | Structures | | | Paved | | | Unpaved | | | $\chi^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | Avail. | Used | $D_{hb}$ | |
| 106 | 22 | 1.72 | -0.883 | 41 | 6.90 | -0.807 | 37 | 91.38 | 0.895 | 73.65** |
| 108 | 18 | 0.00 | -1.000 | 30 | 6.25 | -0.731 | 52 | 93.75 | 0.866 | 11.32** |
| 112 | 10 | 0.00 | -1.000 | 16 | 5.56 | -0.528 | 74 | 94.44 | 0.713 | 22.46** |
| 116 | 20 | 47.00 | 0.565 | 32 | 0.00 | -1.000 | 49 | 53.00 | 0.084 | 9.33** |
| 118 | 12 | 0.00 | -1.000 | 17 | 0.00 | -1.000 | 71 | 100.00 | 1.000 | 4.90 |
| 120 | 20 | 6.25 | -0.579 | 28 | 0.00 | -1.000 | 52 | 93.75 | 0.865 | 11.36** |
| 122 | 19 | 10.00 | -0.357 | 28 | 4.55 | -0.782 | 53 | 85.45 | 0.678 | 48.16** |
| 128 | 24 | 37.93 | 0.319 | 31 | 6.90 | -0.717 | 45 | 55.17 | 0.201 | 8.45* |
| 140 | 23 | 18.92 | -0.123 | 36 | 8.11 | -0.729 | 41 | 72.97 | 0.591 | 17.49** |
| 142a | 24 | 23.53 | -0.013 | 37 | 2.94 | -0.902 | 39 | 73.53 | 0.626 | 21.06** |
| 142b | 25 | 36.67 | 0.269 | 36 | 6.67 | -0.775 | 39 | 56.67 | 0.343 | 11.20** |
| 148 | 11 | 8.33 | -0.153 | 20 | 4.17 | -0.704 | 69 | 87.50 | 0.518 | 4.35 |
| 150 | 12 | 10.56 | -0.072 | 21 | 2.74 | -0.808 | 67 | 86.70 | 0.525 | 16.60** |
| 152 | 17 | 11.11 | -0.242 | 33 | 0.00 | -1.000 | 50 | 88.89 | 0.778 | 17.63** |
| 168a | 15 | 17.50 | 0.092 | 17 | 0.00 | -1.000 | 68 | 82.50 | 0.220 | 8.18* |
| 168b | 6 | 5.56 | -0.040 | 9 | 0.00 | -1.000 | 85 | 94.44 | 0.500 | 2.89 |
| 170 | 21 | 36.96 | 0.376 | 29 | 2.17 | -0.897 | 51 | 60.87 | 0.194 | 18.14** |
| 172 | 18 | 9.38 | -0.359 | 23 | 0.00 | -1.000 | 59 | 90.63 | 0.741 | 14.10** |
| 174 | 21 | 89.29 | 0.938 | 32 | 0.71 | -0.970 | 47 | 10.00 | -0.777 | 394.50** |
| Mean | | | -0.172 | | | -0.861 | | | 0.503 | |
| SD | | | 0.550 | | | 0.141 | | | 0.408 | |

[a] * P < 0.05, ** P < 0.01

Overall, non-denning activities of opossums were concentrated in undeveloped areas and on unpaved surfaces. Commercial and industrial areas, and paved surfaces were underutilized while use of residential areas and structures was variable.

# DISCUSSION

## Activity Patterns

Although activity level was not directly measured in this study, time of activity and relative seasonal activity patterns did not differ appreciably from previous studies of opossums in the laboratory or in rural habitats. Average period of activity in Corvallis was from 2100-0400. In a study of captive opossums, McManus (1971) also found consistent times of activity through the year, with opossums active 1900-0500.

Using distance moved per night as an index, activity in Corvallis was twice as high in June through October as in November through March (Fig. 3). McManus' (1971) findings that the level of activity in captive opossums (percent of time spent in activities other than sleep) was approximately 3 times greater in spring and summer than in fall and winter are in close agreement. Similarly, in Wisconsin, Amin (1974) found opossum activity at a low in April, increasing to a peak in July, and declining to a "moderate" level in the fall. Timing and relative seasonal levels of activity of opossums in the urban environment did not appear to differ from those observed in rural or artificial environments.

Distance moved per night was shorter in the urban habitat than in more rural habitats. In Corvallis, average distance moved was about 400 m in June through October, and 200 m in November though March. Average distance moved per night was similar for males and females in most months (Signed-Rank test, $P > 0.92$). When averages were widely different, sample sizes were limited to a few animals and the standard deviation was high (Fig. 3, Appendix II). In these cases the particular habitat occupied may have been more important than sex of the opossum in determining distance moved per night. Opossums with the largest home ranges (i.e., #'s 106, 122, 108, 112) tended to move longer distances each night, influencing the means of some months. Foraging ranges (distance between den and most distant nightly location) in a radiotelemetry study in Wisconsin were at least twice as long as distances moved in Corvallis (Appendix II), and males had significantly longer movements than females (mean males = 946 m, mean females = 413 m) (Gillette 1980). In Kansas, distances from den to foraging locations (mean males = 229 m, mean females = 155 m), and den to den distances (mean males = 305 m, mean females = 299 m) were not significantly different for males and females (Fitch and Shirer 1970). All these indices measured a "one way" distance, whereas the index used in Corvallis was cumulative or "round trip", indicating that the total distance covered each night was probably greater in non-urban habitats. The shorter distances moved by opossums in the urban habitat are probably influenced by reliable and abundant food supplies and den sites. Year-round food sources such as garbage, compost, and pet food may reduce the need to explore new areas.

Minimum daily temperature appeared to influence how active opossums were, as indicated by distance moved per night, and whether they left the den at all. In Corvallis there were 14 nights of no movement outside the den at temperatures of 0°C or below, 28 nights at 3°C or below, and rain appeared to exacerbate the effects of low temperatures. Other authors have noted that opossums remained in dens and did not forage at temperatures near or below freezing (Brocke 1970, Fitch and Shirer 1970, Gillette 1980, Pippitt 1975). However, opossums remained in dens at higher minimum temperatures in Corvallis than in other studies, perhaps because they were acclimated to the milder climate. Rain may have acted to reduce the already poor insulating qualities (Pippitt 1975) of opossum fur, causing thermal stress at somewhat higher minimum temperatures than documented elsewhere.

Opportunity to forage most nights and year-round food availability may have given Corvallis opossums an energetic advantage compared to rural environments and colder climates. Gill and Bonnett (1973) felt that the continuous availability of urban food resources eliminated the "winter pinch period." Because food was readily available even in winter, Corvallis opossums could afford not to forage on some cool, wet nights which might have required activity in colder climates.

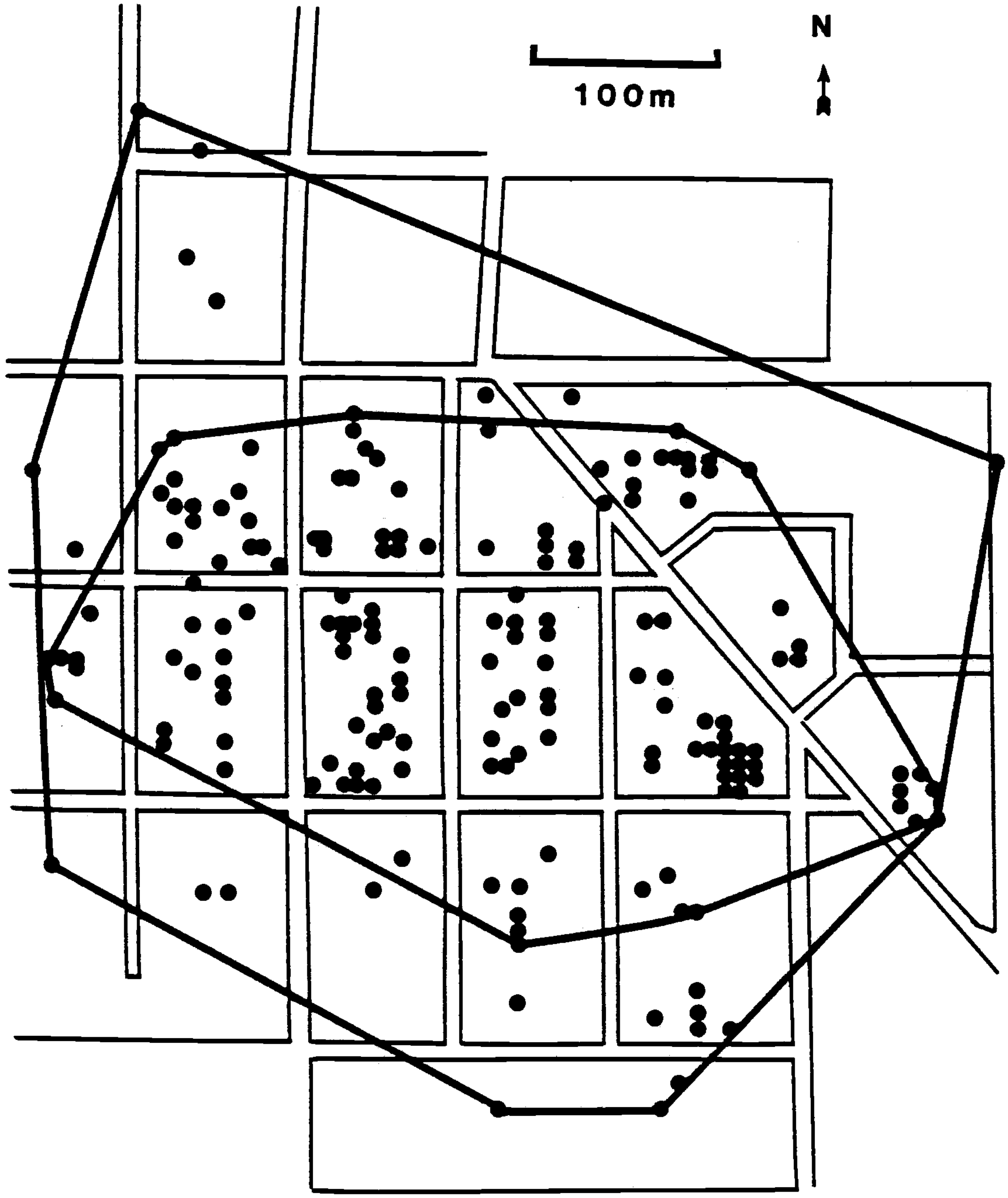
## Home Range

Within their home ranges, opossums concentrated activity in alleys and back yards, away from areas of high human activity (Fig. 6) and near food resources. Gardens, compost heaps and garbage are all usually found behind houses. Vegetation in back yards probably also provides escape cover and travel routes.

Opossums did not travel the same route each night, and appeared to have good familiarity with their home ranges. In 3 typical consecutive nights, female #122 used 2 main den sites, and lines

Figure 6. Minimum convex polygon home range plot and radio-telemetry locations of female opossum (#122) in Corvallis, Oregon, Jun 1981-Jan 1982. Solid lines outline the 100% and 95% home ranges.

Figure 6.



connecting successive observations encompassed about 1/3 of her 95% home range (Fig. 7). If we assume familiarity with the area within 50 m of an observation, it appears that the pattern of use enables an opossum to maintain good familiarity with its 95% home range. Observations outside the 95% home range may represent ephemeral food sources or occasional exploration of habitat. Because no difference was found in habitat availability between 100% and 95% home ranges, the 95% home range may be a better representation than the 100% home range of an area familiar to an opossum which supplies most of the required resources.

Differing methods of data collection and of calculating home range sizes prevented statistical comparisons of home range estimates in the literature and in this study. However, relative sizes can be compared when the biases of the different methods are known. Locations determined from trapping data are usually more limited and more influenced by the method than locations determined from radio telemetry data. Given the same data points, circular home ranges will be largest, with ellipses and minimum convex polygons resulting in progressively smaller size estimates. Home ranges estimated from den sites will be smaller than those including foraging locations.

In spite of different results from different methods, home ranges in the urban environment were consistently smaller than home ranges calculated with similar methods in rural environments (Table 10). For example, Gillette (1980) used radio-telemetry and a 95% minimum convex polygon and found home ranges substantially larger than those

Figure 7. Three typical consecutive nights movement of female opossum (#122) in Corvallis, Oregon, 30 Jun-2 Jul 1981. Solid lines outline the 100% and 95% home ranges. Dashed lines connect observations of individual nights.

Figure 7.

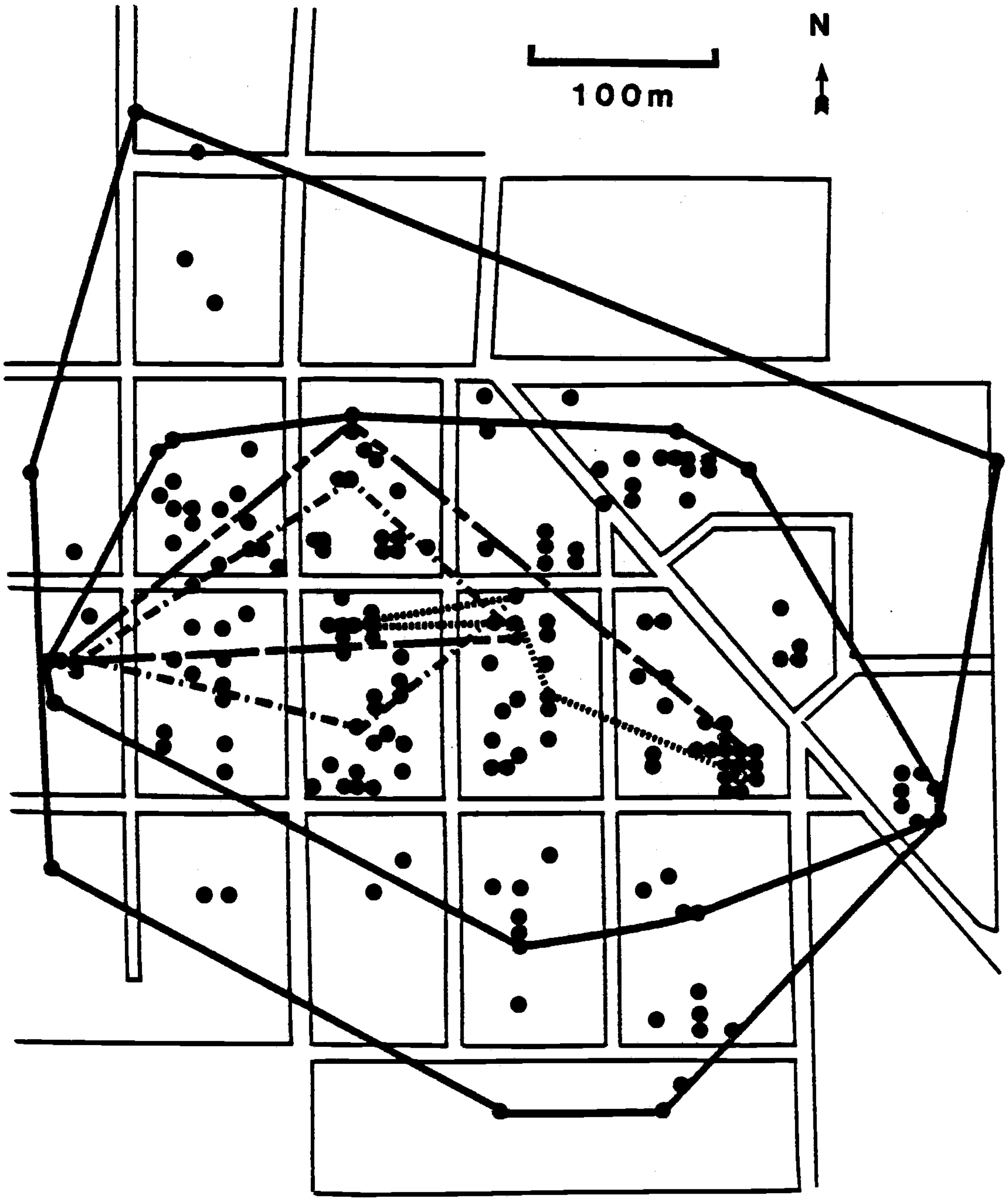


Table 10. Home range size of Virginia opossum as reported in the literature.

| Reference | Location | Method | Age Sex[a] | # of Anim | # of points | Mean size[b] ha | Range ha |
|---|---|---|---|---|---|---|---|
| | | **TRAPPING** | | | | | |
| Lay 1942 | Texas | Minimum convex polygon. | 3,3 | 29 | 3-13 | 4.7 | 0.1-23.5 |
| (from Hunsaker 1977) | | Circle, diameter = mean maximum distance between captures. | 3,3 | | | 15.6 | |
| (from Verts 1963) | | Ellipse. | 3,3 | | | 12.6 | |
| Fitch and Sandidge 1953 | Kansas | Circle, diameter = mean maximum distance between captures. | 3,3 | 49 | 2->5 | 20.3 | 17.0-28.3 |
| (from Verts 1963) | | Ellipse. | 3,3 | | | 13.4 | |
| Sanderson 1959 | Illinois | Circle. | 3,3 | 8 | >6 | | 7.3-16.4 |
| Verts 1963 | Illinois | Circle, diameter = mean maximum distance between captures. | 3,3 | 13 | 2-7 | | 54.3-82.2 |
| | | Ellipse. | 3,3 | | | 38.9 | |
| Llewellyn and Dale 1964 (from Hunsaker 1977) | Maryland | Circle. | 3,3 | 110 | 2-19 | 16.7 | |
| Holmes and Sanderson 1965 (from Hunsaker 1977) | Illinois | Circle. | 3,3 | | | 14.2 | |
| | | **TELEMETRY** | | | | | |
| Fitch and Shirer 1970 | Kansas | Circle. Area encompassed by dens. | 1,1 | 8 | 5-16 | 26.9 | 2.2-137.9 |
| | | | 1,2 | 5 | 3-19 | 16.4 | 2.6-36.3 |
| Shirer and Fitch 1970 | Kansas | Minimum convex polygon Den sites. | 1,1 | 3 | 6-19 | 25.2 | 3.2-66.5 |
| | | | 1,2 | 4 | 5-26 | 17.5 | 2.6-36.2 |
| | | | 3,3 | 9 | 3-26 | 17.0 | 2.2-66.5 |
| Van Druff 1971 | New York | Composite activity range. | 3,3 | 6 | 1-6[c] | 23.1 | 5.8-42.9 |
| Gillette 1980 | Wisconsin | 95% minimum convex polygon. | 3,1 | 8 | 59[d] | 78.6 | 27.0-223.0 |
| | | | 3,2 | 16 | 103[d] | 38.9 | 10.0-80.0 |
| This study. | Oregon | 100% minimum convex polygon. | 3,3 | 17 | 52-493 | 18.7 | 2.4-102.9 |
| | | 95% minimum convex polygon. | 3,3 | | | 11.6 | 0.7-83.7 |
| | | 100% circle. Diameter = maximum distance between observations. | 3,3 | | | 51.9 | |
| | | 100% ellipse. | 3,3 | | | 25.7 | 3.7-141.3 |

[a] Age: 1 = Adult, 2 = Juvenile, 3 = All

Sex: 1 = Male, 2 = Female, 3 = All

[b] Home range sizes previously reported in acres were converted to hectares for this table.

[c] Weeks followed.

[d] Days followed.

found in Corvallis (mean males = 76.6 ha vs. 21.1 ha; mean females = 38.9 ha vs. 4.9 ha).

Home ranges in previous studies averaged 2.7 to 2.9 times longer than wide (Hunsaker 1977), compared to only 1.7 times longer than wide in this study (Appendix IV). Elongated home ranges in rural studies may have been due to opossum dependence on linear habitat components such as streams. Animals with the most elongated ranges in the current study tended to be those with relatively high proportions of unbuilt habitat types in their home ranges which frequently contained riparian areas. The more uniform checkerboard distribution of food resources in the urban environment may have counteracted the impact of linear elements in the urban design.

In contrast to my findings, Hoffman and Gottschang (1977) in a radio telemetry study found that urban home ranges of raccoons averaged 5.5 times longer than wide, more elongated than home ranges of rural raccoons. They attributed the shape to "readily available food supply and the effect of the linear urban habitat." Raccoons in their study followed linear "beaten paths" to regular feeding grounds. Although paths taken by opossums on any one night may have been linear (e.g., along alleys), they did not follow fixed nightly routes, and cumulative paths over many nights resulted in more rounded home ranges.

Because resources in the urban habitat are distributed almost uniformly in fine-grained, small patches, as compared to rural habitats, the influence of linear habitat components (such as streets) is reduced. Hence, home ranges were less elongated than those found in rural settings.

Examples of 2 extreme home range sizes and shapes were provided by 2 radio-tracked females. Female #106's 100% home range encompassed 10.8 ha and was 3.94 times longer than wide. Her 95% home range was only 2.18 ha but was over 20 times longer than wide. The 95% range encompassed a narrow strip of vegetation along the riverfront which offered rich resources compared to the bordering commercial area. At the other extreme, female #120's 100% home range was 2.39 ha and was only 1.7 times longer than wide. Her 95% range was completely within one city block and encompassed only 0.76 ha. This small area supplied cover, food, and den sites sufficient to raise a litter.

In Corvallis, most animals had stable, well-defined home ranges. Only 2 of 7 males (#'s 108, 112) had fluid or gradually shifting home ranges. In contrast, Fitch and Shirer (1970:178) described all opossum home ranges as "extremely fluid" and composed of overlapping segments with dens as focal points. However, Gillette (1980) found that while males had this type of shifting range, females maintained well-defined home ranges, and made infrequent shifts to entirely new areas. Van Druff (1971) also found some animals (usually female) had very stable home ranges, while others (usually male) made longer, more frequent movements. It may be that resources in the urban habitat are sufficiently abundant and reliable that the risks and energy expenditures of continually exploring new areas become unnecessary. The urban habitat appears to allow opossums to maintain smaller home ranges, and allows some males to be less nomadic.

Opossums have never been found to be territorial. Radio-collared opossums with overlapping home ranges (Fig. 4) appeared to minimize interactions by using separate portions of the range on any given night. The only opossum interactions I observed were mother-young groups and brief male-female associations during the breeding season.

Dens

Opossums made frequent use of urban habitat components for dens. The propensity of opossums to use houses, garages, and other man-made structures, as well as natural den sites in Corvallis indicates that den sites were probably not limiting opossum density. Only in commercial neighborhood types with little cover and opossum-proof foundations were dens less available. This may have influenced the low use of commercial areas (Table 6). Human activity near a den did not seem to disturb opossums, and may have been associated with a rich food supply.

Dens were not considered limiting in any previous opossum studies (Lay 1942, Sandidge 1953, Stuewer 1943). Opossums in rural habitats occasionally denned under buildings (Sandidge 1953, Wiseman and Hendrickson 1950) although most dens were in natural locations. Sandidge (1953) felt that with an abundance of natural dens and the opossum's adaptability to using a variety of dens, dens were never limiting in his study area.

Opossums in Corvallis used more than one den, a habit also noted in other opossum studies (Shirer and Fitch 1970, Van Druff 1971). On the average, in Corvallis, a single den accounted for over 30% of den use for most animals, and 2 dens accounted for over 50% of den use (Appendix V). Fitch and Shirer (1970), found that in Kansas, on average, 40% of sojourns ("the period spanned by an animals's use of a den for sleep or protection") were at a single favorite den, with 20% at the next favorite den. The majority of sojourns spanned only a few days at most, prompting them to describe den use as temporary. While frequent den shifting was also found in the urban environment, I feel it is significant that only a few dens accounted for most den use. Establishment of main dens is only possible if an animal maintains a fairly stable home range. Intermittant use of dens may indicate a memory of locations over several months. Opossums may have stable home range areas within which they focus on different areas (perhaps ephemeral food resources) while remaining familiar with the entire area. Frequent den shifting may also constitute exploration of the home range and provide familiarity with escape cover and alternate dens should a main den be unavailable. With the high level of disturbance present in the urban environment, knowledge of alternative dens and use of a variety of types of dens could be very advantageous.

While only one case of den sharing was found in this study, it is possible that opossums shared dens with untagged opossums or other species. Most studies of opossums in rural habitats noted intraspecific and interspecific den sharing (Fitch and Shirer 1970, Gillette 1980, Lay 1942, Pippitt 1975, Sandidge 1953, Shirer and Fitch 1970, Yeager 1936). Den sharing does not necessarily imply a shortage of den sites, but rather that the den has characteristics attractive to more than one animal.

## Habitat Use

Urban opossums appeared well adapted to using urban components of the environment. Their ability to use a variety of dens in rural areas translated directly to use of man-made structures for dens. Their omnivorous appetite suited them to a variety of urban food sources not available in rural habitats. Their nocturnal activity patterns allowed them to coexist with humans with a minimum of interactions or disturbance.

Opossum's use of buildings for dens, and garbage and vegetable gardens for food, was similar to the use of urban habitat components by other urban wildlife. Squirrels in Michigan denned in buildings and traveled along telephone cables. Raccoons foraged in garbage cans and occasionally denned in garages (Cauley 1973, Hoffman and Gottschang 1977). However, Cauley (1973) believed raccoons were largely dependent on natural areas for dens, food, and travel routes. Similarly, in comparing raccoon use of 3 suburban habitats, Hoffman and Gottschang (1977) found that woodlots received most activity, and residential areas and fields received less activity than expected.

Opossums studied in Corvallis did not appear to need large patches of undeveloped habitat in their home ranges. Most of the animals studied had home ranges completely within the city, and often completely within residential areas. Habitat requirements of opossums were satisfied within areas as small as one city block.

## CLASSIFICATION OF URBAN HABITAT AS WILDLIFE HABITAT

The primary feature of urban habitat is that humans dominate and manipulate the entire environment. Wildlife living in an urban environment must be suited to habitats with high disturbance. "Natural" habitat remaining in urban environments is in small patches. Animals requiring large home ranges (such as predators) or climax successional stages are largely excluded from the urban wildlife community.

A description of urban habitat must take into account its patchy nature while focusing on the characteristics important to wildlife. The classification systems chosen for this study divided the urban habitat into neighborhood types based on different human densities and use, which might affect opossum densities and use. Although not quantified, neighborhood types differed in regards to amount of vegetative cover, food resources, human density, disturbance, and times of human activity. Choice of surface types assumed that resources were distributed differently on the 3 surfaces, and that opossums were responsive to this level of differentiation.

Broad classification of neighborhood types as residential, commercial, or unbuilt appeared most useful, and could easily be used in other urban wildlife studies. The more narrow classifications of housing density, and specific commercial and unbuilt types, were apparently not distinguished by opossums. Other possible neighborhood type classifications might be based on age or economic value of residential neighborhoods, human population density, or pet distribution and density. Unfortunately, most census and survey data do not have the fine resolution required for wildlife home range analyses. Direct habitat sampling may be difficult in urban habitats due to problems associated with trespass and reduced visibility due to fences, vegetation and buildings.

Surface types provided a useful index of opossum habitat use. Although it was clear that opossums used structures for dens, specific uses of unpaved areas could only be speculated. Unpaved surfaces should probably be further separated into small patches, including yards and landscaping, and large patches, such as fields, forests, and riparian areas.

As a first approximation for description of urban wildlife habitat, the classsifications used provided insight into availability and opossum use of urban habitat.

# CONCLUSIONS

Opossums are an example of a wildlife species that has successfully adapted to the urban habitat. Necessary resources of food, dens, and cover are all available and accessible to opossums. Opossum's ability to use almost any food source or den permits them to exploit non-traditional resources. The size of the animal and its resource requirements fit well into the scale of resource distribution and habitat patches in a city. The urban environment eliminates some of the dangers a rural environment includes. Predators are limited to humans, their cars, and their pets. Dogs may succeed in killing some opossums, but are usually restrained in a house or yard, and can be avoided.

Animals most likely to compete with opossums are not as well-suited to the urban habitat. Raccoons and skunks may be observed on the fringes of urban settings, but appear to need larger natural areas than opossums, so are not as common in the city. Domesticated pets are more likely to be of benefit to opossums by making pet food available, than to compete with them.

Wildlife with more specific requirements may not fare as well in the city as the opossum. Disadvantages of the urban habitat may include the discontinuous nature of resources and habitat types, a shortage of dispersal corridors, increased mortality from car traffic, and a higher disturbance level from human activities. But for a generalist animal, such as the opossum, the urban habitat may be more productive than the non-urban habitat. A reliable food supply, freedom from competitors and predators, and readily available dens combine to make urban habitat attractive to the opossum.

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# APPENDICES

Appendix I. A method for determining the 95% minimum convex polygon home range.

The minimum convex polygon home range method is the quickest, simplest, reproducible method of determining home range size from animal location data. Other methods have been suggested which have useful statistical characteristics, but most are complex and require use of a computer. These methods include 95% ellipses (Jennerich and Turner 1969, Koeppel *et al*. 1975), grid methods (Inglis *et al*. 1979) and isoclines around centers of activity (Dixon and Chapman 1980).

One of the critisms of the 100% minimum convex polygon is that it does not always realistically define the area used by an animal. The restriction of convexity frequently results in inclusion of large areas where no animal use was recorded. The 95% home range eliminates many of these areas by eliminating points on the outskirts of the home range which received minimal use. The objective of determining the 95% home range is to delineate an area of concentrated activity where an animal spends most of its time, and presumably aquires most of the resources required for survival.

The 95% home range is defined as the minimum convex polygon encompassing 95% of the observations. It is possible to determine this area through visual inspection of a home range plot, but a standardized, easily implemented method is necessary to insure reproducible results. Computer algorithms are sometimes used (Harestad 1981) but can be expensive and unnecessary on small data sets. The following method was used in this study and is suggested as a standard method:

1. A point is a physical location or set of coordinates on a map. There may be more than one observation at a point.
2. The number of observations eliminated will be the nearest whole number equal to or less than 5% of the total observations.
3. No point which contains greater than 5% of the total observations will be considered for elimination from the home range plot.
4. Connect the outermost points of the home range plot to form the 100% minimum convex polygon.
5. Inspect each point on the perifery eligible under step 3 and determine the reduction in area that would result from removal of that point.
6. Select the point which would result in the greatest reduction in area.
7. Remove observations from the selected point until the point is removed, or the 5% limit is reached.
8. Again connect the outermost points to form a convex polygon.
9. Repeat steps 5-8.
10. Stop removing points when the 5% limit of observations is reached.

Appendix II. Mean distance moved per night (m) by opossums in Corvallis, Oregon, 1981-1982.

| Animal | April | May | June | July | August | Sept | Oct | Nov | Dec | Jan | Feb | March |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FEMALES | | | | | | | | | | | | |
| 106 | 354.71 | 713.63 | 760.26 | 826.99 | | | | | | | | |
| 116 | | | 176.96 | | | | | | | | | |
| 118 | | | 244.45 | | | | | | | | | |
| 120 | | | 69.00 | 167.94 | | | | | | | | |
| 122 | | | 413.00 | 406.20 | 440.11 | 390.06 | 743.47 | 372.98 | 235.76 | 63.92 | | |
| 128 | | | 269.75 | 375.57 | | | | | | | | |
| 140 | | | | 343.73 | 414.30 | 459.23 | | | | | | |
| 148 | | | | 326.79 | 480.33 | | | | | | | |
| 170 | | | | | | | | 153.92 | 252. | 199.82 | 207.36 | 204.89 |
| 172 | | | | | | | | 285.60 | 264.82 | 180.28 | 202.33 | 233.34 |
| Mean | 354.71 | 713.63 | 322.24 | 407.87 | 444.91 | 424.65 | 743.47 | 270.83 | 250.89 | 148.01 | 204.85 | 219.12 |
| SD | | | 242.55 | 221.34 | 33.28 | 48. | | 110.27 | 14.57 | 73.47 | 3.56 | 20.12 |
| MALES | | | | | | | | | | | | |
| 108 | 859.97 | 1181.10 | | | | | | | | | | |
| 112 | | 503.68 | 1444.90 | | | | | | | | | |
| 142 | | | | 269.60 | 256.57 | 263.65 | 205.13 | 149.52 | 116.21 | 196.07 | | |
| 150 | | | | 426.11 | 560.76 | 555.39 | 266.47 | 205.97 | 271.27 | 284.84 | | |
| 152 | | | | 643.43 | 747.83 | | | | | | | |
| 168 | | | | | | | | 410.39 | 289.44 | 261.86 | 1024.89 | |
| 174 | | | | | | | | | 100.80 | 154.73 | 240.62 | 172.59 |
| Mean | 859.97 | 842.39 | 1444.90 | 446.38 | 521.72 | 409.52 | 235.80 | 255.29 | 194.43 | 224.36 | 632.76 | 172.59 |
| SD | | 479.01 | | 187.74 | 247.95 | 206.29 | 43.37 | 137.25 | 99.69 | 59.74 | 554.56 | |
| Mean all | 607.34 | 799.47 | 482.62 | 420.71 | 483.32 | 417.08 | 405.02 | 263.06 | 218.63 | 191.64 | 418.80 | 203.61 |
| SD | 357.27 | 346.77 | 478.62 | 199.51 | 163.72 | 122.72 | 294.70 | 111.68 | 77.14 | 72.45 | 404.42 | 30.40 |

Appendix III. Seasonal opossum home ranges (95% minimum convex polygon) in Corvallis, Oregon, 1981-82.

| | | Feb-May | Jun-Sep | Oct-Jan | Total |
|---|---|---|---|---|---|
| MALES | | | | | |
| Adults | mean | 45.9 | 83.7 | 3.3 | 30.9 |
| | SD | 6.2 | | 1.1 | 33.4 |
| | n | 2 | 1 | 3 | 6 |
| Juveniles | mean | | 4.7 | 11.0 | 6.2 |
| | SD | | 2.9 | | 3.9 |
| | n | | 3 | 1 | 4 |
| All Males | mean | 45.9 | 24.5 | 5.2 | 21.1 |
| | SD | 6.2 | 39.6 | 4.0 | 28.0 |
| | n | 2 | 4 | 4 | 10 |
| FEMALES | | | | | |
| Adults | mean | 2.7 | 4.8 | 5.9 | 4.5 |
| | SD | 0.8 | 3.3 | 4.8 | 3.1 |
| | n | 3 | 7 | 2 | 12 |
| Juveniles | mean | | 11.4 | 2.9 | 7.1 |
| | SD | | | | 6.0 |
| | n | | 1 | 1 | 2 |
| All Females | mean | 2.7 | 5.6 | 4.9 | 4.9 |
| | SD | 0.8 | 3.7 | 3.8 | 3.4 |
| | n | 3 | 8 | 3 | 14 |

Appendix IV. Circular and elliptical home range size (ha) and linearity index of opossums in Corvallis, Oregon, 1981-82.

| Opossum | Circular Home Range 100% | Circular Home Range 95% | Elliptical Home Range 100% | Length/Width |
|---|---|---|---|---|
| FEMALES | | | | |
| 106 | 104.72 | 83.15 | 26.60 | 3.94 |
| 116 | 4.50 | 2.29 | 4.07 | 1.10 |
| 118 | 49.82 | 23.98 | 26.46 | 1.88 |
| 120 | 6.25 | 2.36 | 3.67 | 1.70 |
| 122 | 27.05 | 17.12 | 24.59 | 1.10 |
| 128 | 15.35 | 12.34 | 8.20 | 1.87 |
| 140 | 16.42 | 10.42 | 11.39 | 1.44 |
| 148 | 30.08 | 12.15 | 19.56 | 1.54 |
| 170 | 10.29 | 5.27 | 7.04 | 1.46 |
| 172 | 12.34 | 6.08 | 7.71 | 1.60 |
| MALES | | | | |
| 108 | 191.72 | 106.10 | 75.20 | 2.58 |
| 112 | 262.79 | 116.80 | 141.25 | 1.86 |
| 142a | 4.82 | 2.85 | 4.15 | 1.16 |
| 142b | 9.28 | 3.77 | 5.97 | 1.58 |
| 150 | 47.93 | 12.82 | 41.15 | 1.16 |
| 152 | 14.72 | 13.90 | 9.54 | 1.54 |
| 168a | 35.53 | 35.53 | 21.34 | 1.67 |
| 168b | 186.16 | 139.72 | 71.88 | 2.59 |
| 174 | 18.98 | 16.70 | 15.67 | 1.21 |
| Mean | 55.20 | 32.81 | 27.65 | 1.74 |
| SD | 75.55 | 43.56 | 34.57 | 0.68 |

Appendix V. Number of dens accounting for indicated percent of den observations of opossums in Corvallis, Oregon, 1981-82.

| Opossum | # den obs. | 100% | 90% | 80% | 50% | 30% |
|---|---|---|---|---|---|---|
| FEMALES | | | | | | |
| 106 | 57 | 13 | 9 | 7 | 3 | 2 |
| 116 | 10 | 1 | 1 | 1 | 1 | 1 |
| 118 | 10 | 7 | 6 | 5 | 2 | 1 |
| 120 | 43 | 2 | 1 | 1 | 1 | 1 |
| 122 | 150 | 7 | 3 | 2 | 1 | 1 |
| 128 | 25 | 6 | 4 | 3 | 2 | 1 |
| 140 | 49 | 7 | 5 | 3 | 2 | 1 |
| 148 | 36 | 13 | 10 | 6 | 2 | 1 |
| 170 | 76 | 7 | 4 | 3 | 1 | 1 |
| 172 | 83 | 4 | 3 | 3 | 2 | 1 |
| Mean females | | 6.7 | 4.6 | 3.4 | 1.7 | 1.1 |
| SD | | 4.0 | 3.0 | 2.0 | 0.7 | 0.3 |
| MALES | | | | | | |
| 108 | 12 | 12 | 10 | 8 | 4 | 3 |
| 112 | 10 | 10 | 9 | 8 | 3 | 2 |
| 142 | 128 | 13 | 6 | 4 | 2 | 1 |
| 150 | 122 | 9 | 5 | 4 | 2 | 1 |
| 152 | 25 | 8 | 6 | 5 | 3 | 2 |
| 168 | 61 | 15 | 8 | 5 | 3 | 2 |
| 174 | 69 | 11 | 5 | 4 | 2 | 1 |
| Mean males | | 11.1 | 7.0 | 5.4 | 2.7 | 1.7 |
| SD | | 2.4 | 2.0 | 1.8 | 0.8 | 0.8 |
| Mean all animals | | 8.4 | 5.6 | 4.2 | 2.1 | 1.4 |
| SD | | 3.9 | 2.9 | 2.1 | 0.9 | 0.6 |

Appendix VI. Sex ratios of opossums examined (n=59), according to age and season in Corvallis, Oregon, 1981-82. Sample sizes in parentheses.

| | Percent Female | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age | Feb-May | | Jun-Sep | | Oct-Jan | | Total | |
| Juvenile | 100 | ( 1) | 56 | (18) | 60 | ( 5) | 58 | (24) |
| Adult | 29 | (21) | 100 | ( 7) | 14 | ( 7) | 40 | (35) |

Appendix VII. Litter size and conception dates of pouch young examined in Corvallis, Oregon, 1981.

| Capture Date | Litter Size | M : F | Conception Dates |
|---|---|---|---|
| 23 February | 8 | | 13 Jan - 15 Jan |
| 24 February | 9 | | 29 Jan - 31 Jan |
| 13 April | 7 | 4 : 3 | 21 Jan - 28 Jan |
| May | 9 | 3 : 6 | |
| 3 June | pregnant | | 22 May earliest |
| 3 June | 8 | 4 : 4 | 22 Apr - 24 Apr |
| 10 June | 9 | | 23 Apr - 25 Apr |
| 27 June | 6 | 0 : 6 | 27 Mar - 17 Apr |
| 2 July | 9 | | 21 Apr - 2 May |
| 9 July | 9 | | 6 May - 10 May |
| 16 July | 6 | | |
| 29 July | | | 7 Jun - 14 Jun |
| Mean | 8 | | |