ACTIVITY AND USE OF HABITAT BY RADIO-TAGGED COTTONTAILS DURING WINTER

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ABSTRACT.—Cottontails were radio-tracked on an orchard during 18 winter nights including one night with 4 inches of wet snow on the ground and one night with blizzardlike conditions. During the latter two nights, rabbits traveled less than during other nights. With wet snow on the ground, they remained in dense woody cover; with blizzardlike conditions, they primarily utilized stands of unmowed weedy forbs and grasses. On 16 nights with moderate weather, individual animals utilized habitat in a manner suggesting cover preferences, but there was little consistency in use of cover types among rabbits. Use of an autumn-planted cover crop of oats as food and a tendency to avoid areas without woody overstory were indicated. Suggestions for improving the methods used in this study are given.

The habits of cottontail rabbits (*Sylvilagus floridanus*) have been difficult to study because of the nocturnal nature and the apparently generalized habitat requirements of this species. The objectives of this study were to measure activity and use of habitat types by cottontails during winter by means of radiotelemetry.

METHODS

Sixteen cottontails, seven males and nine females, were radio-tracked during winter nights on the University of Illinois orchard near Urbana. Observations were made during January 10 through February 10, 1966, and during February 6, through 28, 1967.

Study Area.—The study area was an experimental orchard, approximately ½ mile square, having well-defined blocks of habitat arranged in rectangular patterns (Fig. 1 *A*). The most common woody plants present were apple (*Pyrus Malus*), and pear (*Pyrus communis*), and peach (*Prunus persice*), trees, and grapes (*Vitis* spp.). Common herbaceous plants were bluegrass (*Poa* spp.), timothy (*Phleum* spp.), foxtail grass (*Setaria* spp.), chicory (*Cichorium intybus*), prickly lettuce (*Lactuca scariola*), plantain (*Plantago* spp.), goldenrod (*Solidago* spp.), and pigweed (*Amaranthus* spp.). About half of the area was mowed at least once each summer.

Each block of habitat was classified according to the density of its overstory and to the type of herbaceous ground cover present. The following classes were used:

Ground cover:
1. Mowed vegetation, primarily grass (Fig. 1 *D*)
2. Plowed ground
3. Unmowed grass (Fig. 1 *F*)
4. Unmowed weedy forbs or grasses and forbs (Figs. 1 *C* and *E*)
5. Partly mowed forbs or grasses and forbs (strips mowed among grape arbors—Fig. 1 *B*)

Overstory (woody vegetation over 2 feet tall):
1. None
2. Sparse to medium (crowns not touching—Figs. 1 *D* and *F*)
3. Dense (crowns mostly touching; includes grape arbors—Figs. 1 *B* and *C*)

Trapping and Tracking Procedure.—Movements of seven cottontails were studied during 1966, nine during 1967. They weighed between 710 and 1,390 g

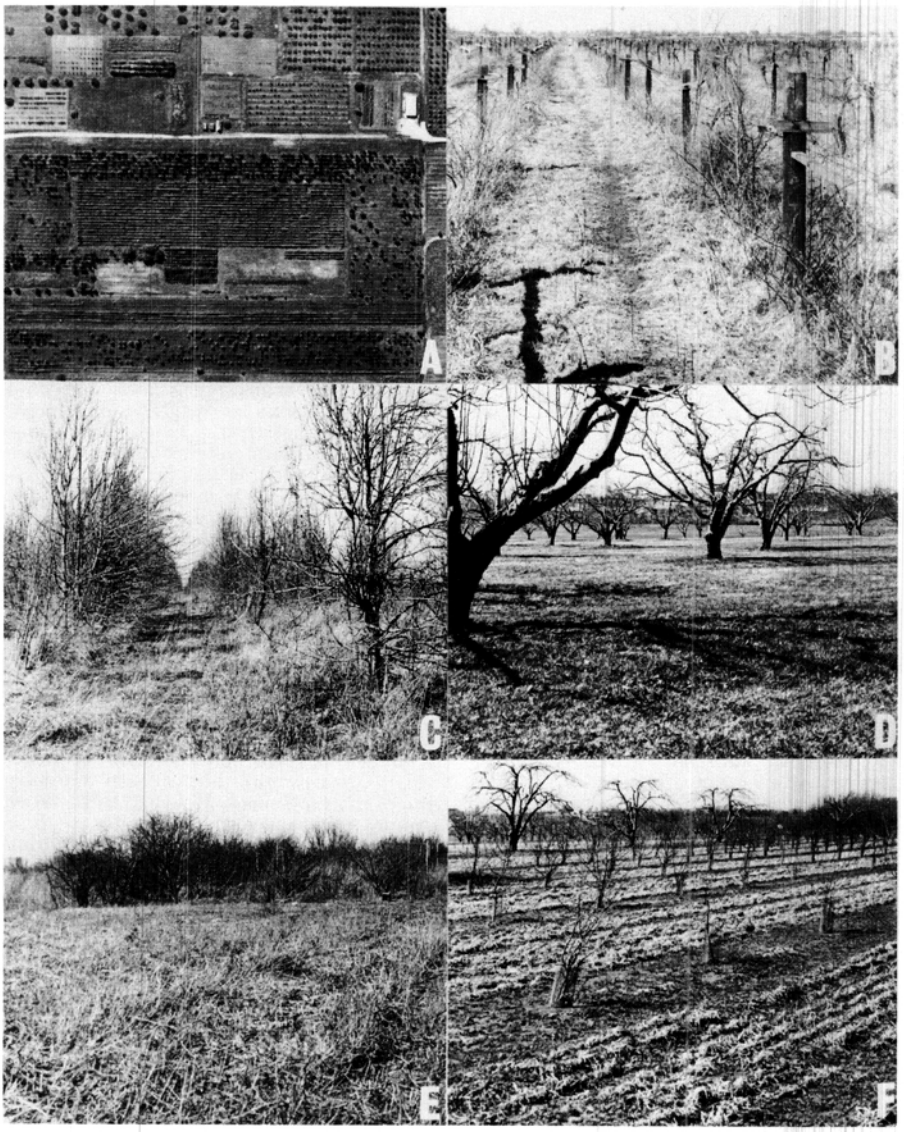

FIGURE 1.—*A*, aerial photograph of the study area taken during the summer of 1966; *B*, grape arbors—dense woody overstory with partly mowed forbs and grasses; *C*, dense woody overstory with unmowed forbs and grasses; *D*, sparse woody overstory with mowed grass; *E*, Foreground—unmowed weedy forbs; *F*, sparse woody overstory with autumn-planted cover crop of oats.

each when captured. Each animal was livetrapped, sexed, eartagged, weighed, fitted with a collar-mounted radio transmitter, and released where captured on the study area. The rabbits were radio-located every 15 minutes between 4 or 5 PM and midnight (CST) during from one to nine nights each (mean = 4.9 nights/rabbit). Tracking was conducted on 18 nights and a total of 72 rabbit-nights of data were obtained.

Transmitters used on the rabbits were designed by Cochran (1967); maximum ranges of the transmitters on cottontails varied between 3/8 and ½ mile.

Movements of the 16 rabbits were monitored using a truck-mounted and a stationary receiver in 1966 and two truck-mounted receivers in 1967. Each receiver had a manually rotated, directional receiving antenna 10-25 feet above the ground. Each antenna was a two-yagi interferometer providing a sharp null between two signal peaks. The receivers were stationed approximately 700 feet apart.

System error (Heezen and Tester, 1967) averaged ± 1.9°. Average distance between 29 positions of test transmitters scattered over the study area and radio-indicated positions of these transmitters was 32 feet. Heezen and Tester (1967) have noted that system error increases in any direction from the optimum location, which is the 90-degree intersection of the bearing lines at the perpendicular bisector of the base line. In the present study, animals were trapped and released near the perpendicular bisector of the base line and receiving equipment was occasionally moved to improve accuracy. As a result, most of the animals' activities occurred in good locations for accurate tracking and the average error in locating rabbits is believed to have been less than 30 feet.

Data Analysis.—Data were analyzed using the University of Illinois IBM 7094 computer. A plotting program similar to one described by Siniff and Tester (1965) was used to draw maps of daily cottontail movements. Activity of each rabbit was measured by computing the average distance between successive radio-indicated locations taken at 15-minute intervals.

Home range limits were determined using all data for each rabbit and drawing lines between the outermost locations recorded, according to the minimum home range method as described by Mohr (1947). Home range area was computed and the area of each habitat type within each home range was measured using an aerial photograph.

A rabbit moving in a random manner within its home range would be expected to use habitat types in proportion to their prevalence within the home range. To evaluate use of habitat by each rabbit, the number of observations within each habitat type was compared with the number of observations expected within the type under conditions of random movement. Chi-square (Steel and Torrie, 1960: 352) was used to evaluate differences. Significant positive chi-square values represent animals using cover types more than expected under conditions of random movement. Significant negative chi-square values represent animals using cover types less than expected. If the rabbits' movements within their home ranges were primarily at random, few significant chi-square values would be expected. Conversely, if the rabbits' movements were primarily nonrandom, many significant chi-square values would be expected.

Since activity of rabbits and their use of habitat appeared to be affected by weather conditions, the data were grouped into (*a*) nights with 0-1 inch of snow on the ground, (*b*) a night with 4 inches of wet snow on the ground, and (*c*) a windy night with blowing and drifting snow. Respectively, these groups included (*a*) 16 nights with a total of 16 rabbits and 65 rabbit-nights; (*b*) 1 night with 2 rabbits; and (*c*) 1 night with 5 rabbits.

Results

Activity.—On nights with 0-1 inch of snow on the ground, the indicated average distance that rabbits moved during 15-minute periods between 4 PM and midnight was 77 feet (Fig. 2). Excluding the first hour which included data on rabbits that appeared to be sitting in daytime forms, the indicated average distance moved per 15 minutes varied between 66 and 95 feet.

Cottontail movements were reduced during the night with 4 inches

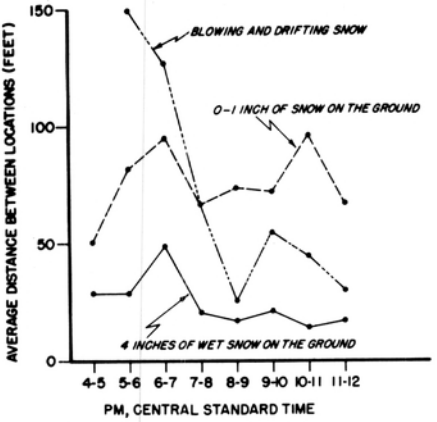

FIGURE 2.—Activity of radio-tagged cottontails during hourly periods on winter nights with different weather conditions. Activity is measured by average distance between radio-indicatel locations taken at 15-minute intervals.

of wet snow on the ground; the radio-indicated average distance moved per 15 minutes was 25 feet (Fig. 2). Although 25 feet approximated the average error of the tracking system, it was confirmed that the rabbits were active since some long movements occurred, some consecutive short moves in one direction occurred, and movements could be detected by changes in signal strength.

On the night with blowing and drifting snow, the radio-indicated average distance moved per 15 minutes decreased sharply from 149 feet during 5 to 6 PM to an average of 38 feet during 8 PM to midnight (Fig. 2). The early-evening movement of the rabbits appeared to be from daytime resting cover into habitat offering more shelter, since the blizzardlike conditions began in the late afternoon and increased in intensity during the tracking period.

Habitat Use.—Regardless of weather conditions, movements of the rabbits within their home ranges were not at random. Nonrandom movement, indicated by the numerous significant chi-square values in Tables 1, 2, and 3, suggests that rabbits were preferring some types of cover.

However, on nights with 0-1 inch of snow on the ground there was little consistency in use of habitat types among rabbits (Table 1). Consequently, when data for all animals were combined, average use of most cover types approximated the average prevalence of the types within the rabbits' home ranges (Table 1). The only notable exceptions were a preference for unmowed grasses in the understory and avoidance of areas with no woody overstory (Table 1). Of 16 rabbits, 8 used areas without woody cover slightly less than expected. Five of six cottontails having plots of an autumn-sown cover crop of unmowed, sparsely planted oats (Fig. 1*F*) within their home ranges used these plots more than expected, but the sixth cottontail appeared to avoid the oat plots.

On the average, 63 percent of the area within the home ranges of radio-tagged rabbits provided no understory cover (mowed and plowed ground, Table 1). On nights with 0-1 inch of snow on the ground, the animals showed no consistent tendency to avoid these open areas (as in Fig. 1*D*) and 57 percent of the radio observations indicated rabbits using mowed or plowed ground (Table 1). Even a freezing rain on January 12, 1966, did not result in a change in this pattern of cover use.

On February 1, 1966, with 4 inches of wet snow on the ground, the two rabbits being radio-tracked remained

TABLE 1.—Average Habitat Composition of the Home Ranges of 16 Cottontails and Their Use of Habitat Types during 16 Winter Nights with 0-1 Inch of Snow on the Ground.

Habitat Type	Average Composition of Home Ranges* (percent)	Average Habitat Use† (percent)	Number of Home Ranges Containing Habitat Type	Number of Rabbits Using Habitat Types Either More or Less Than Expected ($P<0.05$) More	Less
Understory					
Mowed grass	54	52	16	2	4
Plowed ground	9	5	13	2	4
Unmowed grass, including oats	3	6	6	5	1
Unmowed forbs and grass	14	17	16	5	2
Forbs and grass, mowed in strips	19	19	16	3	3
Unclassified	3	1	11	1	1
Total	102	100			
Woody overstory (2-20 feet tall)					
None	42	32	16	0	8
Sparse, crowns not touching	16	22	16	6	3
Dense, crowns mostly touching	39	44	15	6	2
Unclassified	3	1	10	0	1
Total	100	99			

* Averages are compiled from the percentages of each habitat type within each home range.

† For each rabbit, the percentages of observations that occurred in each habitat type were computed. These percentages were averaged to obtain figures in this column.

in habitat with dense woody overstory and with either mowed or partly mowed weedy forbs and/or grasses in the understory, (Fig. 1*B*, 1*C*). Chi-square values (Table 2) indicate their preferences for woody cover and their avoidance of areas, within their home ranges, that did not have woody cover.

On February 23, 1967, with blizzardlike conditions developing in late afternoon and persisting through the period of radio-tracking, five rabbits were being monitored. These animals spent most of their time in mixed stands of unmowed weedy forbs and grasses (Fig. 1*E*), especially after 8 PM, as snow drifts became deeper on the west edges of habitat blocks with ground vegeta-

TABLE 2.—Average Habitat Composition of the Home Ranges of two Cottontails and Their Use of Habitat Types during a Night with 4 Inches of Wet Snow on the Ground.

Habitat Type	Average Composition of Home Ranges* (percent)	Average Habitat Use† (percent)	Number of Home Ranges Containing Habitat Type	Number of Rabbits Using Habitat Types Either More or Less Than Expected ($P<0.05$) More	Less
Understory					
Mowed grass	45	0	2	0	2
Plowed ground	17	0	2	0	2
Unmowed grass, including oats	14	0	2	0	1
Unmowed forbs and grass	14	25	2	1	1
Forbs and grass, mowed in strips	9	75	2	2	0
Unclassified	1	0	1	0	0
Total	100	100			
Woody overstory (2-20 feet tall)					
None	45	0	2	0	2
Sparse, crowns not touching	14	0	2	0	0
Dense, crowns mostly touching	41	100	2	2	0
Unclassified	1	0	1	0	0
Total	101	100			

* Averages are compiled from the percentages of each habitat type within each home range.

† For each rabbit, the percentages of observations that occurred in each habitat type were computed. These percentages were averaged to obtain figures in this column.

tion. Most of these habitat blocks did not have woody overstories. Chi-square values (Table 3) indicate the rabbits' avoidance of open areas and their preference for areas with vegetation capable of stopping blowing snow near the ground.

DISCUSSION

On winter nights without deep snow or blizazrd conditions, this technique for studying cover use by cottontails failed to produce much evidence of cover preferences. While individual rabbits appeared to prefer certain cover types and to avoid others, there were few consistent patterns of apparent preference and avoidance among the animals monitored. This situation could have re-

TABLE 3.—Average Habitat Composition of the Home Ranges of five Cottontails and Their Use of Habitat Types during a Windy Night with Blowing and Drifting Snow.

Habitat Type	Average Composition of Home Ranges* (percent)	Average Habitat Use† (percent)	Number of Home Ranges Containing Habitat Type	Number of Rabbits Using Habitat Types Either More or Less Than Expected ($P<0.05$) More	Less
Understory					
Mowed grass	49	11	5	0	4
Plowed ground	9	0	5	0	1
Unmowed forbs and grass	21	61	5	4	0
Forbs and grass, mowed in strips	23	28	5	1	1
Total	102	100			
Woody overstory (2-20 feet tall)					
None	48	66	5	3	1
Sparse, crowns not touching	13	4	5	0	0
Dense, crowns mostly touching	40	30	5	2	2
Total	101	100			

* Averages are compiled from the percentages of each habitat type within each home range.

† For each rabbit, the percentages of observations that occurred in each habitat type were computed. These percentages were averaged to obtain figures in this column.

sulted from one or more of the following possibilities: (1) This species' habitat requirements may be so generalized that in all but severe weather they are fulfilled within many different cover types. (2) Our method for classifying cover types may have been so superficial that we failed to measure the components of the habitat that were important to the animals. (3) Factors other than habitat preference or avoidance may have been more important in determining the rabbits' movements. The last two possibilities have the support of evidence in Table 1. This evidence is the preponderance of significant chi-square values, both positive and negative, indicating that the rabbits were not moving within their home ranges in a random manner but that habitat factors, as measured, were not responsible for their nonrandom movement. Social factors,

perhaps avoidance of other individuals or social groups, may have determined this nonrandom movement. Marsden and Holler (1964:32, Fig. 10) recorded similar nonrandom use of the area within a pen by cottontails from two, apparently territorial, breeding groups.

Data obtained on nights with 0-1 inch of snow on the ground suggested that the rabbits preferred to use a sparse stand of planted oats. The lower portions of these plants remained green throughout the winter and we believe that rabbits were attracted to them as food. Hendrickson (1938), Allen (1939), Hosley (1942), and Tiemeier et al. (1965) have noted that lagomorphs use planted grains as winter food.

During nights without deep snow or blizzard conditions, the rabbits made much use of the extensive areas of mowed grass on the study area. They may have been feeding on these grasses (mostly bluegrass). The rabbits' use of areas without concealing cover near the ground suggests that good habitat for cottontails need not include broad areas of dense herbaceous cover which hinders visibility and travel.

On nights with 0-1 inch of snow on the ground, the rabbits showed a slight tendency to avoid areas without woody cover. This trend was pronounced on the night with 4 inches of snow on the ground, when the animals moved less and remained in areas with dense woody cover. Allen (1939), Haugen (1942), and Johnson and Hendrickson (1958) have cited evidence of increased use of heavy cover by cottontails during winter, especially during periods with deep snow.

During blizzard conditions, the cottontails showed a preference for habitat with unmowed weedy forbs and grasses. This cover offered the most protection from wind and blowing snow near the ground.

Although considerable time and effort were expended in this research, our objective of ascertaining habitat preferences of cottontails during winter was not well met. It is suggested that future research of this type be conducted in such a way as to satisfy as many as possible of the following conditions: (1) All of the animals within the population should be radio-tagged, as can be done with a penned population. (2) Habitat on the study area should be controlled to provide fairly large blocks of homogeneous, well-defined cover types providing distinctly different habitat conditions. (3) Visual observations should supplement radio-tracking to clarify the activities associated with radio-observed movements. (4) The social structure of the observed population should be studied and the movements of the animals should be examined for interactions among individuals.

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