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# POPULATION STUDIES OF SEED-EATING MAMMALS

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The Sewanee Research Center has installed studies concerning direct seeding and planting of southern pines on the Cumberland Plateau near Sewanee, Tennessee. A major consideration in the success or failure of these installations is the effect of pine-seed-consuming mammals and gnawing rodents on germination, growth, and/or survival, respectively. This investigation is primarily a study of the species on a two-acre experimental tract, their abundance during the months and seasons, the extent of their ranges, their habitat preferences, sex and age ratios, food habits, and breeding seasons for a period of one year. In addition, laboratory studies were made to determine the effectiveness of repellent coatings on pine seed and to enable recognition of damage to pine seed by various species of small mammals captured from the tract.

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## Review of Literature

According to Smith and Aldous (1947), attempts to restock coniferous forests by sowing seed have been successful only often enough to keep foresters interested in this mode of reforestation. They list 44 small mammal and 37 bird species found to eat conifer seed therefore potentially important factors in the failure of conifer seed-sowing. They mention that weather, fungus, chemical composition of the soil, etc. may play as much or greater role than birds and mammals and that some animals actually disperse seed and aid in germination of seed by passing them through the digestive tract.

McCarley (1954a, 1954b) indicates that the cotton mouse (*Peromyscus gossypinus*), an important seed eater, has its peak of highest population density in winter and lowest in late summer for eastern Texas. This may indicate that the breeding season for this species is in late fall, unless his high winter catch is due to hunger when food is scarce. On the other hand, if mice are more abundant in winter, their density peaks would be at the time when pine seed are on the ground and suscep-

tible to consumption by rodents. Guttenburg (1953), however, found that in southern Arkansas, rodent populations at times decline so much that they are temporarily, at least, not a menace to pine seed.

Calhoun (1941) found that *Peromyscus leucopus* mice are decidedly herbivorous and *P. gossypinus* predominantly carnivorous in the vicinity of Reelfoot Lake, Tennessee. Annual flooding of the latter's habitat may influence its diet.

Fitch (1954) shows that shrews, classified as insectivores, can be potential pine seed enemies. He trapped shrews using pine seed as bait, but caught more in wet weather and winter when invertebrates are not readily available. Shrews caught in live traps had gnawed the seed in characteristic manner, making them distinguishable from rodent-gnawed seed and shrew damage was later identified in artificially and naturally sowed pine seed.

Mohr (1943) states that mammals may not be uniformly distributed in an area, if they are not numerous enough to fill the area uniformly or if there are undesirable or uninhabitable portions of the area.

Townsend (1935) found that shrews would move into a "trapped-out" area even during a short census trapping period. If shrews are removed from their territories, others replace them if they are available from nearby areas.

Burt (1940) found that 13 *Peromyscus leucopus* mice occupied practically all of an area of 1.8 acres in southern Michigan between August 11 and October 15. During July, 8 mice occupied only 1.6 acres or about 5 mice per acre. The highest density was 7.4 mice per acre. Average home range of 65 adult females was 1,012 square yards and of 58 adult males was 1,412 square yards. Home ranges did not overlap each other and equalled home territories or the areas defended by mice against competitors.

Stickel (1954) found for wood mice that average length of range was about 100-150 feet with a few males ranging as far as 220 feet and a few females as far as 205 feet. Greater travel records are common among sub-adults which have not usually established home territories.

McGregor (1958), working on the Maybeso Experimental Forest in southeastern Alaska, live trapped 147 separate small mammals (chiefly *Peromyscus maniculatus*). Of these, 124 mice were toe-marked and released. Twenty-three were recaptured once; 7 twice; 1, three times; and 1, four times. Twenty-three per cent of the mice died in the live traps and many died soon after release. He made no mention of cotton bedding in traps, and, as the temperature dropped to 29° to 33° F., the mice probably died of exposure. He found that between August and

October is the time for population increase and that small mammal density on favorable plots was as high as 6 per acre, but averaged 1.2 to 4.0 per acre on clear cut plots. He experimented with poisoning (wheat grains dyed green and soaked in sodium fluoroacetate-formula 1080). On the hillside area, mice were eliminated within 2 weeks and after 14 weeks were less than 40% of the original level. In the valley bottom, where mice were always of higher density than on the hillside, two weeks of poisoning markedly reduced the population, but after 14 weeks about 90% of the original level was found. He indicated that the usefulness of poisoned baits is limited because the population vacuum created is sometimes quickly reoccupied by mice from adjacent areas.

Blair (1941) gives precise techniques for trapping, marking, range studying, and recording of results. He mentions that the number of individuals is constantly changing. Because of this, trapping should be over a short period. He found that one week of intensive trapping at various intervals (months or seasons) during the year to be a satisfactory unit of time in most studies.

Davis (1956) gives the best and most complete directions for trapping and study of small mammals. Some of his methods, however, can be improved upon; namely, 1. the type of live traps he recommends has proven unsatisfactory in this locality, 2. a "hardware cloth" funnel makes a much better receptacle for removal of mice from live traps than a cloth bag, and 3. ear markings are much easier to accomplish and to detect than are toe markings in mice.

## Materials and Methods

During July and October, 1957, and January and April, 1958, which are representative months of the seasons, there were ten days of live trapping using 70 no. 0 Havahart traps set in a semigrid arrangement to prevent trap-tenders from trampling seedlings (see map 1). Because some lines ran through thick underbrush, all lines were laid out using kite string. Trap locations were marked with flags of starightened coathanger wire with a red cloth tied to the ring at top. Trapped mammals were ear-marked by clipping notches with scissors and by punching holes with a small ear punch. An almost unlimited number of different markings and combinations were thus secured and the mammals were more easily identified than those marked by toe clipping. A half-inch mesh "hardware cloth" cone to which was sewed a twelve inch cloth sleeve was used to remove mammals from traps and for securing them for marking and identification. A trap was inserted into the sleeve and the door opened to let the captive enter the cone which was then flattened somewhat by a squeeze to hold the animal tightly in the apex. Ears could then be pulled through the

mesh for marking. Marked animals were released for recapture so that their movements could be followed and populations calculated.

During the other months there were two days of dead trapping to enable the making of study skin and skull collections for systematic studies and stomach analyses and to remove mice from the area to check replacement rates. Seventy Victor museum-type snap traps placed in the same positions as the live traps were used for this trapping. They were fastened to the above-mentioned flags with small wires. All traps whether live or snap traps were baited with a mixture of peanut butter, rolled oats, and a slight amount of bacon grease, as suggested by Davis (1956). The live traps always contained a small wad of cotton for use as nesting material which, unless soaked by heavy rains, protected the captured animals from death by exposure.

At the completion of both July and January live-trapping periods, two whitefoot mice were caged for tests with untreated and repellent-treated pine seed and to secure seed hulls for mouse damage recognition studies. The ingredients of the repellent and the rate of application were as follows:

(1) Endrin: 0.01 pound ENDRIN (50% wettable powder) per pound of seed. This amounts to 0.5% active Endrin per pound of seed.

(2) Thiram: 0.054 pounds ARASAN 75 (75% tetramethyl thiuram disulphide) per pound of seed. This amounts to 4% active thiram per pound of seed.

(3) Aluminum powder: 0.1 ounce per pound of seed.

(4) Dow Latex 512-R: Enough diluted latex (1 part 512-R to 10 parts water) to wet the seed.

The two mice in July were offered dishes of 20 untreated and 20 treated shortleaf pine seed simultaneously to determine if there was any acceptance preference. This offer was repeated for four nights to determine if mice learn by taste experience to avoid treated seed.

The two mice in January were offered treated and untreated, mixed shortleaf and Virginia pine seed every night for a week. Next, treated and untreated loblolly pine seed were placed in the cages for seven nights. This was followed by offering the mice untreated seed of both shortleaf-Virginia mixture and loblolly to determine if there was a preference for certain kinds of pine seed. Finally, the mice were offered the choice of eating treated seed or going hungry for two nights.

## Results and Interpretations

The ten-day live-trapping periods yield information on the approximate number of white-foot mice that the tract supports, their home ranges and territories, and social habits. In addition,

live trapped animals are used for testing the effectiveness of repellent coat on pine seed. The two day trapping periods enable the making of study-skins and skulls for exact identification and determination of food contents of stomachs. Live-trapped animals are either empty or full of bait. Combined live-trapping and dead-trapping gives information on the species encountered, their sex ratio, their breeding habits, their preferences for disked or undisked plots, and make it possible to determine if and when other individuals move into the tract when teh residents are removed.

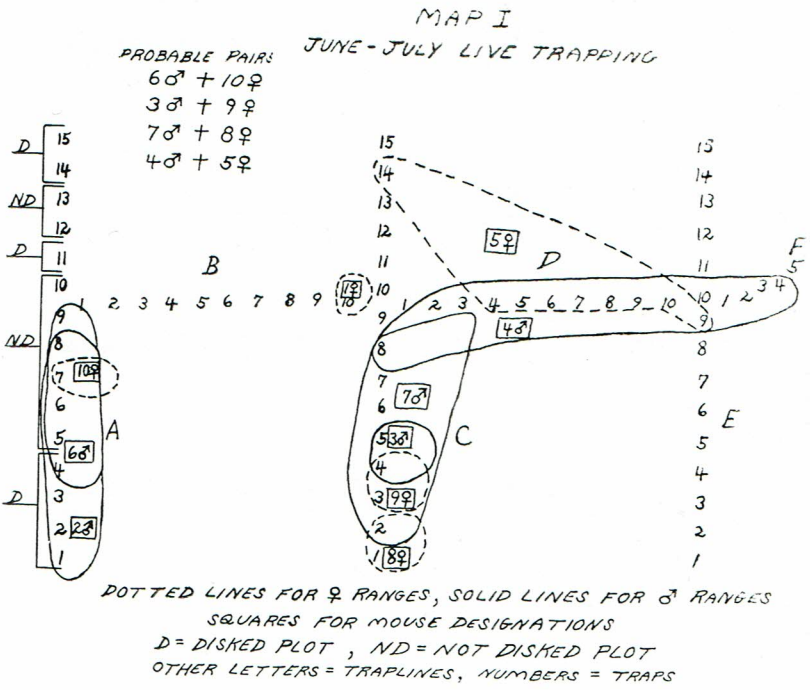
## List of Species

Because hereafter in this report only common names of small mammals are used, it is best to list the scientific names at the first of the results. The following potential enemies of pine seed were trapped during the year investigation: Bachman's shrew, *Sorex longirostris longirostris* Bachman; short-tailed shrew, *Blarina brevicauda carolinensis* (Bachman); lesser short-tailed shrew, *Cryptotis parva parva* (Say); and white-foot mouse, *Peromyscus leucopus leucopus* (Rafinesque). Representative specimens of these were made into study skins and skulls. The lesser short-tailed shrew is a new record for this species on the Cumberland Plateau.

## Sex Ratios

Tables 1, 2, 3, and 4 show the sexes of the captured white-foot mice. Sexes were remarkably even, indicating that trapping was rather complete in the ten day live-trapping periods. In July and in October 5 males and 5 females were captured; in January, 3 males and 5 females; and in April, 1 male and 1 female. One male and one female were caught during two different periods; therefore, they count only once in the total sex counts. Thus, there were 13 males and 15 females for live-trapping results. The two-day dead-trapping periods yielded a total of 6 males and 5 females. Three of these males and two females had been marked and counted in the live-trapping periods; therefore they are not included in the combination totals of both types of trapping. Thus, 16 different males and 18 different females, making a total of 34 white-foot mice, were captured during the year. There is evidence that one male sometimes takes more than one female (see discussion of Social Habits, below).

The 3 long-tailed shrews, 1 short-tailed shrew, and 1 lesser short-tailed shrew were all females. Male shrews were probably on the tract or in the surrounding area, but avoided capture. No special effort was made to collect shrews, and they do not very readily enter mouse traps when insects are abundant.




## Capture Sites in Relation to Plant Cover

Map 1 shows the arrangement of disked and not disked plots within the experimental tract. The data from both live and dead-trapping were examined to determine if there is any correlation between the site of small mammal capture and the amount of plant cover. Data from lines B and D are omitted because they both lie entirely within undisked tracts. Thus the total count of traps in undisked plots equalled that of the disked plots for this comparison.

Combining the data from July through October showed:

| | Disked | Not Disked |
|---|---|---|
| Line A | 11 | 10 |
| Line C | 13 | 12 |
| Line E | 2 | 9 |
| Line F | 0 | 2 |
| Total Captures | 26 | 33 |

Table I. First Live Trapping Data, June 30-July 9, 1957.

| Mouse Designation | Sex | Age | Breeding Condition | No. of Times Caught | Taken on Lines | Distance in one Night | Distance Between any 2 Coll. Traps |
|---|---|---|---|---|---|---|---|
| P. L. 1 | ♀ | Small | Negative | 1 | B | ——— | ——— |
| | | Adult | ——— | | | | |
| P. L. 2 | ♂ | Immature | ——— | 6 | A | 129 ft. | 141 ft. |
| P. L. 3 | ♂ | Adult | ——— | 2 | C | 12 ft. | 12 ft. |
| P. L. 4 | ♂ | Adult | ——— | 7 | C.D.F | 108 ft. | 192 ft. |
| P. L. 5 | ♀ | Adult | Negative | 7 | C.$\overline{D}$.E | 121 ft. | 137 ft. |
| P. L. 6 | ♂ | Adult | ——— | 6 | $\overline{A}$ | 24 ft. | 52 ft. |
| P. L. 7 | ♂ | Adult | ——— | 5 | C.D | 80 ft. | 140 ft. |
| P. L. 8 | ♀ | Adult | Pregnant | 2 | $\overline{C}$ | 0 ft. | 0 ft. |
| P. L. 9 | ♀ | Immature | ——— | 2 | C | 12 ft. | 12 ft. |
| P. L. 10 | ♀ | Adult | Negative | 1 | A | ——— | ——— |
| S. L. 1 (shrew) | ♀ | Adult | Nursing | (found dead in trap 13, line A on July 7) | | | |

Table II. Second Live Trapping Data, October 10-19, 1957

| Mouse Designation | Sex | Age | Breeding Condition | No. of Times Caught | Taken on Lines | Greatest Distance in one Night | Greatest Distance Between any 2 Coll. Traps |
|---|---|---|---|---|---|---|---|
| P. L. 9 | ♀ | Adult | Negative | 4 | *C*,D | 35 ft. | 35 ft. |
| P. L. 11 | ♂ | Adult | ——— | 5 | *A*,*B*,D | 92 ft. | 182 ft. |
| P. L. 12 | ♀ | Adult | Negative | 8 | E,*C* | 183 ft. | 183 ft. |
| P. L. 13 | ♂ | Adult | ——— | 3 | *C*,E | 175 ft. | 180 ft. |
| P. L. 14 | ♀ | Adult | Negative | 2 | A | 24 ft. | 24 ft. |
| P. L. 15 | ♂ | Adult | ——— | 2 | B | 12 ft. | 12 ft. |
| P. L. 16 | ♀ | Adult | Pregnant | 2 | E | 12 ft. | 12 ft. |
| P. L. 17 | ♂ | Adult | ——— | 1 | A | ——— | ——— |
| D. 1 | ♂ | Adult | ——— | 1 | E | ——— | ——— |
| D. 2 | ♀ | Adult | Negative | 1 | A | ——— | ——— |
| C. P. (shrew | ♀ | Adult | Negative | (trap 8, line C on October 12) | | | |
| S. L. 3 (shrew) | ♀ | Adult | Negative | (trap 10, line D on October 16) | | | |

Table III. Third Live Trapping Data, January 15-25, 1958.

| Mouse Designation | Sex | Age | Breeding Condition | No. of Times Caught | Taken on Lines | Greatest Distance in one Night | Greatest Distance Between any 2 Coll. Traps |
|---|---|---|---|---|---|---|---|
| P. L. 7 | ♂ | Adult | ——— | 5 | A | 134 ft. | 134 ft. |
| P. L. 18 | ♀ | Adult | Negative | 7 | C.E | 180 ft. | 292 ft. |
| P. L. 19 | ♀ | Adult | Negative | 9 | A.B | 133 ft. | 166 ft. |
| P. L. 20 | ♀ | Adult | Negative | 6 | A.B.C | 102 ft. | 138 ft. |
| P. L. 21 | ♀ | Adult | Negative | 6 | E | 85 ft. | 85 ft. |
| P. L. 22 | ♂ | Adult | ——— | 2 | C.E | 165 ft. | 165 ft. |
| P. L. 23 | ♂ | Adult | ——— | 3 | B.D | 120 ft. | 120 ft. |
| P. L. 24 | ♀ | Adult | Negative | 1 | E | ——— | ——— |

Table IV. Fourth Live Trapping Data, April 17-27, 1958.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| P. L. 25 | ♀ | Immature | ——— | 7 | C | 11 ft. | 11 ft. |
| P. L. 26 | ♂ | Immature | ——— | 1 | D | ——— | ——— |

Table V Dead Trapping

| Date | Designation | Sex | Age | Breeding Condition | Taken On Line | Trap No. |
|---|---|---|---|---|---|---|
| Aug. 14 | P. L. a. | ♂ | Adult | ——— | C | 13 |
| Aug. 15 | P. L. 6 | ♂ | Adult | ——— | B | 6 |
| Sept. 28 | P. L. b. | ♀ | Adult | Negative | C | 4 |
| Sept. 30 | P. L. 8 | ♀ | Adult | Negative | C | 1 |
| Sept. 30 | B. B. (shrew) | ♀ | Adult | Negative | A | 14 |
| Sept. 30 | S. L. 2 (shrew) | ♀ | Adult | Negative | E | 5 |
| Nov. 28 | P. L. 17 | ♂ | Adult | ——— | E | 10 |
| Dec. 18 | P. L. c. | ♀ | Adult | Negative | A | 4 |
| Feb. 26 | P. L. 24 | ♀ | Adult | Negative | A | 7 |
| Feb. 26 | P. L. d. | ♂ | Adult | ——— | A | 8 |
| Feb. 26 | P. L. 23 | ♂ | Adult | ——— | C | 6 |
| Mar. 29 | P. L. e. | ♂ | Adult | ——— | C | 3 |
| Mar. 29 | P. L. f. | ♀ | Negative | ——— | C | 6 |

These data indicate that the tracts which remained undisked and therefore undisturbed as to cover and burrows yield more catches than the disked areas, but not noticeably more. After October, the disked tracts were not easily distinguished from the undisked tracts because they were quickly being grown up with brush, weeds, and saplings.

As a check on the above results, data for November through June was summarized. The totals were more equal when the plots were more equal in cover:

| | November through June | |
|---|---|---|
| | Disked | Not Disked |
| Line A | 12 | 3 |
| Line C | 4 | 12 |
| Line E | 7 | 6 |
| Line F | 0 | 0 |
| Total Captures | 23 | 21 |

## Breeding Seasons

Comparing the data for the 12 months, it is notable that immature mice were captured in July and April and that pregnant mice were caught in July and October (see Tables). Evidently no young white-foot mice were born in the area during August and September, but were born in June, July, late October, late February, and early March. Whether this holds true every year has not been determined. Much depends upon the ages of the resident mice as to the time of breeding, when the season is favorable.

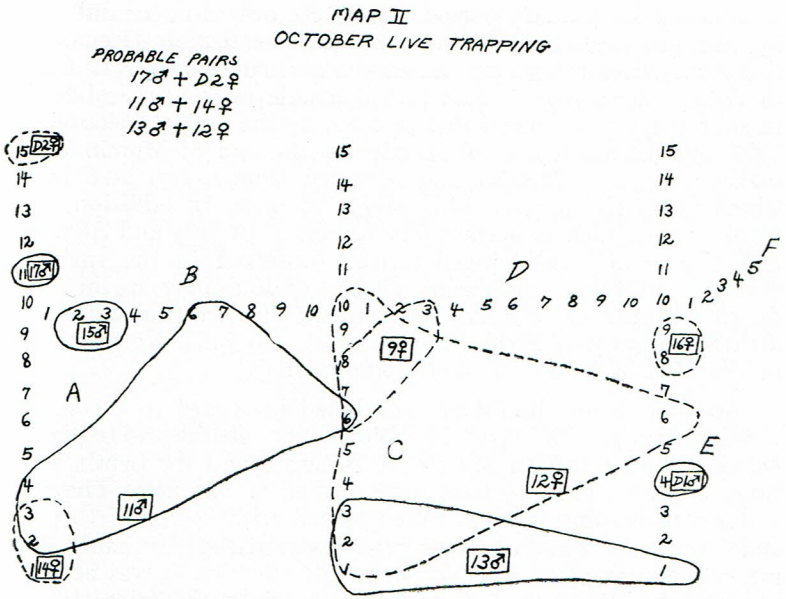
Only one shrew, the long-tailed species, gave any information on its breeding season. It was captured on July 7 and was nursing young.

## Number of Mice per Acre

The first ten day live-trapping periods give a fairly good idea of how many mice the tract supports (see tables I and II). During each of the first two periods 10 mice were captured. These were equally divided as to sex. Although there was a high percentage of recaptures, it is not believed that all mice on the tract were captured during either period. Probably 11 or 12 mice normally inhabit this area of two acres. The short spur of 5 traps making up line F is not within the two acres, but the only mouse (see map 1) taken on this spur was a regular inhabitant of the two-acre tract, and therefore this spur can be ignored. Therefore, the density of white-foot mice is about 5 to 6 per acre. This is about the usual density found by Burt (1940) for this species in southern Michigan.

MAP II

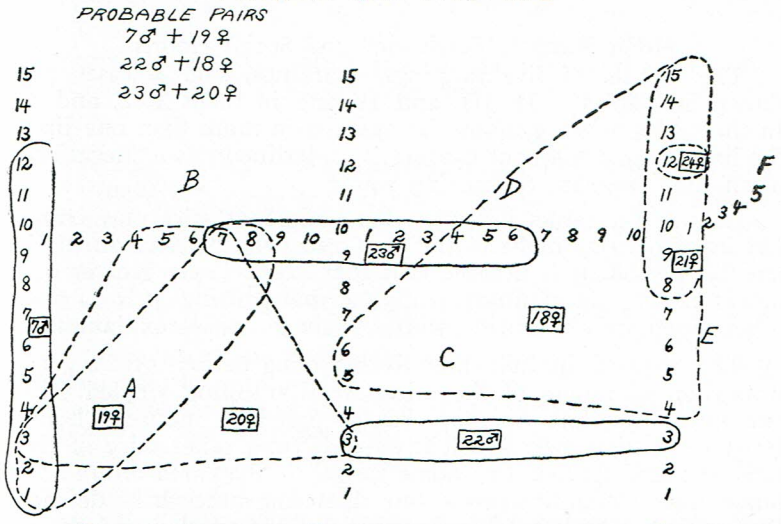
OCTOBER LIVE TRAPPING




DOTTED LINES FOR ♀ RANGES, SOLID LINES FOR ♂ RANGES
SQUARES FOR MOUSE DESIGNATIONS

MAP III

JANUARY LIVE TRAPPING




DOTTED LINES FOR ♀ RANGES, SOLID LINES FOR ♂ RANGES
SQUARES FOR MOUSE DESIGNATIONS

During the January period there were only 8 mice, and during the last period there were only 2. The section "Removals and Replacements", giving the known permanent removals from the tract, shows that 7 male and 6 female mice were collected in snap traps or drowned in live traps by the end of December, 1957, and 12 males and 10 females by the end of March. This makes a total of 22 mice trap-removed from a two acre tract which normally supports only about 12 mice. In addition, natural enemies such as blacksnakes (observed in July and August) and a pair of broad-winged hawks (observed in the spring), disease, and other population checks undoubtedly further reduced the number of mice. Recruitment of mice from adjacent areas is apparently rather slow, because no mice were caught in the May and June dead-trapping periods.

Another factor should be mentioned in regard to the small number of mice. On March 14 loblolly pine seedlings were planted on the tract and on March 19, 20 and 21 all the brush, saplings, etc. were cut and trees were girdled on the area. The cut surfaces of brush and trees were sprayed with 2, 4, 5-T to prevent regrowth. The cut brush was scattered, but probably did not offer much cover for mice to escape enemies. It was at first thought that the 2, 4, 5-T might have driven the mice out of the area or have poisoned them, but the two April-caught mice were in excellent physical condition, indicating that replacement from nearby areas by immature mice was slowly taking place. One of these mice was removed from the area for experiments and the other probably was killed by natural enemies, because no mice were caught in May and June.

## Home Ranges, Territories, and Social Habits

The results of live-trappings, markings, and releases are shown in Tables I, II, III, and IV and in maps 1, 2, and 3. In the tables, when a mouse is captured in more than one line, the line of most frequent capture is underlined; also, "negative" means not pregnant or nursing young.

Data in the tables indicates that white-foot mice may travel 183 feet from one night to the next and over 290 feet during a ten day period. It is notable that they ranged over greater distances during the January trapping than during July or October. Food scarcity during winter is the probable explanation.

The maps of the first three live-trapping periods give a good indication of ranges of the mice. April trapping yielded only two mice; therefore no map was prepared. A mouse's "home territory" is that area which it defends from other mice of the same sex and species. Its "home range" is that area around its home over which it travels but does not necessarily defend. Burt (1940) found that home ranges did not overlap and therefore equalled home territory in southern Michigan. Ranges on

the Sewanee tract do overlap, so home range exceeds home territory in area. We might expect immature mice to be found on the ranges of an adult mouse of the same sex. The adult is likely to be one of its parents and this is probably the case in map 1 of mouse no. 2, an immature male inhabiting the same range as no. 6 which is an adult male. In July, the range of adult male no. 7 overlapped that of adult male no. 4 and included that of adult male no. 3. This overlapping of male ranges is rather unusual and did not occur in October and January. In October, the range of adult female no. 9 overlapped the extensive range of adult female no. 12. In January, ranges of females nos. 18, 21, 24 overlap as do those of females no. 19 and 20. Perhaps it is not unusual for the female ranges to overlap, as females may not defend home territories to the same extent as do males.

In June, July and January, male mice tended to confine their ranges to certain paths made by the trap tenders. This was not noted in October.

A list of probable pairs or mates of mice based on ranges is shown on each map. It is notable that ranges of members of a pair do not exactly coincide. In October, there is some indication that male no. 11 is promiscuous because his range overlaps those of females nos. 14, 9, and 11. In January, male ranges overlapped the ranges of two different females, but female no. 19 is most likely the mate of male no. 7 because they were usually caught only two traps apart. This also holds true for the other males and females listed as probable pairs on the map.

Trap captures over a short period do not show the full extent of any mouse's range, and low number of recaptures or no recaptures give very little idea of the ranges of some mice. There are examples in each of the three maps.

## Removals and Replacements

Mice and shrews were permanently removed from the tract when caught in snap traps and when they died in live traps. As might be expected, all the shrews, which have a high metabolic rate, were found dead in the live traps. In spite of cotton bedding in live traps, unusually heavy rains managed to soak the cotton and kill the mice at times. Undoubtedly natural enemies – disease, inclement weather, owls, hawks, snakes, etc. removed small mammals from the tract every month. The following were removed by trapping:

July—1 female long-tailed shrew.
August—2 male white-foot mice.
September—3 female white-foot mice, 1 female short-tailed shrew, 1 female long-tailed shrew.
October—4 male and 2 female white-foot mice, 1 female lesser short-tailed shrew, 1 female long-tailed shrew.
November—1 male white-foot mouse.
December—1 female white-foot mouse.

January—1 male and 2 female white-foot mice.
February—2 male and 1 female white-foot mice.
March—2 male and 1 female white-foot mice.
April—1 female white-foot mouse.

No mammals were captured in May and June.

Data in Tables I and II indicate a marked turnover in the mouse population. "New" mouse inhabitants came from adjacent areas and/or from young mice maturing within the tract.

There is evidence that mice may shift their ranges considerably. Male no. 7 was captured 5 times on lines C and D during July, but if it was on the tract during the months from then until January, it was unusually successful in evading the traps. In January, it reappeared and was captured 5 times on line A, indicating a shift of range.

On November 28, male no. 17 was captured in trap no. 10, line E. It had been captured and marked on October 18 from trap no. 11, line A. Thus it had moved a distance of 334 feet since its first capture. Because it was killed by the snap trap, no proof can be shown that it had changed its territory after the October capture, but mice can move and establish new territories in areas where former residents were removed.

Female no. 24 was captured on February 26th. from snap-trap no. 7, line A. It had been live trapped in trap no. 12, line E in January; therefore it had moved 345 feet since February. Whether this represents a shift of territory for this female to line A, from which a female was removed by drowning in January, cannot be determined, but is suspected.

Mice nos. 6, 8, and 23, which were dead-trapped, kept in the same general region as their original ranges.

Up through January there was little diminution in number of mice on the two acres, but after that month, perhaps the drain on breeding stock by trap and natural enemies had reduced even the population from adjacent areas. Nevertheless, this is only a two-acre tract, and methods which might control mice in such a small experimental area would not give satisfactory results nor be financially feasible on large pine-planting areas. In all mouse control projects, areas adjacent to planting areas would have to be cleared of mice to delay replacement.

## Difficulties

The main difficulties encountered in this investigation are included here because they affected the number of mice captured and because they may help other persons avoid them.

During warm and hot weather, insects, especially ants, would swarm over the bait and would effectively clean out snap traps overnight. Crickets, grasshoppers, long-horned locusts, and snails also caused some loss of bait and often sprung both live traps and snap traps. Wrens were caught in live traps three times

and fence lizards twice. They were probably seeking the ants on the bait. The chief interest of all these animals in this investigation is that they spring and debait traps and make them unavailable for rodents and shrews. When numerous, they may seriously interfere with trapping. Live traps are less affected by insects than snap traps because the former carry much more bait and are generally not as easily sprung. They can be used for both dead and live trapping, but have the disadvantages of being more expensive and more cumbersome to handle the snap traps.

During the October live-trapping period, many traps were repeatedly turned over and robbed of their bait, but a large boxtrap baited with the same mixture as the mouse traps soon captured a large male opposum and the robbing ceased. The use of boxtraps to temporarily eliminate opposums and raccoons from interference in rodent studies may be quite desirable because these particular predators would rarely catch a free, live mouse and only rob or disturb the traps. By employing live trapping, they can be returned to the area when the 10-day trapping period is completed, if desired. It would be undesirable in an ecological study to remove the natural mouse enemies.

Rain and snow sometimes interferred with trapping by killing the live-trapped mice in spite of cotton bedding material. Placing the traps in sheltered spots helps prevent this.

### Mouse Food Habits

Examination of stomach contents was rather disappointing. Of 11 white-foot mice which were dead-trapped, only 5 stomachs contained food material. The two males collected in August contained remains of grasshoppers. In September and December, the three females contained carabid beetle remains and unidentified chewed seed material. These experiments show that white-foot mice are omnivorous and eat both seeds and insects when they are available.

As mentioned in "Review of Literature" above, shrews are classified as insectivores but eat seed when insects are scarce. All the trapped shrews were empty, but one live long-tailed shrew captured on another area readily ate pine seed which it chewed in such a manner that the hull remains were usually horseshoe-shaped. Whitefoot mice, on the other hand, usually gnawed pine seed in a different manner from shrews and left large and small hull fragments which were rather irregular in shape.

### Effectiveness of Repellent Coat on Pine Seed

In the laboratory experiments on effectiveness of repellent coat on pine seed (see "Materials and Methods"), the July mice ate the majority of both treated and untreated shortleaf pine seed for the first two nights, but it was observed early each

night that the untreated seed were attacked first. On the third night a noticeably greater quantity of untreated seed than treated seed was eaten. On the last night the treated seed were left relatively unmolested whereas the untreated seed were nearly all eaten. This test indicated that there was some establishment of preference for the untreated seed and avoidance of the treated seed after several days of tests.

In the January experiments, the two mice (different individuals than the July mice which had been adapted to eat only untreated seed) ate the untreated mixed shortleaf-Virginia pine seed and avoided the treated seed unless there were no untreated seed left to eat. When only treated seed were left in the cages, they were sparingly eaten. Thus these two mice showed less inclination to eat treated seed than did the July mice.

The next week, these mice left the treated loblolly seed unmolested and ate the untreated loblolly seed sparingly. They also favored the small untreated shortleaf and Virginia pine seed over the large untreated loblolly pine seed. Untreated loblolly seed were eaten only if nothing else was available or if the mice had to choose between untreated loblolly and treated seed of any kind. After being forced to eat loblolly seed, the mice were again allowed to choose between untreated shortleaf-Virginia seed and loblolly seed. This experiment was to determine if they would change their preference after having learned to open the loblolly and having tasted the loblolly seed. As previously, the mice always chose the shortleaf-Virginia seed. The shells of the loblolly seed are considerably harder and thicker than those of the shortleaf and Virginia pine seed and because white-foot mice are not prone to cut through hard seed or nuts, they prefer to eat more easily obtainable food. Mr. T. A. Harrington of the Sewanee Research Center has informed me that in actual seeding with untreated pine seed, the loblolly seed are not eaten as frequently by mice as those of shortleaf and Virginia pines.

In the final test in which the mice were forced to eat treated pine seed or go hungry for two nights, few seed were eaten, but those eaten had no apparent adverse effects on the mice. Hooven (1957) scattered ½ pound of Douglas fir seed per pound over three ten-acre plots in north-western Oregon. Two plots were seeded with Endrin-treated seed (Endrin at the rate of one per-cent of the weight of the seed) and one with untreated seed. Apparently his Endrin-treated seed acted as a rodenticide as there was a great reduction in mice and shrews in the first two plots and only a slight reduction in mice and shrews in the plot with untreated seed. Plot no. 2 apparently was completely cleared of mice and shrews for over 6 weeks. In the above laboratory tests, in which 0.5% active Endrin per pound of seed

was used, no deaths resulted in any mice. More experiments will be necessary to determine if Endrin is a good rodenticide.

I conclude that the repellent mixture gives considerable protection to pine seed from rodents when any other food is available and that loblolly seed, because of their thick, hard shells, are not eaten as readily as the thin-shelled seed of shortleaf and Virginia pines. For this reason, it may be desirable to plant loblolly instead of these other pine seed where ecologically and geographically feasible and where mice are common. It is doubted that the hard shells of loblolly seed will offer much protection against chipmunks, red squirrels, rats, and certain seed-eating birds.

## Summary

White-foot mouse, Bachman's shrew, short-tailed shrew, and lesser short-tailed shrew were captured, the last species being a new record for the Cumberland Plateau. Sex ratios of mice were remarkably even and young were born during June, July, late October, late February and early March. A predominance of mice were captured in the undisked plots until November when underbrush growth covered the disked plots. This indicated a preference for areas which contain cover. Although 34 different mice were captured during the year, the tract supported only 5 to 6 mice per acre at any one time. By the end of the investigation the mouse population was reduced to one per acre due to dead-trapping and natural enemies. This is not indicative that trapping is a good method of control. Recruitment of mice from adjacent areas rapidly replaced the mice during summer and fall trapping periods. Pairs of mice established home ranges but these overlapped one another to a certain extent. It was not unusual for a mouse to range 183 feet during one night, but usually ranged less in the summer and fall when food is more accessible. Laboratory experiments with captured mice showed that repellent-coated (Arasan 75 and Endrin) seed were less readily eaten than untreated seed and that mice learned to avoid the former. The untreated, large, hard-coated loblolly pine seed were not eaten when any of the thinner-shelled pine seed such as Virginia and shortleaf were available. In conclusion, the wide-ranging white-foot mouse poses a definite problem to re-seeding forested areas. Population control measures are, as yet, not practical, but the use of repellent-treated seed and loblolly pine seed where ecologically and geographically feasible should greatly enhance the success of re-seeding.

## LITERATURE CITED

Blair, W. F. 1941. Techniques for the study of mammal populations. *Jour. Mammology 22* (2):148-157.

Burt, W. H. 1940. Territorial behavior and populations of some small mammals in southern Michigan. *Misc. Publ. Museum Zool., Univ. Mich. 45*:1-58.

Calhoun, J. B. 1941. Distribution and food habits of mammals in the vicinity of Reelfoot Lake Biological Station. *Jour. Tenn. Acad. Sci. 16*:207-225.

Davis, D. E. 1956. Manual for analysis of rodent populations. Div. of Vert. Ecology, School of Hygiene and Public Health, The Johns Hopkins University.

Fitch, H. S. 1954. Seasonal acceptance of bait by small mammals. *Jour. Mammology 35* (1):39-47.

Guttenberg, S. 1953. Direct seeding of old fields with rodenticide-treated loblolly pine. Office report summary, Southern Forest Experiment Station (Unpublished)

Hamilton, W. J. 1943. The mammals of eastern United States. Comstock Publishing Co., Ithaca, New York.

Hooven, E. F. 1957. Field test of Endrin-treated Douglas fir seed. Research note No. 28. Oregon Forest Lands Research Center, Corvallis, Oregon.

Kellog, Remington. 1939. Annotated list of Tennessee mammals. *Proc. U. S. Nat. Mus. 86*:245-303.

McCarley, W. H. 1954a. Fluctuations and structure of *Peromyscus gossypinus* populations in eastern Texas. *Jour. Mammology 35* (4):525-532.

McCarley, W. H. 1954b. The ecological distribution of the *Peromyscus leucopus* species group in eastern Texas. *Ecology 35* (3):375-379.

McGregor, R. C. 1958. Small mammal studies on a southeast Alaska cutover area. Station Paper No. 8, Alaska Forest Research Enter, U. S. Dept. Agri., Forest Service, Juneau, Alaska.

Mohr, C. O. 1943. A comparison of North American small mammal censuses. *Amer. Mid. Nat. 29* (3):545-587.

Smith, C. F. and S. E. Aldous. 1947. The influence of mammals and birds in retarding artificial and natural reseeding of coniferous forests in the United States. *Jour. Forestry 45* (5):361-369.

Stickel, L. F. 1954. A comparison of certain methods of measuring ranges of small mammals. *Jour. Mammology 35* (1):1-15.

Townsend, M. T. 1935. Studies on some of the small mammals of central New York. *Roosevelt Wildlife Annals 4* (1):1-120.

## NEWS OF TENNESSEE SCIENCE

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*Biology Division — Oak Ridge National Laboratory*

Franco Celada, a United States Public Health Service Fellow, joined the Radiation Immunology Group in October. Dr. Celada received the M.D. degree from the University of Milan, Italy, in 1956, and since that time has served in the Italian Army.

Valerio C. Monesi, also a United States Public Health Service Fellow, has joined the Mammalian Genetics and Development Section. Dr. Monesi received the M.D. degree from the University of Pavia, Italy, and comes to the Division from the National Division for Nuclear Researches, Frascati, Italy.

Charlotte R. Lea is spending this year with the Enzymology Group as a Research Associate. Miss Lea expects to receive the Ph.D. in Biochemistry from Emory University in December.

Gustavo Cudkowicz, under a grant from the International Cooperation Administration, has joined the Pathology and Physiology Section for a period of one year. Dr. Cudkowicz received his M.D. from the Medical School of

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