RODENT PROBLEMS ON PRIVATE FOREST LANDS IN NORTHWESTERN CALIFORNIA

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FOREST RODENTS

Rodents damage is important to forest management and is adequately described in the literature (Kverno, 1964; Hooven, 1958, 1959; Lawrence, 1958; Isaac, 1943; Kangur, 1954; Tevis, 1956a). It is not the intent of this paper to reiterate the types of damage or the rodents involved; the reader who is interested in this topic is particularly directed to the work of Lawrence, Kverno, and Hartwell (1361).

This paper is concerned with the major forest rodent control efforts currently being employed in northwestern California. It will describe the background of literature and investigation from which present practices evolved, the implications that these practices have on forest management, and the indicated future needs for the control of forest rodents.

The most dramatic examples of rodent damage to forest crops occur during the early years of the forest stand. The ecological vacuum created by logging results in the creation of many new ecological niches which did not exist under the canopy of the well stocked conifer forest. Significant species suddenly appear in the ecosystems that succeed logging until the forest canopy again closes and a relatively few species of the plant kingdom again dominate.

It is during the open canopy phase of the forest rotation that most of the dramatic rodent damage occurs. Controlling this damage has received considerable attention by a wide range of organizations and workers. Rodent damage to forest stands is often spotty and always complex. Actual damage is frequently severe locally, moderate over considerable area, and totally lacking in certain locations. Because of the variety of cover types which succeed logging and rodents' adaptability to these conditions, studies of these rodents must, of necessity, become highly involved. Often what is a solution for one area is not applicable to adjoining areas. A bibliography of literature concerned with control of forest damaging mammals was published by the U. S. Forest Service (Radwan, 1963). This, coupled with the work published since that time, makes rodent control information relatively available.

It will, perhaps, be instructive to trace the development of the major rodent control efforts in California over the past five years so that the present state of the art is seen in proper perspective.

CONTROL OF SEED EATING RODENTS

Because of the vast acreages of old growth timbers which have been logged in the past twenty years, the first job of the upland manager usually is the re-establishment of forest cover. It is my opinion that the rodent problems associated with reforestation have received far more attention than any other phase of forest rodent control.

I became concerned with control of forest seed eating rodents in 1961 when a preliminary attempt at artificial forest seeding failed. At that time, reforestation by direct seeding was widely used in the Pacific Northwest, but in California only about 2100 acres had been so treated. These early attempts were widely scattered over northwestern California and had produced highly erratic results.

A review of the literature indicated the need for rodent control through the use of treated tree seed and perhaps baiting (Dick, et al., 1958; Hooven, 1953, 1957, 1958a; Lavender, 1952; Roy, 1961). Conversations with workers in this field and skepticism on the part of the county Department of Agriculture cast doubt on the effectiveness of these means of control. An investigation was initiated to gain experience and information concerning tree seed losses to rodents.

Feeding Study

The first study was laboratory cage feeding of field trapped white-footed deer mice (Peromyscus maniculatus). The procedure started with trapping the mice, bringing them into

the laboratory where they were fed prepared laboratory pellets for a week. After this week of acclimation, other feeds were introduced for a week at a time. Table 1 indicates the results of this feeding. While this study was not a full research experiment, it did explore some hypotheses presented at that time.

TABLE 1. Peromyscus maniculatus Feeding Study

Trial No.	Feed	Treatment	Lab Chow Available?	Average Consumption per animal per night (No. of Seeds)	Remarks
1.	Oats	None	Yes	30	Color preference due to position in cage.
		Dyed yellow	Yes	36	
		Dyed green	Yes	30	
				96	
2.	Oats	None	No	52	
		Dyed yellow	No	47	
		Dyed green	No	62	
				161	
3.	Oats	None	Yes	31	Treated oats soaked in water for 72 hrs.
		Soaked	Yes	94	
				130	
4.	Oats	None	No	33	"
		Soaked	No	94	
				127	
5.	Oats	None	No	90	
	Douglas-fir	None	No	112	
				202	
6.	Oats	None	No	50	
	Ponderosa pine	None	No	27	
				77	
7.	Oats	None	Yes	100	
	Grand fir	None	Yes	21	
				121	
8.	Douglas-fir	None	Yes	117	Treated Douglas-fir seed soaked in water at 2° C for 4 weeks.
		Stratified	Yes	115	
				232	
9.	Douglas-fir	None	No	164	"
		Stratified	No	170	
				334	
10.	Grand fir	None	No	42	Treated grand fir seed soaked in water at 2° C for 4 weeks.
		Stratified	No	34	
				76	
11.	Monterey pine	None	Yes	18	Treated Monterey pine seed soaked in water at 2° C for 4 weeks.
		Stratified	Yes	72	
				90	
12.	Monterey pine	None	Yes	38	"
		Stratified	Yes	56	
				94	
13.	Douglas-fir	1/2% Endrin	Yes	24	All mice survived.
14.	Ponderosa pine	1/2% Endrin	Yes	5	Mortality 75%. Appeared that surviving mice did not eat any seed.

Table 1. (continued)

Trial No.	Feed	Treatment	Lab Chow Available?	Average Consumption per animal per night (No. of Seeds)	Remarks
15.	Monterey pine	1/2% Endrin	Yes	9	All mice survived.
16.	Douglas-fir	1/2% Endrin	Yes	20	Mortality 75%. One mouse died 5 days after last exposure.
17.	Ponderosa pine	1/2% Endrin	Yes	54	Mortality 25%

Whole oats, dyed green, were then being used for bait. The hypothesis that "whole oats are a preferred food" seems to be substantiated by trials 1 and 2. When mice had a choice between lab pellets and oats, about 60% of the diet was oats. This proportion was about the same when the choice was between oats and Douglas-fir seed (trial 5).

We were told that "the effectiveness of bait over a period of time decreased because of the moisture absorbed by the bait, rendering it less attractive to the mice." Trials 3 and 4 did not support this.

"Tree seed is a preferred food" is substantiated by trials 5, 6, and 7 for the more commonly seeded species. Of the foods tested, the preference was for Douglas-fir, whole oats, ponderosa pine, and white fir, in descending order.

The erratic results of the testing of the Endrin treated seed are seen in trials 13 through 17. These trials were to test the hypothesis "Endrin is a rodent repellent which decreases acceptance of the tree seed."

First, it is seen that consumption of Endrin treated seed was lower than for untreated seed. Comparing this acceptance with that of untreated seed in trials 5, 6, and 7 indicated that the decrease was about 80%. Trials 13 and 15 inferred high repellent action because of the low acceptance and high survival.

Trial 14 showed low acceptance, but high toxicity. In this trial, the mice that survived were totally repelled by the treated seed.

After these first trials with Endrin were finished, the surviving mice were fed laboratory pellets only for one week then subjected to trials 16 and 17. Mice surviving trial 13 were used for trial 16; surviving mice from trials 14 and 15 were grouped together and used in trial 17.

Trial 16 had about the same consumption as the first trial with Endrin treated Douglas-fir. Mortality was so much higher in the second test that the means of reduction in consumption from untreated seed is very much in question. Trial 17 reversed these results by having a considerably higher rate of consumption and much lower mortality.

In these Endrin trials I do not feel that there is any indication that mice learned to avoid treated seed. Trial 17 implies that these mice "learned" how to eat treated seed and avoid the Endrin. (Tevis 1956b)

Mice surviving all these trials were kept in the laboratory for approximately three months after testing. Mo additional mortality occurred and all females reared what appeared to be normal litters.

Population Studies

Early in 1962 an investigation was initiated to test the effect of baiting on rodent populations in conjunction with forest reseeding. This investigation was done through the cooperation of the following agencies: Humboldt County Dept. of Agriculture, Humboldt County Dept. of Forestry, California Dept. of Fish and Game, Van Vleet Wood Products Co., and Western Timber Services, Inc.

Procedures. Two pairs of similar areas were selected for this study. These four areas were all timber sites, recently cut over, and located in eastern Humboldt County. NACSM, type B, traplines were established on each area (Calhoun, 1948). These lines were serviced in the prescribed manner, using snap traps, four times during the winter and spring of 1962. At each time of trapping three of the four areas were censused. Trap lines were serviced at the end of January and early February, mid April, early May and mid June.

All areas were seeded with Endrin treated tree seed in early April 1962. Areas 1 and 2 were seeded with Douglas-fir seed at a rate of one pound of seed per acre. Areas 3 and 4 were seeded with ponderosa pine seed at a rate of three pounds of seed per acre. All seed was treated with Endrin at a rate of 0.5% actual active chemical (Dick, et a!., 1958). One area in each pair was baited four days prior to seeding (areas 1 and 3). In addition to the seeding area, a 330 foot adjacent strip was baited outside the area seeded. The bait was 1080 applied to whole oats at the rate of four ounces per hundred weight of oats; Rhoplex was the binding agent used, and an inert color was added.

During the entire length of this study, game biologists made period visits to all treatment areas monitoring the resident game populations.

Discussion. The estimate of the number of mice per acre was determined from the captures on these NACSM trap lines using the regressions developed by Brant (1962). The Clethrionomys californicus population was estimated from Brant's regression for Reithrodontomys. Figure 1 gives the results of these censuses.

Area 2, unbaited, showed a population fluctuation similar to Brant's and Hooven's experience (Brant 1962, Hooven 1958). Area A, also unbaited, showed an unexplained population decline through the entire period.

Areas 1, and 3, baited, showed rather large populations at the first of February, with complete control indicated after baiting. No rodents were captured during the first two trappings following baiting.

Population levels in June, when the investigation terminated, were still below the January levels. On the baited areas, terminal populations were still below the unbaited populations six to eight weeks previous. It is during this period, April through June, that a majority of the tree seed germinate. (Lavender 1958). Tevis (1956) indicated that most of the seed lost to rodents occurred within one month of application.

Encroachment Study

In addition to the rodent censusing described above, area 1 was studied to monitor the re-establishment of the small rodent population through encroachment.

Lines of trapping stations were established across the perimeter of the baited area at four locations. These lines were similar to NACSM type B lines except that each line consisted of but 10 stations. Figure 11 indicates the location of the trap lines and the vegetative cover types involved. Trapping stations were numbered consecutively from the perimeter of the seeding area outward leaving stations 8, 9 and 10 outside the treated area.

Lines B and C were in freshly logged land containing slash, brush, advanced conifer regeneration, and a few seed trees. The brush type supported dense stands of Ceanothus spp. and Arctostaphylos spp. The timbered areas were well stocked with old growth Douglas-fir, sugar pine, and tan-oak. Table 11 summarizes the rodent captures made on these lines.

TABLE 11. Captures on Encroachment Traplines

Line	Species and Station No. at Which Captured		
	April Trapping	May Trapping	June Trapping
B	P. #10	P. #10, 8, 7	P. #9, 5, 4
C	None	P. #9, 5	P. #10, 7, 4, 2
D	None	P. #10, 7	P. #9, 8, 5, 1
E	S. #5	S. #10	S. #8, 4

Abbreviations: P = Peromyscus maniculatus
S = Sorex vagrans

It is of importance to note that two weeks prior to the June trapping, the brush field sampled by line D was accidently burned.

It can be seen from Table 11 that considerable suppression of the rodent population was affected outside the baiting area. Repopulation of the seeding area progressed, in general, by an encroachment process as one might expect. The timber type did not afford much habitat for Peromyscus or Clethrionomys, but Sorex vagrans did appear to be present in significant numbers. Burning the brush field drastically increased the rodent population in that type.

Summary. These data indicate that baiting in early April produced some measure of rodent control. The tests support much of the work done in the Pacific Northwest in developing Endrin seed treatment and rodent baits.

Of the four areas seeded in the course of the population studies, subsequent reforestation inventories indicate one area being well stocked with conifer seedlings, two areas moderately stocked, and one area inadequately stocked.

Lawrence and Rediske's (1952) work with radio-tagged tree seed causes me to question whether the forester's efforts are best spent in rodent control. In both the work cited above and in similar but unpublished work, they found the extent of rodent damage to seed to be highly variable and often below the level previously reported. It appears that much seed damage has erroneously been assessed to rodents. This work offers good explanation for the apparent discrepancies and contradictions found in our forest rodent control studies, the literature, and other foresters' experience (Besser and Welch, 1959).

DANGERS TO NON-TARGET SPECIES

The danger of 1080 to non-target species is rather well documented (Rudd and Genelly, 1956; Rudd 1964). Suffice it to say that 1080 is highly soluble and stable. There is considerable danger of secondary poisoning, particularly at high concentrations on the bait. The use of this toxicant in California is regulated by Section 1080 of the California Agriculture Code. Presently the 1080 bait used in reforestation is completely controlled by the county department of agriculture in which it is being used. The departments supply the bait, prescribe its use, and supervise its application.

Late in 1965, the California Department of Fish and Game initiated an investigation of Endrin as used in reforestation (Hunt, 1966). These toxicity studies verified the reports of Rudd (1964) and Rudd and Genelly (1956) that Endrin treated tree seed is very toxic, particularly to fish life. No hazard studies have been reported. I understand that this work is now in progress at the California Department of Fish and Game and at the Oregon Forest Research Laboratory, Corvallis. It appears significant that, in view of the quantities of Endrin treated seed used in the Pacific Northwest, no significant damage to fish and wildlife has been reported.

RODENT CONTROL AT THE OPERATIONAL LEVEL

Seed eating rodents.

Greatest interest has been in controlling seed losses to rodents during reforestation. This has been a most fruitful effort because of the immediate need the industry has had for fast, inexpensive restocking and because of the short time in which control is needed or wanted.

Common practice today is to treat all conifer seed used in direct seeding. This treatment is with Endrin in concentrations of from 0.5% to 3% actual Endrin formulated as described by Kverno (1964) and Dick, et al. (1958). Common application rates for the conifer species most used in direct seeding are as follows:

Species	Application Rate (Pounds of seed per acre)
Douglas-fir	0.75 to 1
Ponderosa pine	3
Monterey pine	0.50 to 0.75
Sitka spruce	0.2
True firs	1 to 4

Most of our clients are currently of the opinion that they want their lands baited as part of the reseeding operation. This is based on the literature cited above and our experience testing the standard techniques. Current baitinq practice now used in Humboldt and Del Norte Counties, California is an application of half a pound of three ounce 1080 treated wheat per acre. Application is made at the same time as the seeding. The use of this bait is controlled by the county Agricultural Commissioner.

I estimate that in California less than half of the private lands that are artificially reseeded are also baited. The major reasons for not baitinq are the administrative problems associated with the controls and the public relation problems associated with pesticides.

Prior to the seeding season of 1966 - 67, no control was exercised over the use of Endrin treated tree seed. This season a system of permits was instituted by the Aqricultural Commissioners of Humboldt and Del Norte Counties under the provisions of Section 2464 of the California Administrative Code. Application for these permits required a declaration of who was applying the seed, who were the landowners involved, the species of seed, rate of application, treatment and concentration of Endrin to the seed, area to be seeded, location of seeding, and date of application. A map of the seeding area was also required. After inspecting each area, the department issued the permit subject to those constraints the department deemed necessary to minimize danger to non-target species. In addition to the usual limitations on equipment used and wind conditions at the time of seeding, the departments have required that no Endrin treated seed be used within fifty feet of live streams or ponds.

FUTURE RESEARCH NEEDED FOR RODENT CONTROL

In the area of seed destruction, we have an immediate need for additional information on the significance of rodent damage in forest reseeding. Work similar to that of Lawrence and Rediske (1962) is needed over as wide a range of environments as we have forest lands to regenerate. This use of radio-tagged seed is a highly efficient means of quantitatively describing what is happening in the process of direct forest seeding. This work would provide much needed information as to the importance of rodent control and where high seed losses may be anticipated.

In view of the recent concern in the dangers to non-target species, an increased effort is needed to assess the hazards produced through the use of Endrin seed coatings and the commonly used rodent baits. Public concern over these toxicants is increasing to the point where emotional opinion is dictating operational policy among some land owners. The productivity of our uplands is in no way serviced by the lack of information in this area.

As intensive upland management continues to grow conifer forests, damage to older stands will become more apparent, i.e., root clipping, basal barking, barking of the bole, and branch clipping.

The summary of research currently in progress dealing with animal control in forest lands prepared by the Animal Damage Committee (1966) indicated the need for increased research in the following areas:

1. Squirrel damage to cone and twigs. Present research is restricted to the western Rocky Mountains. 2. Pocket gopher damage to root and lower stem. The usual situation for this damage is for it to be of local significance so that interest in this damage is restricted to the landowner currently sustaining damage. It is suspected that considerable damage is being sustained in scattered locations over a wide area. 3. Porcupine damage by barking. It was the finding of the committee that presently there is no research being conducted in California with primary interest in porcupines, 4. Repellents for the protection from browsing and clipping damage. This approach to rodent control has wide appeal to forestry because of the lack of disruption of the ecosystem. Although considerable activity is centered in repellents, only one study is concerned with side effects of the repellents being screened. 5. Damage to upper bole by barking by tree squirrels and wood rats. No work is now underway in this area. Again, as more manage stands reach an age in which this type of damage may be sustained, more damage will become apparent.

In view of the many problems confronting forest management and the demands which are being made on these uplands, rodent control research needs to move ahead at a pace equal to these demands. A major contribution which rodent control can make to forest management

is for more efficient use of the land management dollar. By either reducing the investment in land management through efficient control or increasing the area of treatment by lowering unit costs, an increase in upland productivity could be affected. If the rate of seed application on certain areas could be reduced by 25% through effective rodent control, this seed could be used to regenerate other under stocked areas. Likewise, if rodent problem areas can be identified prior to damage, time and funds could be expended in other management activities.

BIBLIOGRAPHY

ANIMAL DAMAGE COMMITTEE, 1966. Weaknesses in animal damage research, prepared for California Forest Action Council, dated 3 November 1966. Sacramento. Mimeo.

BESSER, J. F. and WELCH, J. F. 1959. Chemical repellents for the control of mammal damage to plants. Trans, of the twenty-fourth North Amer. Wildl. Conf. p. 166.

BRANT, D. H. 1962. Measures of the movement and population densities of small rodents. Univ. of Calif. Pub. in Zool., Vol. 62, No. 2, Univ. of Calif. Press, Berkeley.

CALHOUN, J. B. ed, 1948 - 1952. North American census of small mammals, releases nos. 1-5.

DICK, J., FINNIS, J. M., HUNT, L. 0., KVERNO, N. B. 1958. Treatment of Douglas-fir seed to reduce losses to rodents, Jour, of Forestry 56:9.

H00VEN, E. F. 1957. Field test of Endrin-treated Douglas-fir seed. Oregon Forest Lands Research Center. Res. Note No. 38. Corvallis.

_____1958a, Deer mouse and reforestation in the Tillamook Burn. Oregon Forest Lands Research Center. Res. Note No. 37. Corvallis.

_____1959. Dusky-footed woodrat in young Douglas-fir. Oregon Forest Research Center. Res. Note No. 41. Corvallis.

HUNT, E. G. 1966, Dangers of rodenticides to nontarget wildlife. Minutes of the *Ik* June 1966 meeting of the California State Board of Forestry, Sacramento.

ISAAC, L. A., 1943. Reproductive habits of Douglas-fir. Charles Lathrop Peck Forestry Foundation, Washington, D.C.

KANGUR, R., 1951. Shrews as tree seed eaters in the Douglas-fir region. Oregon State Board of Forestry. Res. Note No. 17, Salem.

KVERNO, N. B. 1964. Forest animal damage control. Proc. second Vertebrate Pest Control Conference, Univ. of California, Davis.

LAVENDER, D. P. 1958. Seeding dates and Douglas-fir germination. Oregon Forest Land Research Center, Res. Note No. 34. Corvallis.

LAWRENCE, W. H. 1958. Wildlife-damage control problems on Pacific Northwest tree farms. North Amer. Wildl. Conf. Trans. 23: 146 - 152.

_____and REDISKE, J. H. 1962. Fate of sown Douglas-fir seed. Forest Science, 8:3.

RADWAN, M. A. I963. Protecting forest trees and their seed from wild mammals. U. S. Forest Service, Pacific Northwest Forest & Range Expt. Sta. Res. Paper PWN 6.

ROY, D. F. 1961. Seed spotting with Endrin-treated Douglas-fir seed in northwestern California. U. S. Forest Service. Pacific Southwest Forest and Range Expt. Sta. Tech, paper No. 6l.

RUDD, R. L, 1964. Pesticides and the living landscape. Univ. of Wise. Press, Madison.

_____and GENELLY, R. E, 1956. Pesticides: their use and toxicity in relation to wildlife. Calif. Dept. of Fish and Game. Game Mgmt. Bul. No. 7, Sacramento.

TEVIS, L. JR. 1956a. Response of small mammal populations to logging of Douglas-fir. Jour. of Mammal., 37:189 - 195.

_____1956b. Behavior of a rodent population of forest mice when subject to poison. Jour, of Mammal. 37: 358-370.

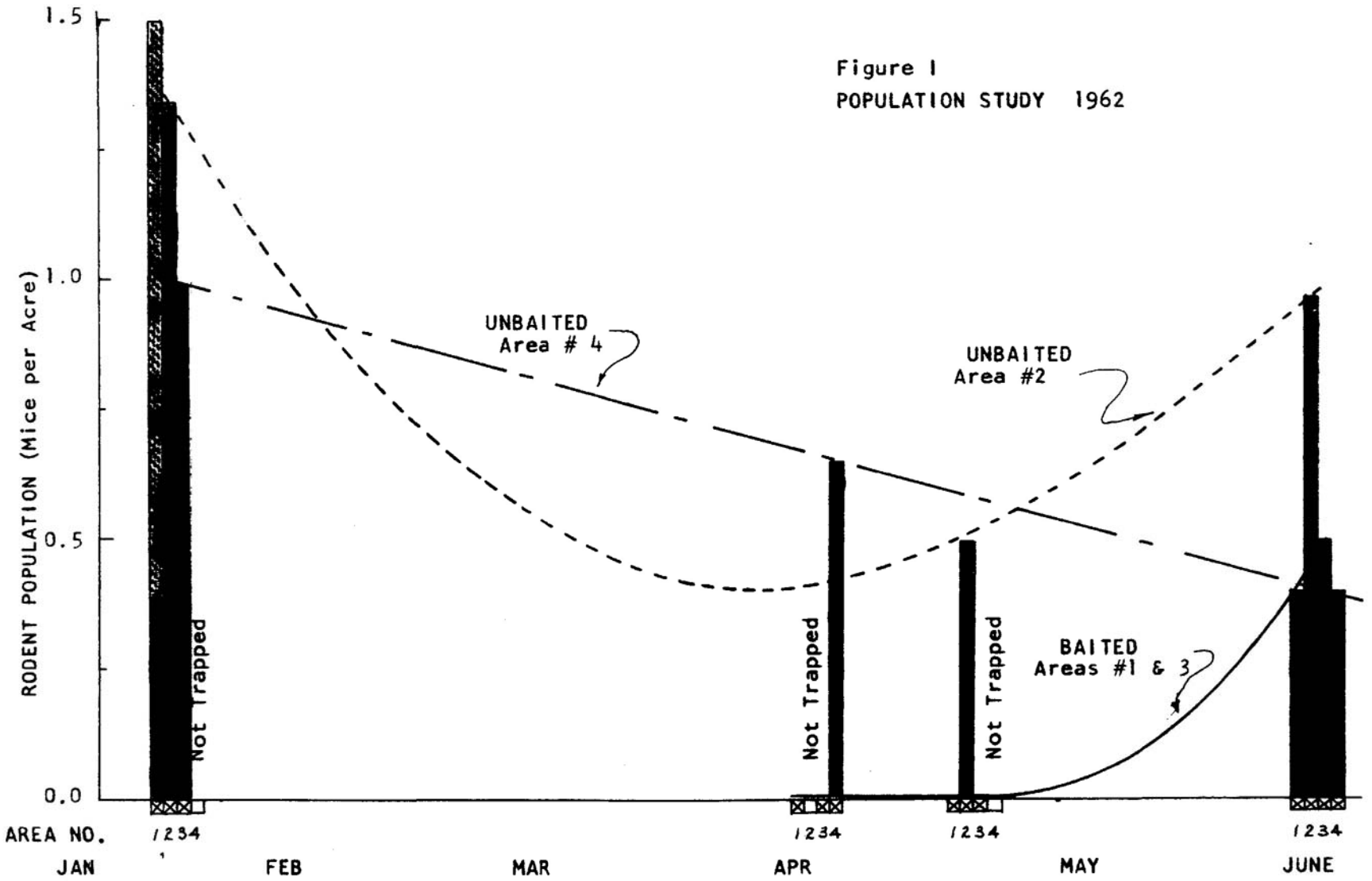
Figure I
POPULATION STUDY 1962
RODENT POPULATION (Mice per Acre)
1.5
1.0
0.5
0.0
UNBAITED
Area # 4
UNBAITED
Area #2
BAITED
Areas #1 & 3
Not Trapped
Not Trapped
Not Trapped
AREA NO.
1234
1234
1234
1234
JAN
FEB
MAR
APR
MAY
JUNE

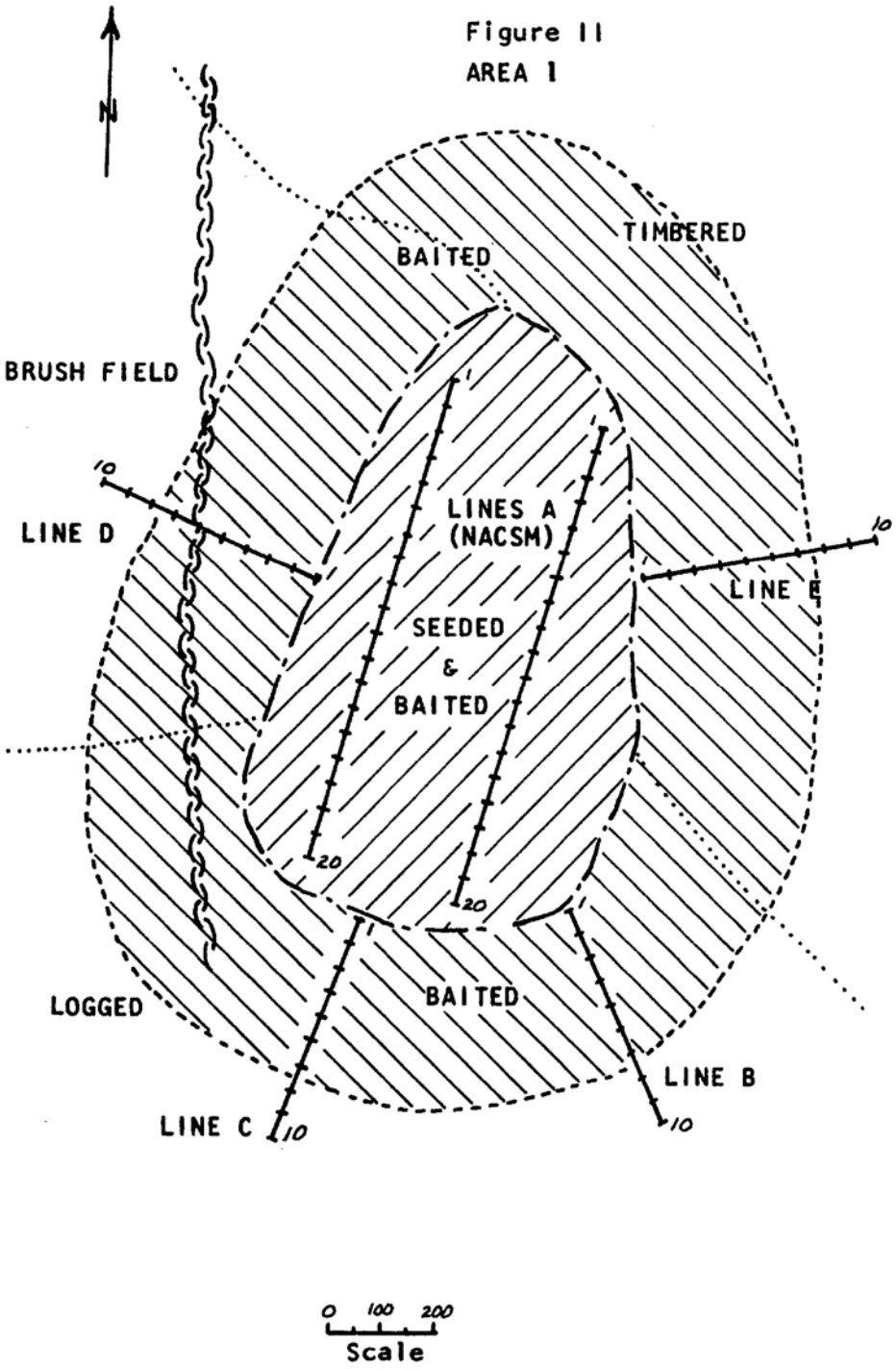
Figure 11
AREA 1
N
TIMBERED
BAITED
BRUSH FIELD
10
LINE D
LINES A
(NACSM)
10
LINE E
SEEDED
&
BAITED
20
20
LOGGED
BAITED
LINE B
LINE C
10
10
0 100 200
Scale