HABITAT SELECTION BY SMALL MAMMALS OF RIPARIAN COMMUNITIES: EVALUATING EFFECTS OF HABITAT ALTERATIONS[1]

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Abstract: Small mammals of riparian communities in Iowa were studied during the summer using live- and snap-trapping techniques. Six general habitat types were identified from the herbaceous vegetation on 28 study plots selected to represent a range of habitats from open fields to deciduous forest. Predominant habitat alterations were grazing, timber removal, and stream-channel realignment. Small-mammal species diversity was highest in channelized habitats and lowest in dry floodplains. An index of breadth of habitat usage was calculated for 9 species of mammals; white-footed mice (*Peromyscus leucopus*) exhibited the most generalized habitat usage. With the use of stepwise multiple regression, relationships were determined between small-mammal species abundances and 12 variables describing microhabitat features. In many instances, small-mammal numbers also were correlated significantly with each other. The potential effects of 6 habitat alterations on the 9 small-mammal species are predicted.

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Suitable habitat probably is the most important factor influencing the distribution and abundance of small mammals within their geographic ranges (Baker 1968:101, Vaughan 1972:250–256). Some small-mammal species have specific habitat requirements and consequently are limited in their distribution, whereas others occupy a wide variety of habitats (Kaufman and Fleharty 1974, Kirkland and Griffin 1974, Briese and Smith 1975, Miller and Getz 1976). Reports of the general habitats occupied by small mammals are common in the literature, but few studies have quantified the factors within a locality that influence a species abundance. Recently, small-mammal abundance and distribution have been related to several measures of habitat structure (M'Closkey 1975, M'Closkey and Fieldwick 1975, M'Closkey and Lajoie 1975, Dueser and Shugart 1978, Holbrook 1978).

Habitat disturbances such as stream-channel realignment (Possardt and Dodge 1978), clear-cutting (Kirkland 1977, Martell and Radvanyi 1977), fire (Krefting and Ahlgren 1974, Fala 1975), and strip mining (Verts 1959, DeCapita and Bookhout 1975) can affect small-mammal populations and alter community composition. Regardless of the nature of disturbance, if vegetation is changed and habitat is altered, populations of some species may benefit while others are affected adversely.

The objectives of our study were (a) to determine habitat preferences of some small mammals and the factors influencing their abundance; and (b) to quantify the effects of habitat alterations, particularly stream-channel realignment and grazing, on community composition and species abundance. Although this study was conducted in southwestern Iowa, the results are applicable to other riparian communities, especially those with similar small-mammal communities.

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TUDY AREA

The study area was in Guthrie County, wa. Northeastern Guthrie County is sit- ated on Wisconsin glacial drift and has ently rolling topography. The remain- er of the county is on loess, overlaying ansan till, and has varied topography ith steep upland slopes and nearly level ottomlands. Annual precipitation aver- ges about 76 cm, with about 70% fall- g from June through August (Russell et . 1974). Twenty-eight study plots were tablished along Brushy Creek, Beaver reek, and the Middle and South Rac- oon rivers, representing a range of ri- arian habitats from open fields to sed-canopy woodland. Five plots e located along channelized streams. Vogler (pers. comm.) identified 34 hab- at types on the study plots by reciprocal eraging ordination (Hill 1973) of the ominant herbaceous plant species cov- ages on each plot. The 34 types were nsolidated into 6 general habitat cate- ories, combining similar types from the dination scale. General habitats repre- nted were channelized; wet and dry odplain; and heavily grazed, lightly azed, and ungrazed upland. The chan- lized habitats generally were devoid of ee cover, and grass species dominated e herbaceous stratum; they also were bjected to periodic grazing, mowing, d herbicide application. Floodplains d ungrazed uplands were relatively disturbed deciduous forests with osed canopies. Heavily and lightly azed uplands had few shrubs and trees, and herbaceous vegetation height was restricted by grazing.

Dominant herbaceous plant species on the channelized habitat type were reed canary grass (*Phalaris arundinacea*) and smooth brome (*Bromus inermis*). Stinging nettle (*Urtica dioica*), honewort (*Cryptotaenia canadensis*), cup-plant (*Silphium perfoliatum*), Jerusalem artichoke (*Helianthus tuberosus*), giant ragweed (*Ambrosia trifida*), moneywort (*Lysimachia nummularia*), smartweed (*Polygonum hydropiper*), reed canary grass, and muhly (*Muhlenbergia racemosa*) characterized wet floodplains. Important herbaceous species on dry floodplain habitat included common dandelion (*Taraxacum officinale*), white clover (*Trifolium repens*), moneywort, buckbrush (*Symphoricarpos* spp.), gooseberry (*Ribes missouriense*), stinging nettle, and sedge (*Carex* spp.). Heavily grazed uplands were dominated by Kentucky bluegrass (*Poa pratensis*), buckbrush, foxtail barley (*Hordeum jubatum*), giant foxtail (*Setaria faberii*), Canada bluegrass (*Poa compressa*), common dandelion, Pennsylvania sedge (*Carex pennsylvanica*), and Japanese chess (*Bromus japonicus*). Buckbrush, violet (*Viola* spp.), hog-peanut (*Amphicarpa bracteata*), Kentucky bluegrass, Pennsylvania sedge, black snakeroot (*Sanicula marilandica*), and moss were important species on lightly grazed upland habitat. Characteristic species on ungrazed uplands were Virginia creeper (*Parthenocissus quinquefolia*), black snakeroot, Pennsylvania sedge, hog-peanut, and moss.

METHODS

Field

Small-mammal trapping stations on each study plot were located 12.5 m apart, along transects paralleling the

stream channel, beginning 12.5 m from the stream edge. The number of traps per plot varied from 40 to 150, depending on the extent of relatively homogeneous vegetation; maximum transect length was 500 m.

Vegetation was sampled in July 1976. The percentage cover of each plant species occurring within a 1-m^2 quadrat, positioned 3 paces from each grid marker at a 45° angle from the transect line, was estimated by using the classes 5%, 25%, 50%, 75%, and 95%. Each species also was assigned to a life form (grass or grass-like, forb, shrub, deciduous tree, or evergreen tree). The following measurements were made of logs and stumps within a 12.5-m^2 quadrat centered at each grid point: number, length (using the classes <0.5, 0.5–1.5, 1.6–3.0, 3.1–5.0, 5.1–7.0, 7.1–9.0, 9.1–12.5, 12.6–17.5, 17.6–22.5, and >22.5 m), maximum diameter (cm), and a subjective determination of whether the structure was hard or soft. The number of brushpiles also was noted. Ground slope was categorized as 0–22°, 23–45°, 46–68°, or 69–90°.

Small-mammal trapping was conducted from 1 May through 25 August on 16 of the study plots in 1976 and on 12 in 1977. Mammals were captured with Sherman live-traps (23 × 8 × 9 cm) following a rotational schedule; 2 or 3 plots were trapped concurrently. Traps were locked open and prebaited for 24 hours and then set for 4 consecutive days and nights; cracked corn was used as bait. Traps were checked in early morning and afternoon. Live-trapped animals were toe-clipped for future identification, and the following information was recorded: date and point of capture, identification number, and species.

After the live-trapping sequence, small mammals were captured on each study plot with Museum Special snap-traps for 4 consecutive days and nights. Peanut butter mixed with cotton was used as bait (Getz and Prather 1975). Information recorded for each animal was the same as that for live-trapped animals.

Analysis

Population estimates were made for white-footed mice, prairie deer mice (*Peromyscus maniculatus bairdii*), eastern chipmunks (*Tamias striatus*), and 13-lined ground squirrels (*Spermophilus tridecemlineatus*) from live-trap data using the method described by Marten (1970). This procedure regresses the increase in the number of marked animals caught, against the decrease in the number of unmarked animals as the trapping sequence progresses. Small-mammal densities were calculated by dividing the estimated number of each species by the area of the particular habitat sampled plus a border zone equal to the intertrap distance (12.5 m).

Meadow vole (*Microtus pennsylvanicus*), short-tail shrew (*Blarina brevicauda*), house mouse (*Mus musculus*), western harvest mouse (*Reithrodontomys megalotis*), and masked shrew (*Sorex cinereus*) populations could not be estimated accurately from live-trap data because of low susceptibility to live traps or complete avoidance of them. For these species, a relative abundance index (catch/effort) was calculated from snap trap data (expressed as the percentage trapping success per 100 trapping units (Nelson and Clark 1973).

Small-mammal species diversity was calculated for each general habitat type by using the Shannon-Wiener information measure ($H = -\Sigma p_i \log_e p_i$, where p_i = relative abundance of the ith species). Because 2 abundance measures were necessary (estimated density and relative abundance), a diversity index

as calculated from abundances determined by each measure, and the 2 indices then were summed to estimate total small-mammal species diversity for each general habitat type.

The reciprocal of Simpson's Index ($1/\Sigma p_i^2$, where p_i = the proportion of the total sample in the ith group) was used as an expression of niche breadth across the resource categories being analyzed (Whittaker and Levin 1975:169, Best et al. 1979). Index values were calculated for habitat selection by the 9 mammal species on the basis of either densities or relative abundances in the 6 general habitat types. Species with broader niches (higher index values) were assumed to be more tolerant of habitat changes. Herein, the index will be referred to as the tolerance index.

Small-mammal species' responses to microhabitat characteristics were determined by stepwise multiple regression analysis by comparing species abundance (at each grid point; $N = 2{,}876$) with the following variables: percentage cover of grasses, forbs, shrubs, deciduous trees, and evergreen trees; number of logs, stumps, and brushpiles; mean log length; plant species richness; vertical stratification (expressed as the number of different strata [herb, shrub, tree] present); and slope. Significance for all regressions was set at $P \leq 0.01$.

Several additional independent variables were derived from vegetation data, but were excluded from the analysis because of high correlations with the variables selected. When 2 variables were correlated highly, they were assumed to measure the same habitat feature(s); therefore, only the variable most strongly related to mammal species abundance was used. Within each life form, plant species richness was correlated positively with percentage cover, but of the 2, cover was related more strongly to mammal abundance. Log diameter and length were correlated positively, but length was related more strongly to mammal abundance. Log number, diameter, and length were divided into hard and soft classes, but these showed weaker correlations with mammal abundance than when the classes were combined.

RESULTS AND DISCUSSION

Habitat Selection

Small-mammal species diversity was highest in channelized and heavily grazed upland habitats (Table 1). Ellis (1976) also reported greater small-mammal species diversity in channelized habitats, attributed to the presence of grassland vegetation. However, Ferguson (1975) found lower species diversity in areas recently channelized (2 years post-channelization) with forbs dominating the herbaceous stratum. The lower mammal species diversities in the other general habitat types may be attributed partly to the dominance of *P. leucopus* and *T. striatus*. Brown (1973) reported that low diversity of rodent species in mesic forest habitats shows a lack of successful partitioning of food resources among species, and Dueser and Shugart (1978) hypothesized that these communities may be ecologically saturated even at a low diversity.

Table 1 presents the abundances of small-mammal species in the 6 general habitat types. Species with low tolerance indices are restricted to fewer habitats and/or use their selected habitats less evenly. Such species would be affected more adversely by loss of their preferred habitat than those that have higher index values and that more regularly use alternative habitats. Three distinct tolerance groupings of small mammals were rec-

Table 1. Species abundances and diversity indices for the 6 general habitat types.[a] Estimated density is given for *P. leucopus*, *T. striatus*, *S. tridecemlineatus*, and *P. maniculatus bairdii*; a relative abundance index is shown for *B. brevicauda*, *S. cinereus*, *M. musculus*, *R. megalotis*, and *M. pennsylvanicus*. Tolerance indices are also listed.

	General habitat type						
	Channelized (3.7)[b]	Wet floodplain (18.0)	Dry floodplain (3.9)	Heavily grazed upland (15.1)	Lightly grazed upland (6.0)	Ungrazed upland (6.1)	Tolerance index
Intolerant species							
M. pennsylvanicus	1.92	0.08	0.06	0.07			1.23
S. tridecemlineatus	0.27			2.11			1.24
R. megalotis	1.84	0.12	0.12	0.16			1.47
P. maniculatus	17.65	1.82		4.41			1.70
M. musculus	0.59	1.23					1.77
Moderately tolerant species							
S. cinereus	0.30	0.50			0.14	0.04	2.65
B. brevicauda	1.48	1.23		0.28	0.11	0.11	2.73
Tolerant species							
T. striatus		4.59	11.86	10.72	14.43	10.64	4.48
P. leucopus	29.95	85.66	80.79	35.26	47.82	49.43	5.12
Diversity index[c]	2.18	1.54	1.02	2.06	1.23	1.05	

[a] *Zapus hudsonius*, *Microtus ochrogaster*, and *Synaptomys cooperi* also were captured, but sample sizes were too small to provide reliable information on habitat selection or population abundances.
[b] Area sampled, hectares.
[c] Shannon-Wiener diversity index.

ognized: intolerant, moderately tolerant, and tolerant. (The general application of tolerance indices is discussed in Best et al. [1979].)

The responses of the small-mammal species to microhabitat variables differed considerably (Table 2). Microhabitat features most frequently related to species abundances were plant-species richness and percentage forb cover. Seven of the 9 small-mammal species avoided areas with high plant-species richness. Of the 5 life forms, percentage forb cover was most consistently correlated with small-mammal species abundances, grass coverage was of lesser importance, and deciduous tree cover evidently was not related to species densities. Eleven of the 14 significant relationships with cover were positive. The significant correlations between the abundance of woody plant debris (logs, brushpiles, or stumps) and small-mammal numbers were all positive.

Geier (1978) presented an extensive discussion of macro- and microhabitat selection reported in the literature for the small-mammal species addressed in this report.

Species Associations

Some small-mammal species have similar habitat preferences and occur together with a greater probability than would be expected by chance. Within suitable habitat, differential use of microhabitat features may permit coexistence of rodent species (M'Closkey 1976, Holbrook 1978). Knowledge of species associations is valuable for predicting the impact o habitat alterations on community composition (Armstrong 1977).

In general, abundances of tolerant anc moderately tolerant species were corre lated positively (Table 3). Dueser anc Shugart (1978) also reported a positive relationship between *P. leucopus* and *T striatus* numbers and noted that these

pecies were the most dissimimilar in ap-
earance and body size of the species
tudied. Divergence in body size may al-
ow coexistence because of the relative
ack of competition between the 2
pecies. Different-sized rodents may use
issimilar food sizes, partly because of dif-
erences in where they forage (M'Closkey
976). Competitive interactions between
hese 2 species also would be reduced be-
ause *Tamias* are diurnal and *Peromys-
us* primarily nocturnal.

Abundances of the 2 shrew species
vere associated positively, largely be-
ause of similarities in habitat require-
nents (Tables 1, 2). Although both are
nsectivores, their body sizes also differ,
Sorex being much smaller than *Blarina*.
This dissimilarity in body size may favor
o-occurrence. Abundances of the 2
hrew species also were correlated posi-
ively with *P. leucopus* numbers, and
Blarina abundance with that of *Tamias*.
-occurrence of these insectivores with
e tolerant rodent species probably is
acilitated by their niche segregation;
hrews are fossorial, and *P. leucopus* and
T. striatus are partly arboreal.

Tolerant species' numbers were cor-
elated negatively with those of the in-
olerant species. The tolerant species
vere primarily woodland mammals,
vhereas the intolerant species were re-
tricted mostly to grassland habitats,
ience explaining the negative relation-
hips. The strongest negative correlation
vas between abundances of the two
Peromyscus species. Habitat segregation
n *Peromyscus* may be the result of re-
productive barriers, morphological dif-
erences, food preferences, behavioral
lifferences, etc. (Dice 1968:75–80). The
iegative relationship between *P. leuco-
pus* and *M. pennsylvanicus* numbers has
een attributed to differences in pre-
erred vegetation height and/or vertical

Table 2. Significant positive and negative relationships ($P < 0.01$) between small-mammal species abundances and microhabitat variables.[a]

								Cover percentage					
	Mean log length	N logs	N brushpiles	N stumps	Plant species richness	Slope	Vertical stratification	Grasses	Forbs	Shrubs	Deciduous trees	Evergreen trees	Multiple R^2 value
Intolerant species													
M. pennsylvanicus					−				+				0.027
S. tridecemlineatus					−				+				0.024
R. megalotis					−				+				0.027
P. maniculatus	−				−		−	−	+				0.110
M. musculus	−				−				+				0.016
Moderately tolerant species													
S. cinereus				+				+		+			0.012
B. brevicauda			+	+	−			+					0.025
Tolerant species													
T. striatus		+			+	+	+		−	+		+	0.156
P. leucopus	+		+		−		+	+	−				0.154

[a] Standardized partial regression coefficients and the sequence in which the variables were entered in the regression analysis are given in Geier (1978).

Table 3. Correlations ($P \leq 0.01$, df = 2,874) between small-mammal species abundances.

	S. tridecemlineatus	*R. megalotis*	*P. maniculatus*	*M. musculus*	*S. cinereus*	*B. brevicauda*	*T. striatus*	*P. leucopus*
Intolerant species								
M. pennsylvanicus							−0.05	−0.07
S. tridecemlineatus			0.20					−0.10
R. megalotis			0.05			−0.05	−0.05	−0.08
P. maniculatus							−0.10	−0.20
M. musculus								
Moderately tolerant species								
S. cinereus						0.05	0.05	0.06
B. brevicauda								0.08
Tolerant species								
T. striatus								0.04
P. leucopus								

strata diversity (M'Closkey 1975, M'Closkey and Fieldwick 1975), or competition (Miller 1969; Drickamer 1970; Grant 1975; Rowley and Christian 1976, 1977).

The only significant correlations among intolerant species were between *P. maniculatus* numbers and those of *R. megalotis* and *S. tridecemlineatus*; these 3 species were caught primarily in treeless habitats. *P. maniculatus* and *S. tridecemlineatus* numbers had the strongest positive correlation of all the species compared.

Expected Impacts of Habitat Alteration

A knowledge of habitat requirements can be used to predict the effects of various habitat alterations on populations of the small-mammal species studied (Table 4). These predictions are based primarily on our results (Tables 1, 2), but for species where data were few, the results

Table 4. Predicted effects on small-mammal abundances of various alterations of riparian habitats. Predictions are based upon the reported results unless otherwise indicated. A − indicates reduction in numbers; +, increase; and blank no effect.

	Deciduous shrubs thinned	Deciduous trees thinned	Deciduous trees removed	Forb cover reduced	Grass cover reduced	Woody plant debris removed
M. pennsylvanicus		+	+	−	(−)[a]	
S. tridecemlineatus		+	+	−	(−)	
R. megalotis		+	+	−	(−)	
P. maniculatus		+	+	−	+(−)[b]	?[c]
M. musculus				−		?
S. cinereus	−				−	−
B. brevicauda					−	−
T. striatus	−	(−)	−	+		−
P. leucopus		−	−	+	−	−

[a] ( ) indicates predictions based primarily on literature (see Geier [1978]).
[b] Our results are at variance with the literature.
[c] ? represents insufficient data to make a prediction, although a change is expected.

ere supplemented by the literature (for listing of literature pertaining to indidual species see Geier 1978). For any ven species, but especially an intolerıt one, perturbations of its preferred ıbitat (where the highest densities ocır) would be more detrimental than alrations of less desirable habitat.

A reduction of shrub cover would low- · *T. striatus* and *S. cinereus* populaons, and selective removal of eastern ɛdcedar (*Juniperus virginiana*) would specially affect *T. striatus*. The effects thinning deciduous trees are similar to ıose resulting from complete tree reıoval. Responses of the mammal species tree removal are directly opposite to ıose for reduction in forb cover, indicatıg that forb coverage increases with the limination of a tree canopy. Populations the 2 tolerant species would be reuced if trees were removed and/or the ɔrb coverage increased; the reverse ould be true for the intolerant species. duction of grass cover would adversely ɔct populations of 6 species, and posbly 7 (our results are at variance with ıe literature with respect to *P. maniculatus*). Removal of woody plant debris ogs, brushpiles, or stumps) from the forst floor would reduce populations of *P. ucopus*, *T. striatus*, and the 2 shrew ɔecies. The effects on *P. maniculatus* nd *M. musculus* are uncertain.

Timber removal, grazing, and streamhannel realignment were the prevailing abitat alterations in this study. These ınd-use practices converted woodlands ıto open communities dominated by erbaceous vegetation. The intolerant ɔecies specialized on these habitats, and ɔnsequently were benefited the most. ther habitat changes, however, such as ıose resulting from invasion of trees and ırubs and/or discontinuance of livestock razing, would severely limit the intolerant species because of their restricted habitat preferences.

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