EVALUATION OF INTENSIFIED RABBIT MANAGEMENT PROCEDURES ON PUBLIC HUNTING AREA IN SOUTHCENTRAL VIRGINIA

by

Alan Scott Krug

Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of

MASTER OF SCIENCE

in

Biology

Major

WILDLIFE MANAGEMENT

June 1960

Blacksburg, Virginia

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

Figure

LIST OF TABLES

Table

LIST OF APPENDIX TABLES

Table

ACKNOWLEDGEMENTS

The writer would like to thank those who cooperated in this project and, in fact, made the project possible. The assistance which these individuals gave is sincerely appreciated.

A great many persons made contributions. Below are listed those to whom much credit is due:

Dr. Burd S. McGinnes and Dr. Henry S. Mosby helped plan the study and provided the necessary guidance.

Wildlife biologist J. B. Redd of the Virginia Commission of Game and Inland Fisheries gave valuable advice and other help.

Lieutenant Colonel W. C. Huber, Post Commander, Camp Pickett, Second U. S. Army, provided the authority under which the project proceeded.

Master Sergeant A. L. Cook, Second Army, Camp Pickett, gave much practical assistance.

Warden J. N. Phelps and Game Manager John Garrett, both of the Virginia Commission of Game and Inland Fisheries, helped select suitable study areas.

The United States Department of Commerce, Civil Aeronautics Administration Communications Station, Blackstone, Virginia, provided climatological data.

Thanks are also due the graduate committee, composed of Dr. McGinnes, Dr. Mosby, Dr. A. B. Massey, and Dr. R. Kral.

The writer's colleague, J. B. Whelan, also deserves credit, as does , the Unit secretary.

Sincere appreciation and gratitude is due my wife, , as it

was her encouragement and assistance in typing and proofreading this manuscript that made it a reality.

Funds and equipment for the study were provided by the Virginia Cooperative Wildlife Research Unit.*

*Cooperating Agencies: The Virginia Commission of Game and Inland Fisheries; The Virginia Polytechnic Institute (College, Extension Service, and Experiment Station); The Wildlife Management Institute; The U. S. Fish and Wildlife Service.

INTRODUCTION

It is often said that research is the key to tomorrow. This is just as true in the field of wildlife management as in any other. For years wildlife management policies were based on opinion alone, with research completely out of the picture. In certain localities this is still true today. However, wildlife research is beginning to make its mark, and it is to be hoped that this situation will prevail. When the day arrives for all game management to be based on sound research, then and only then will we have sound management.

The cottontail rabbit is one of our most important game animals. It is the real backbone of American hunting. As such, it has received considerable attention from game agencies. Various management procedures and techniques have been designed to improve the habitat of the rabbit. Some of these management procedures and techniques have been based on research findings, but many have been based on pure opinion.

The Virginia Cooperative Wildlife Research Unit has undertaken a twelve-year program of research designed to test some of the rabbit management techniques now being utilized in the state of Virginia. This study comprises the fourth phase of the program.

During the first phase of the program (1955-1956), J. B. Redd studied the distribution of the cottontail as affected by land use. Next, B. S. McGinnes investigated various factors influencing cottontail rabbit populations in Southwestern Virginia. In 1958, D. K. Fortenbery tested some rabbit management procedures as applied in Southeastern Virginia.

This present study also involves, among other things, the testing

of rabbit management procedures in Southeastern Virginia. The study had the following objectives:

1. Determine the validity of the several trap-retrap formulae for estimating rabbit populations, and measure rabbit population fluctuations by roadside counts.

2. Determine which wildlife management land-cultural treatments extant on Camp Pickett are most utilized by cottontails.

3. Measure the influence of cover on the relative abundance of the rabbit.

4. Maintain a record of diseases and parasites infesting the rabbits encountered on the study area.

5. Prepare recommendations for improved rabbit management.

All field work was carried out from June, 1959, thru May, 1960, on the Camp Pickett Military Reservation located in Nottoway, Brunswick and Dinwiddie Counties, Virginia. The rabbit of this locality, according to Llewellyn and Handley (1945:381), is Sylvilagus floridanus mallurus (Thomas).

The wildlife management land-cultural treatments evaluated in this study are a part of the cooperative management agreement in effect between the Virginia Commission of Game and Inland Fisheries and the United States Second Army.

LITERATURE REVIEW

Any review of literature concerning the cottontail rabbit should conceivably cover the following subject matter: life history; food; cover; mortality; and management.

The literature reviewed below is concerned only with the above aspects of the cottontail. A complete bibliography on the cottontail has been assembled by Makepiece (1956).

A thesis by Majors (1955) was concerned with the life history of the cottontail in Alabama. Bruna (1952) published a comprehensive report on the life history of the rabbit in Kentucky. Similar studies were made by Dalke (1937 and 1942) in Connecticut. In Virginia, life history data are given by Llewelyn and Handley (1945), Redd (1956), and McGinnes (1958).

Dalke (1942) in Connecticut also studied food habits, as did Allen (1939) in Michigan and Hendrickson (1938) in Iowa. Dusi (1949) presented a new microtechnique for histological food habit studies in the cottontail. Coprophagy in the rabbit has been described by Myers (1955) in Australia, Kirkpatrick (1956) and Geis (1957) in Michigan.

Linduska (1947 and 1949) determined winter den use. He enlisted the aid of the ferrett in doing so. Other cover preference studies were conducted by Hendrickson (1938) in Iowa and Fay and Chandler (1955) in Massachusetts.

Mortality in the rabbit is due to numerous factors, including hunting, predation, parasites, and disease. The autumnal decimation of the Mearns cottontail was reported on by Kline and Hendrickson (1954) in Iowa.

Kirkpatrick (1950) reported on crow predation on nestling cotton-

tails. Craighead and Craighead (1950) described the ecology of raptorial predation. The food habits of coyotes, foxes, housecats and bobcats in Missouri were determined by Korschgen (1957). Eberhard (1954) in Pennsylvania also studied the food habits of housecats. Errington (1946) presented relationships between predation and vertebrate populations.

Whitlock and Gower (1938) dealt with tapeworms in rabbits. Ledune (1933) published data on cottontail parasites in Ohio, as did Cheatum (1952) in New York and Ecke and Yeatter (1956) in Illinois. An Illinois study of ectoparasitism was done by Stannard and Pietsch (1958). Smith and Cheatum (1944) studied the role of ticks in the decline of an insular cottontail population. In Michigan, data on the incidence and effect of warbles were collected by Geis (1957).

Most of what has been written on disease has not been directly concerned with the cottontail rabbit. The study of wildlife diseases is still a very new field, but great strides are being made along this line at the present time. A considerable amount of work has been done on diseases of domestic rabbits, however.

Yeatter and Thompson (1952) in Illinois wrote on "Tularemia, Weather and Rabbit Populations." McGinnes (1958) in Virginia studied tularemia in the cottontail. A comprehensive study of Shope's rabbit fibroma in cottontails was conducted by Herman, Kilham and Warback (1956) at the Patuxent Research Center in Maryland.

For a number of years stocking of rabbits was the primary management tool. Stocking experiments have been reported on by Dell (1953) in New York, and Latham (1952), Bowers (1954), and McDowell (1955)

in Pennsylvania.

Other well-known publications on cottontail rabbit management are those by Beule (1947), Studholme (1951) and Bowers (1956) in Pennsylvania, Handley (1951) in West Virginia, Haugan (1943) and Allen (1958) in Michigan, and Lemke (1952) in Wisconsin.

Census methods have been evaluated by Crunden and Hendrickson (1955) and Hendrickson (1939) in Iowa, Peterle and Eberhardt (1959) in Michigan and Redd (1956) in Virginia. Fortenbery (1959) in Virginia tested the validity of population estimation formulae.

PROCEDURE AND TECHNIQUES

SELECTION AND DESCRIPTION OF STUDY AREA

Camp Pickett, Virginia, is a 47,000 acre inactive military reservation located in Nottoway, Brunswick, and Dinwiddie Counties. In 1958-59 Fortenbery found Camp Pickett well-suited for the planned field research on the cottontail rabbit. The Camp was chosen for this study on the basis of this previous experience.

A physical description of the reservation, along with a listing of some of the plant and animal fauna, has been given by Fortenbery (1959:13-15).

The history of Camp Pickett as an area managed for game begins in 1957. In February of that year a four-year cooperative habitat improvement program was begun by the Virginia Commission of Game and Inland Fisheries and Army personnel, under a cooperative agreement effected in August of 1956 between the Virginia Commission of Game and Inland Fisheries and The United States Second Army.

Management techniques employed in this program include trapping of foxes, installation of food patches, bulldozing and seeding of fire lanes, mowing and burning. The results of the fox trapping are given in Appendix Table 1. Data pertaining to the land-cultural treatments are listed in Appendix Table 2.

Also included in the program are the administration of the reservation as a game management unit, enforcement of all state hunting laws, and installation of boundary and "off-limits" signs. All hunting on the area is by permit only, with hunters checking in and out at an official checking station. All game must be checked and complete records are kept.

ROAD COUNTS

Selection of Route

The following criteria were used in selecting a suitable route:

1. A route five to ten miles long.
2. The immediate roadside area mowed much the same as a lawn, or at least less than eight inches high (Figure 1).
3. The direction of the route such that the observer will not be driving directly into the sun.
4. Traffic on the route minimal.

The route that was chosen was exactly ten miles in length; all within the cantonement area (Figure 2). Besides meeting the above requirements, this route also had other desirable characteristics:

1. The barracks and other camp buildings on the cantonement area provide the rabbits with excellent cover.
2. The cantonement area is in an early stage of ecological succession, favorable to the cottontail.
3. The barracks and other structures on the area break the land into small units, and the "edge effect" is therefore great.
4. The roadside edges within the cantonement area are mowed rather frequently, thereby providing a good view of rabbit activity; the mowing also produces fresh succulent grass for the rabbits.

Method of Operation

The road counts were driven between ten and twenty miles per hour. This range of speeds was the slowest at which the car could be driven

Figure 1. The immediate roadside area mowed much the same as a lawn, or at least less than 8" high.

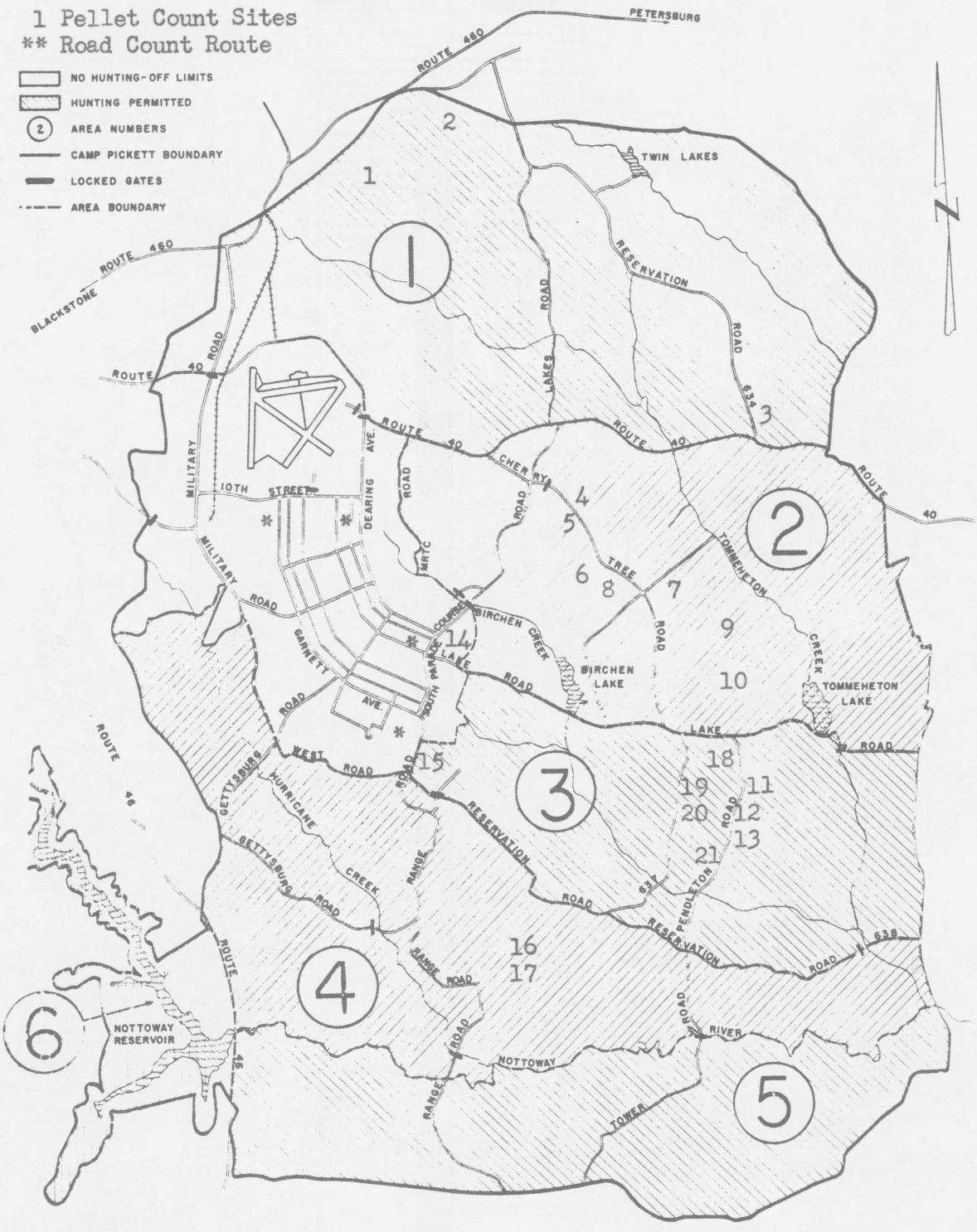


Figure 2. Camp Pickett, Va., showing road count route and pellet count sites.

in high gear. It required approximately one-half hour to cover the route.

All rabbits seen were counted. No distinction was made between rabbits seen on and off the road proper. Newman (1959:290) in Iowa divided the total number of rabbits seen on his road counts into those seen on the road, those seen in ditches, and those seen in adjacent fields. Such a division as this is not practical on Camp Pickett as the vegetation becomes too thick to allow rabbits to be seen as soon as they leave the immediate roadside.

Rabbits were, however, tallied according to size. Each rabbit seen was classed as 1/4, 1/2, 3/4, or full-grown. This method was a help in determining reproduction success among the rabbit population.

Data were recorded on 3 by 5-inch cards. A separate card was used for each road count. At the end of each day, the data were typed on duplicate cards. Each set of cards was kept in a separate place, so that if one set were to be lost or destroyed, the other set would be available.

The investigator enlisted the aid of his dog, a female German Shepherd, in making the road counts. Riding in the front seat and hanging out the window, she brought to the investigator's attention many rabbits along the roadside that would otherwise have been missed. In the process of conducting a road count of this sort, it is practically impossible for one person to watch both sides of the road and operate the motor vehicle at the same time.

PELLET COUNTS

Location of Quadrats

An old artillery impact area was selected as a control area. Three years ago this area was subjected to controlled burning as a game management measure, but ecological succession in this locality is so rapid that already the effect of the burning is no longer visible. The land is grown up primarily to broom sedge (Andropogon virginicus), ragweed (Ambrosia artemisifolia), blackberry and dewberry (Rubus spp.), sumac (Rhus spp.), aster (Aster spp.), goldenrod (Solidago spp.), and buttonweed (Diodia teres). Numerous stands of 15-25 year old loblolly pine (Pinus taeda) are also present. The entire area is pock-marked with shell holes, but other than this the land can be classed as typical farmland of 15-25 years abandonment.

No other sites were suitable for control areas. The site selected was the only one on the entire Camp Pickett area that had not been recently burned, mowed, or had patches planted in various wildlife foods.

A map of Camp Pickett showing the control area was gridded into numbered blocks. Three of these blocks within the control area were randomly selected as representing sites for pellet counts. Each was five acres in extent, laid out by compass and pacing and marked on the ground.

Another old artillery impact area was subjected to controlled burning for wildlife management purposes in the spring of 1959. Three five-acre pellet count sites were located in this area in the same manner as were the controls.

Many 5-15 acre areas throughout Camp Pickett were subjected to mowing during the summer of 1958 to improve the habitat for wildlife.

Fortenbery found both mowing and burning to be valuable management tools (1959:78). These mowed areas were plotted on a work map and assigned a number; three were selected randomly for this part of the study. Five acres at each of the three sites were laid out by use of a compass and pacing, then marked on the ground.

All of the annual mix and clover-small grain food patches planted on Camp Pickett by the Virginia Commission of Game and Inland Fisheries during the year 1959 were plotted on a work map and numbered. Three of each type were then randomly selected. The composition of these food patches is given by Fortenbery (1959:16). A square containing five acres was laid out by compass and pacing around each of the selected food patches. These patches were all approximately 1/2-acre in size and were rectangular in shape; the width of the patch 20-30 yards. Although extending beyond the boundary on two sides, the food patch was located in the approximate center of the five-acre area. All areas were marked on the ground.

Fire lanes on Camp Pickett have been sown in fescue grass (Festuca spp.) or a combination of white clover (Trifolium repens) and fescue. The lanes are approximately 30 yards in width and are bisected by a dirt road. Six five-acre pellet count sites, equally representing the two types of plantings, were arbitrarily selected along the fire lanes. All were laid out with compass and pacing, then marked on the ground.

A total of 21 pellet count sites, randomly selected and representing six different land-cultural treatment types as well as control areas, were investigated (Figure 2).

Method of Operation

Two types of quadrats, the one-square-foot and the milacre, were utilized in the pellet count work. The former was chosen randomly by tossing a wire square while the latter was located in a definite, prescribed manner.

On each five-acre pellet count site, nine milacre quadrats were mechanically established. These quadrats were gridded so that each one was located in the center of a smaller square representing 1/9 of the five-acre area. This same system was used by Fortenbery (1959:19) for the placement of his traps when he evaluated land-cultural treatments by live-trapping. The center of each milacre quadrat was marked with a stake. A string was tied to the stake and cut to such length that when held taut it correctly portrayed the radius (3.7 feet) of a circular milacre quadrat. The string was then rotated as pellets were counted, thereby insuring the inclusion of only those pellets lying within the bounds of the quadrat proper.

The one-foot-square quadrats were located by tossing a four-foot length of wire bent into a square. The investigator began by taking a stand in the southwest corner of the five-acre area, facing the opposite corner, and tossing the wire square in that direction an estimated 10 feet. That located the first of 20 quadrats of this type. The wire square was then tossed toward the opposite corner an estimated 50 feet. This located the second quadrat. The latter process was repeated until ten quadrats had been located. Following this, the investigator began anew, this time in the northwest corner, repeated the entire procedure, and in this manner located ten more quadrats. By this technique, 20 one-foot-square quadrats were randomly selected for each five-acre pellet count site.

In order that no pellet be counted more than once, each was removed from within the confines of the quadrat as it was tallied.

Only "recent" pellets were included in the count. As defined by Hendrickson (1939:209) a "recent" pellet is one that: 1) has an outer surface that is quite intact; 2) is not badly weathered; 3) is not under debris.

PELLET DURABILITY

Pellets used in the study of pellet durability were ones obtained from box traps in which rabbits had been captured. Rabbits enter the traps during the night and sometimes defecate before being released the next morning. As the traps were attended daily, the exact age of the pellets was known.

Pellets obtained in the foregoing manner were counted and placed in natural habitat, but always on a bare spot of at least one square foot in area so that they could easily be found at a later time. The one-foot square was marked by a stone implanted into the ground at each corner, and was considered to be the center of a milacre quadrat. In order to avoid a confusing situation, any other pellets within the milacre quadrat were removed. The pellets of known age were then counted at weekly intervals. Any pellet that was blown or carried away from within the milacre quadrat was considered lost.

TRAPPING

Location of Traps

The three five-acre control areas used for the pellet count work

were also utilized for trapping. A fourth five-acre control area was selected and laid out in the same manner as the others (Fig. 3).

All the five-acre areas planted to fescue and to the clover-fescue combination that had been used for pellet counts were likewise used for trapping. In addition, another of each type was selected and located in the same manner as were their counterparts.

Entrance to a large portion of Camp Pickett is controlled by the presence of gates across the roads. Of the six annual mix and clover-small grain food patches that were utilized for the pellet counts, two of each type are located within the area guarded by these gates. These four five-acre areas were also used for trapping. All the rest of the food patches within this area were plotted on a work map and assigned a number. Two more of each type were then randomly selected; laid out by use of compass and pacing.

Six traps were assigned to each five-acre area. Spacing of the traps was according to an assumption made by Redd (1956:10) that the radius of influence of each trap is 100 feet. This assumption proved satisfactory for McGinnes (1958:15) and Fortenbery (1959:18).

Ordinarily, nine traps would be necessary to cover a five-acre area using such a system of spacing (Fortenbery (1959:19)). A modification was necessary in this case because of the limited number of traps that were available. Accordingly, a sketch map of each trapping site was made in which the area was divided into nine smaller squares, each having a number. The squares that would be occupied by a trap were then selected randomly. In the writer's opinion, such a modification does not impair adequate coverage. The most important function of this particular system is the avoidance of setting out more traps than are necessary.

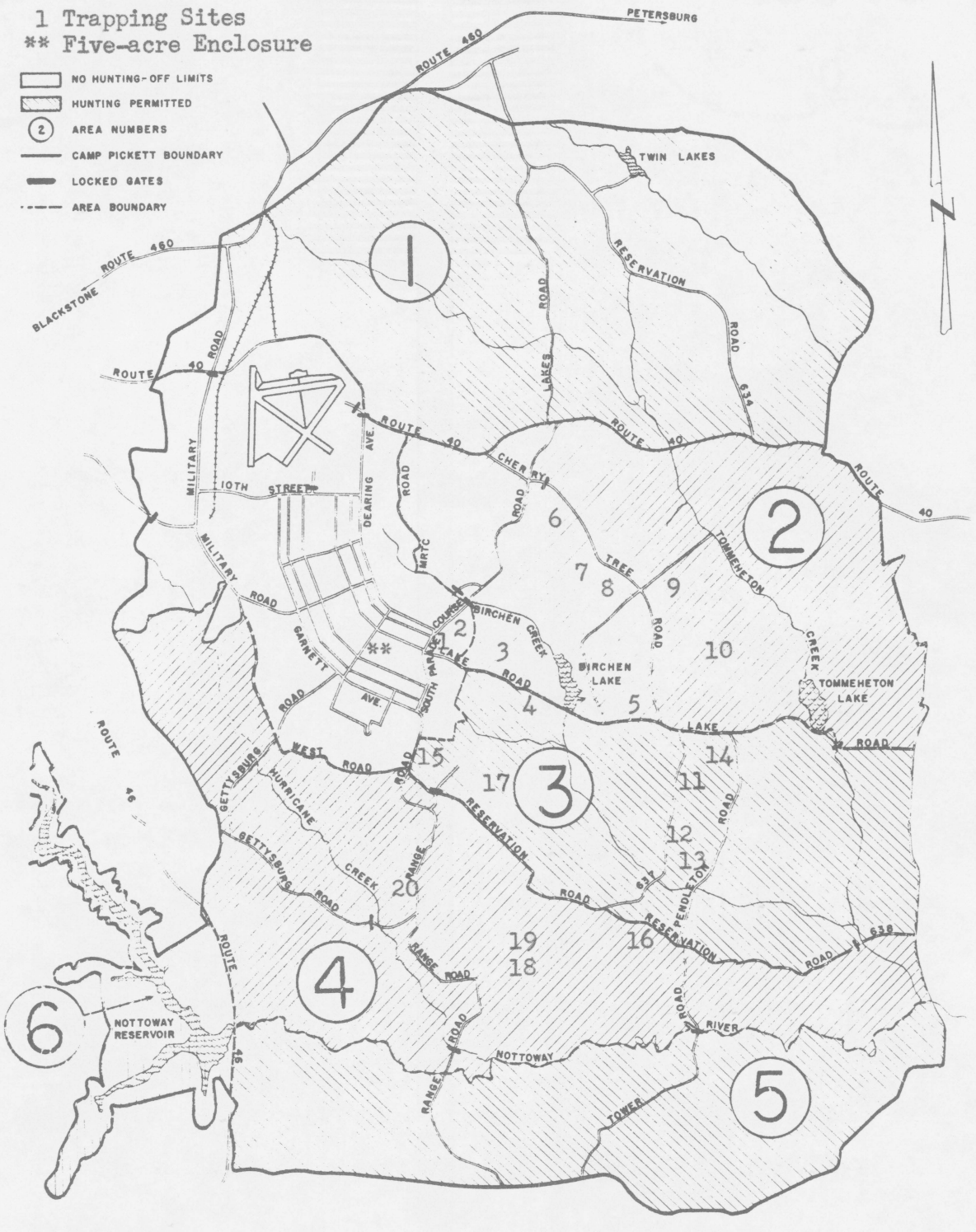


Figure 3. Camp Pickett, Va., showing five-acre enclosure and trapping sites.

For the purpose of testing the validity of the several trap-retrap formulae available for estimating rabbit populations, a five-acre area within the cantonement area was enclosed by a fence (Fig. 3). This fence was 30 inches high, three inches being buried in the ground, and was composed of one-inch mesh wire. Before study was begun, a 1/2-acre annual mix food patch was installed in the center of the area by the Virginia Commission of Game and Inland Fisheries. A total of 13 traps were placed in this rabbit pen. Nine of these traps were situated in accordance with the previously described system. The other four were placed in the corners of the enclosure. The idea behind the latter placement was that, if a rabbit were to be pursued into a corner by a predator, said rabbit would have some chance of escaping by entering the trap.

All trap lines were checked daily.

Wooden box traps of the type described by Redd (1956:10) were used in this investigation.

Handling and Marking of Trapped Rabbits

Rabbits were removed from traps by hand. The investigator reached into the trap, seized the rabbit by the hind legs, and withdrew it. Following this, the rabbit was aged, sexed, examined for parasites and injuries and tagged. Other methods for the handling of captured rabbits are those described by Redd (1956:11) and McGinnes (1958:15). Tags and tagging methods used for all rabbits were those described by McGinnes (1958:15).

Field data were compiled according to the method of Fortenbery (1959:20), the only difference being that 3 by 5-inch cards were used in this study.

Baits

Even though the question of baiting traps is somewhat controversial, no baits were used in this investigation. In Kentucky, the best bait was found to be apples with corn second in effectiveness (Bruna, 1952:6). In Connecticut, Dalke (1937:545) listed as effective baits carrots, apples, and parsnips. Both Redd (1956:32) and McGinnes (1958:104) found baited and unbaited traps equally effective. Fortenbery (1959:36) found a correlation coefficient of -0.273 indicating a possible correlation between trapping success and minimal daily temperature. He believed that rabbits enter the traps in search of cover rather than food. The writer concurs in this belief, at least when it is applied to this geographical section.

SEX DETERMINATION

Sexing of rabbits was done, using the technique described by Petrides (1951:315-316). In addition, criteria described by Fortenbery (1959:24) were used.

AGE DETERMINATION

Rabbits were classed as 1/4, 1/2, 3/4 or full-grown. Body size was used as the criteria for rabbits observed in the road counts. In addition to body size, criteria used for aging rabbits trapped were those listed by Petrides (1951:327-333) and Fortenbery (1959:25).

PARASITE EXAMINATION

A record was made of all flea, tick, and bot fly larva infestations

encountered during the course of the investigation. If fleas were present, they could be found around the orbital region. A general inspection was made of each rabbit handled for ticks or bot fly larvae.

If bot fly larva (Cuterebra bucatta) were found to be present, they were removed. Removal was accomplished by the method described by Fortenbery (1959:25).

DISEASE AND INJURY

All rabbits seen and handled were carefully observed and inspected for signs of disease and/or injury. A record was maintained of all abnormal findings.

Rabbits found dead were autopsied when in suitable condition for such a procedure. Autopsies were performed in the field and were therefore somewhat limited in scope. No histological work was done. Autopsies performed consisted of a careful inspection of the external anatomy, and a dissection with careful inspection of the gastrointestinal tract, heart, lungs, kidneys and liver.

FOX PREDATION

All fox stools found in the field were examined. Entrances to fox dens were inspected for remains of prey species.

COVER MANIPULATION

Selection of Site

Within the cantonement area on Camp Pickett is a five-acre field supporting an excellent growth of orchard grass (Dactylis glomerata).

A few 1-2 year old loblolly pines (Pinus taeda) are scattered over the area, as are numerous clumps of broom sedge (Andropogon virginicus). While this field supported a good rabbit population during the summer and early fall, it was apparent even at that time that when winter arrived cover would become exceedingly scarce and rabbit utilization would be close to zero. Accordingly, this acreage was selected for a cover manipulation study.

Construction of Brush Piles

Brush piles built for this study were of evergreens. Old pine cuttings were used for the construction of an understory. Logs two to four inches in diameter were laid crosswise so that brush piled on top would be somewhat elevated. The toppings consisted of newly-cut pine and cedar. These brush piles were from 10 to 15 feet in diameter, and reached a height of four feet.

Placement of the brush piles was such that each was located in the center of a circle having an area of 5/9 acre. In this manner nine brush piles served a five-acre area.

Use of Traps

The effect of the added cover was evaluated by means of live-trapping. One box trap was placed not more than 50 feet from each brush pile. All captive rabbits were handled in the manner previously described.

TRACK COUNTS

In a further attempt to evaluate the various land-cultural treat-

ments, track counts were conducted in the snow. Sites of the track counts were those previously chosen for live-trapping. The investigator traversed the perimeter of each five-acre site and counted all tracks that crossed his path.

HIGHWAY KILL

A record was made of all rabbits found dead on roads open to motor vehicles. This information was correlated with the number of miles traveled.

RESULTS OF INVESTIGATION

ROAD COUNTS

Evening Road Counts

Field data revealed that the best time to conduct an evening road count is from 1/2 hour before sunset until sunset. This appears to be the optimal time of rabbit activity.

Evening road counts were conducted daily during July and August; Table 1 and 2 present these data. The July road counts show a great day-to-day fluctuation.

During September evening road counts were conducted every Sunday, Tuesday, and Thursday. Few rabbits were seen; Table 3 gives these data.

Figure 4 presents the weekly average number of rabbits seen per road count in July and August, disregarding those counts which were rained out before completion. It is seen from Figure 4 that during the week of August 12-18 there was a precipitous drop in the number of rabbits observed.

In order to determine if the decline in rabbit activity was real

Table 1. Rabbit roadside count, 10-mile route, Camp Pickett, Va., July, 1959

Date	Rabbit size 1/4	1/2	3/4	Full	Total
1	2	2	2	1	7
2	1	2	1	2	6
3	2	4	1	2	9
4	1	2	3	0	6
5	0	3	2	3	8
6	2	0	4	1	7
7	3	6	0	0	9
8	0	7	3	0	10
9	1	1	2	3	7
10	1	0	2	1	4
11*	10	14	2	1	27
12	10	12	7	0	29
13	4	16	4	0	24
14	0	0	0	0	0
15	7	7	7	5	26
16	9	7	5	7	28
17	1	4	2	1	8
18	6	8	3	4	21
19	4	10	1	3	18
20	0	0	0	0	0
21	1	4	1	5	11
22	10	8	4	4	26
23	10	3	2	1	16
24	7	7	1	2	17
25	3	3	1	4	11
26	3	3	1	3	10
27	1	1	0	2	4
28	4	9	3	3	19
29	6	6	2	2	16
30	4	6	3	1	14
31	2	1	2	3	8
Totals	115	156	71	64	406

*Began new route.

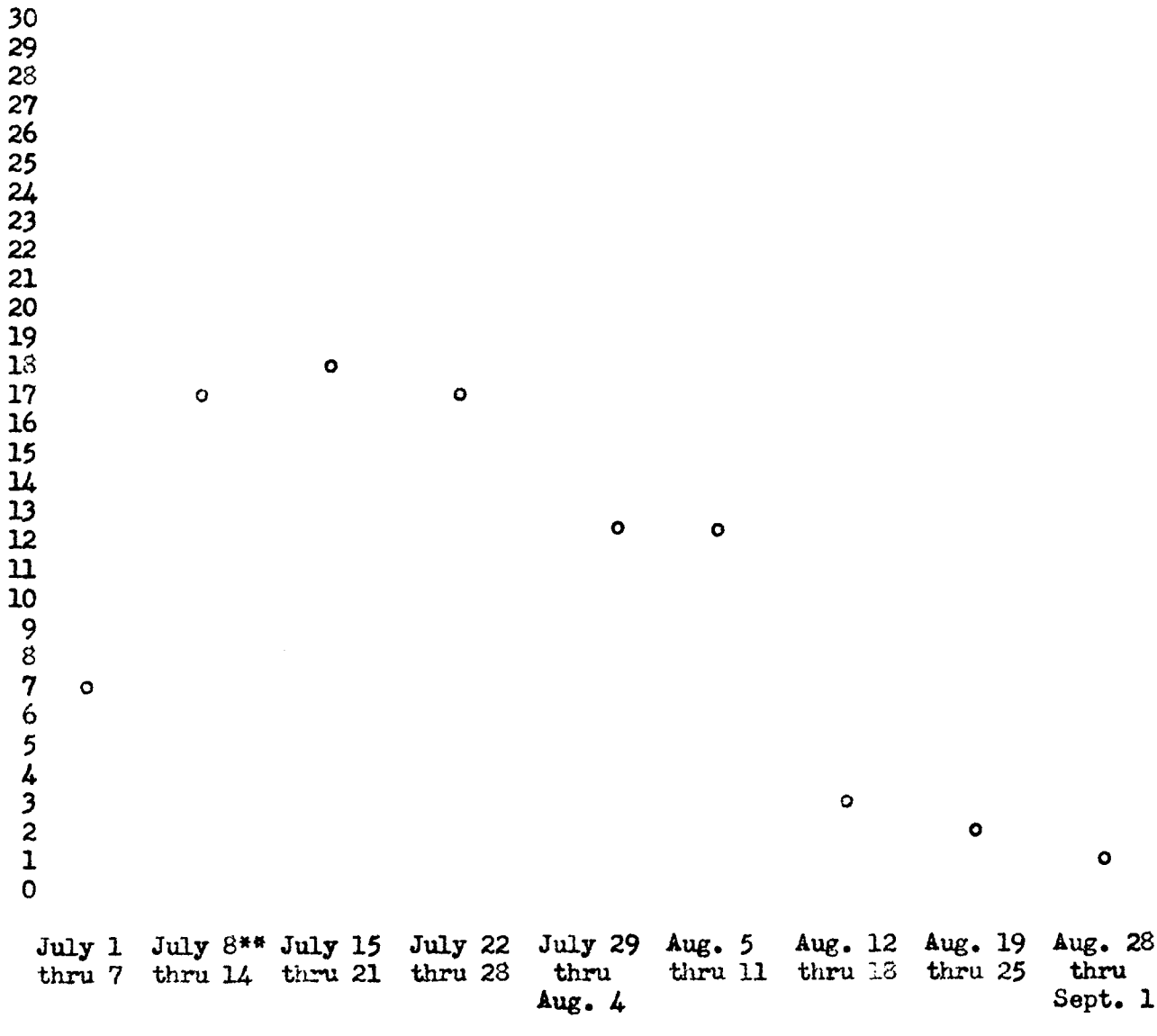
Table 2. Rabbit roadside count, 10-mile route, Camp Pickett, Va., August, 1959

Date	Rabbit size 1/4	1/2	3/4	Full	Total
1	3	11	8	3	25
2	3	6	1	0	10
3	1	1	2	0	4
4	0	0	0	0	0
5	1	2	1	0	4
6	7	4	4	1	16
7	3	6	3	0	12
8	1	2	1	0	4
9	8	7	1	0	16
10	8	8	1	1	18
11	3	3	2	0	8
12	2	1	0	0	3
13	4	1	1	0	6
14	0	2	1	0	3
15	0	0	0	0	0
16	0	0	0	0	0
17	1	0	1	0	2
18	1	0	0	2	3
19	2	0	0	1	3
20	0	1	0	0	1
21	1	0	0	1	2
22	0	1	0	1	2
23	0	1	1	0	2
24	1	0	0	1	2
25	0	0	0	1	1
26	0	0	0	1	1
27	0	1	0	0	1
28	0	0	1	0	1
29	0	1	0	0	1
30	0	1	0	0	1
31	0	1	0	0	1
Totals	50	61	29	13	153

Table 3. Rabbit roadside count, 10-mile route, Camp Pickett, Va., September, 1959

Date	Rabbit size 1/4	1/2	3/4	Full	Total
1	0	0	0	0	0
3	0	1	3	0	4
6	0	0	0	2	2
8	0	1	0	0	1
10	0	0	0	0	0
13	0	0	0	0	0
15	0	0	1	0	1
17	0	0	0	0	0
20	0	1	0	0	1
22	0	0	0	0	0
24	0	0	0	0	0
27	0	0	0	0	0
29	0	1	1	0	2
Totals	0	4	5	2	11

Figure 4. Rabbit roadside count, Camp Pickett, Va., July and August, 1959



*Disregarding those counts that were rained out.
**Began new route July 11.

or only apparent, a brush-beating survey was conducted and a search for dead rabbits was made simultaneously. The latter was done in an attempt to uncover evidence of disease among the rabbit population, if any such disease were present.

Roadside areas were checked along the road count route at 1/2-mile intervals. The investigator's dog was turned loose in each such area and while the dog covered the area, the investigator beat the vegetation with a long stick. All rabbits seen were counted. A careful inspection was made to discover any dead rabbits that might be present.

Twenty of these roadside areas were covered, ten in the morning and ten in the afternoon. Each area checked was approximately one hundred yards square and was bisected by the road.

The ten areas checked in the morning yielded three live rabbits. One of these was 1/4 grown, one 3/4 grown, and one full-grown. No dead rabbits were found in the morning. No rabbits, either dead or alive, were observed in the afternoon.

The day these counts were conducted was very hot. The small number of rabbits seen may have been due to the fact that rabbits tend to stay in burrows during hot periods.

Early in October, when the weather was cool, the above procedure was repeated. Results were two rabbits jumped in the morning and none in the afternoon. All rabbits seen were full-grown. No dead rabbits were found.

Hendrickson (1939:214) found that the amount of dew present was an important factor in determining the number of rabbits that could be flushed from a given area. He was able to flush more rabbits when the dew was heavy than when it was medium or light. This was the condition found

by the investigator, as all rabbits flushed on the above counts were observed in the morning when considerable dew was still present.

Fortenbery (1959:41-43) tested the reliability of flush counts as indicators of rabbit population and found them to be rather unreliable. The investigator agrees with this finding.

Three factors that influenced the daily count were rain, traffic, and mowing. If a moderate to heavy rain was falling during a count, no rabbits would be seen. However, if the road count fell within a few hours after a rain, the number of rabbits observed would be much greater than usual. Heavy traffic caused a drop in the count. Mowing along the roadside the day of the count caused a reduction in the number of cottontails seen. One or two days were required after a mowing for the count to return to normal.

No significant association was found between the number of rabbits observed on the road counts and temperature, wind velocity or barometric pressure. The investigator believes, however, that an association may exist. Newman (1959:292) was able to determine that many weather factors, including wind velocity, influence the number of cottontails observed on road counts, especially during evening hours. In the latter instance, snow was the most important factor encountered.

The reason for the lack of association between the various weather factors and numbers of rabbits observed on the Camp Pickett counts was probably the sudden drop in population that occurred in mid-August. This population drop had such a profound effect on the counts that other controlling factors became practically insignificant in comparison.

The road count is a suitable method for obtaining data relative to

the success of annual reproduction. The greater the young-to-adult ratio, the greater the success of reproduction. Table 4 gives the percentages of each size rabbit observed during the road counts of July, August, and September, and during the September-October period of live-trapping. The percentage of immature cottontails in the population is also listed.

From Table 4 it can be seen that in the month of September, although the population is starting to "grow up," there is still a large proportion of immature rabbits present. Even in October, evidence of late summer breeding is considerable.

The greatest usefulness of the road count data is realized when it can be compared with data of past or future breeding seasons. In this manner it is possible to obtain a valid comparison of the success of two different breeding seasons. Many game agencies use the road count as a tool for collecting data that enables them to set reasonable hunting season lengths. It must be kept in mind, however, that the road counts must all be run under the same conditions if the data from different years are to be compared. Road count data collected in one geographical location can rarely if ever be successfully compared with data collected from another geographical section. There are many factors that influence the number of rabbits that are to be seen on any road count.

Fortenbery (1959:50) conducted road counts on Camp Pickett, but his data can not be compared with the data collected this year because the counts were not conducted under similar circumstances. Full utilization of this year's data will depend on work done in years to come.

Table 4. Size of rabbits, Camp Pickett, Va., July, August, September, October, 1959

Month	Total No. of Rabbits	Percentage of Total 1/4	1/2	3/4	Full	Per cent Immature
July[1]	406	28.3	38.4	17.5	15.8	84.2
August[1]	153	32.7	39.9	18.9	8.5	91.5
September[2]	24	16.7	29.2	37.4	16.7	83.3
October[3]	72	2.28	16.7	18.1	62.9	37.1

[1]From road count data.
[2]From road count data and trapping data.
[3]From trapping data.

Morning Road Counts

Morning road counts were attempted, but were not successful. Optimal time of rabbit activity in the morning is probably from about one hour before sunrise to sunrise. The count before sunrise depends entirely upon the number of rabbits that come into view of the car's headlights. The number of rabbits that did so averaged less than two per road count during the time that the morning counts were being run. Morning rabbit activity ceases after sunrise and few or none may be seen on a road count at this time; therefore, morning road counts were discontinued.

Moon Counts

In an attempt to determine if the moon affects rabbit activity, road counts were run at night during the time of the full moon and during the time of the new moon over the same route. Five counts, one each night, were made for each of the two occasions. Counts were begun two nights before full moon and continued until two nights after the full moon; counts at the time of the new moon were made in the same manner. Too few rabbits were observed to draw any conclusions. These counts were conducted in the latter part of August and the early part of September, after the previously mentioned precipitous drop in the rabbit population had occurred. It is the investigator's belief that moon road counts conducted during the month of July would yield some worthwhile data.

PELLET DURABILITY

In September, 62 pellets of known age were collected and placed in natural habitat. Beginning with the first week of October, 25 fresh pellets were collected each week and put out for observation. Table 5 shows the per cent loss for the pellets during each of the months this part of the study was conducted. It will be noted that the winter loss is practically nil. This fact has great significance when pellet counts are used as a tool in evaluating wildlife management practices. Since the greatest number of pellets are left on the ground in summer and early fall when the rabbit population is highest, pellet counts conducted later may give erroneous results. Pellets counted in winter may reflect earlier usage of an area and not give a true picture of the situation as it exists at that time. Only the use of a permanent quadrat in pellet counts can completely avoid this difficulty.

This interference on the part of the "old" pellet is minimized, however, in cases where cover is periodically weighted down by heavy snow. In such instances the "fresh" pellets can be distinguished from older pellets lying under debris. Where cover is sparse, complications are likely to be encountered. The investigator found that estimating the age of pellets located in open areas was a rather difficult, often impossible, task.

When hot weather arrives in the spring of the year, rabbit pellets apparently disintegrate rapidly. Many are broken up by insects. Even "fresh" pellets disappear within a short time. Of the 200 pellets set out in April, more than half were carried away or completely covered by ants within 24 hours.

Table 5. Pellet durability, Camp Pickett, Va., September thru April, 1960

Month	Number of Pellets	Per cent Loss							
		Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total
September	62	37.	6.0	0.0	0.0	0.0	0.0	0.0	43
October	200	—	0.0	2.0	1.0	17.	0.0	1.0	21
November	200	—	—	0.0	2.0	4.0	3.0	2.0	11
December	200	—	—	—	6.0	2.0	2.0	2.0	12
January	200	—	—	—	—	0.0	5.0	8.0	13
February	200	—	—	—	—	—	3.0	15.0	18
March	200	—	—	—	—	—	—	100	100

The fact that very few pellets survive the initial hot spring weather is substantiated by the low pellet counts obtained in the land-cultural treatment evaluation conducted in April.

PELLET COUNTS FOR CULTURAL TREATMENT EVALUATION

Summer pellet counts for cultural treatment evaluation were conducted between August 18 and September 16, 1959. Counts were conducted on three each of six different land treatment types as well as on three control areas. The counts were made in rotation according to type, thus eliminating error that would result if one treatment type were to be evaluated later than another. During the summer months the rabbit population is quite high and a week can make a vast difference in the number of pellets occupying any given food patch.

Two types of quadrats were utilized in this phase of the study: the permanent plot one milacre in size, and the randomly chosen plot one-square-foot in size. Each has advantages and disadvantages. When the permanent type is used, pellets can be removed at the time of counting, making it possible to recognize new pellets when counts are repeated at a later date. However, the chance of missing pellets is much greater when the milacre-size plot is used than when the one-square-foot plot is used. In order to completely search the larger plot for pellets, the investigator found it necessary to disrupt much of the vegetation within the area. This change in the physical characteristics of the permanent quadrat would conceivably affect later counts, if such were to be conducted. The randomly selected quadrat makes for much faster work than does the permanent quadrat. Permanent quadrats must first be located, then established, and thereafter maintained. The permanent plot offers considerable difficulty

if there is game management or forestry being practiced in the area. On several occasions the investigator returned to a permanent quadrat only to find the stake removed by some other person and the location of the plot lost. This can result in the loss of much valuable time.

Table 6 gives the number of pellets counted on all the sites, both on the permanent and randomly selected quadrats. In Table 7 the average number of pellets found on each of the control areas has been assigned a value of 1.00. The six cultural treatment types are ranked accordingly.

Spring pellet counts were conducted during the week of April 10-16, 1960, on all the land-cultural treatment types as well as the control areas. In these counts only the one-square-foot quadrat was used. The results are given in Table 8. In Table 9, the average number of pellets on each of the control areas has again been assigned a value of 1.00, and the other cultural treatment types are compared accordingly.

Control Area Pellet Count Results

Summer

The control areas, setting the unit of comparison for the cultural treatment types, yielded 13.7 per cent of all pellets counted in this phase of the study. The usage on the control areas was 16.7 (milacre quadrats) and 3.70 (one-foot-square quadrats) times that on the mowed areas; 16.7 (milacre quadrats) and 2.78 (one-foot-square quadrats) times that of the burned areas; 7.14 (milacre quadrats and one-foot-square quadrats) times that on the fescue firelanes; and 4.17 (milacre quadrats) and 0.85 (one-foot-square quadrats) times that on the clover-fescue

Table 6. Rabbit pellet counts, Camp Pickett, Va., August and September, 1959

Site No.	Treatment Type	Total No. of Pellets Milacre quadrats	Total No. of Pellets 1-foot square quadrats
3	Annual Mix	784	220
15	" "	905	0
16	" "	4	0
	Total	1693	220
2	Clover-small grain	316	49
14	" " "	205	44
17	" " "	87	89
	Total	608	182
4	Clover-fescue	16	4
7	" "	0	74
9	" "	85	0
	Total	101	78
5	Fescue	33	3
6	"	27	6
8	"	0	0
	Total	60	9
11	Burning	0	0
12	"	12	18
13	"	11	5
	Total	23	23
1	Mowing	27	6
10	"	0	0
18	"	0	12
	Total	27	18
19	Control	27	8
20	"	309	48
21	"	81	10
	Total	417	66

Table 7. Evaluation of cultural treatments by pellet counts, Camp Pickett, Va., August and September, 1959

Cultural Treatment	Milacre Quadrats		One-square-foot Quadrats	
	Avg. No. Pellets	Rating	Avg. No. Pellets	Rating
Control	139	1.00	22	1.00
Annual Mix	564	4.05	73	3.32
Clover-small grain	203	1.46	61	2.82
Clover-fescue	34	0.24	26	1.18
Fescue	20	0.14	3	0.14
Mowing	9	0.06	6	0.27
Burning	8	0.06	8	0.36

Table 8. Rabbit pellet counts, Camp Pickett, Va., April 10-16, 1960

Site No.	Treatment Type	Total No. of Pellets 1-foot square quadrats
3	Annual Mix	26
15	" "	273
16	" "	17
	Total	316
2	Clover-small grain	84
14	" " "	16
17	" " "	24
	Total	124
4	Clover-fescue	10
7	" "	0
9	" "	16
	Total	26
5	Fescue	7
6	"	0
8	"	6
	Total	13
11	Burning	36
12	"	30
13	"	47
	Total	113
1	Mowing	5
10	"	10
18	"	8
	Total	23
19	Control	2
20	"	11
21	"	51
	Total	64

Table 9. Evaluation of cultural treatments by pellet counts, Camp Pickett, Va., April 10-16, 1960

Cultural Treatment	One-square-foot Quadrats	
	Avg. No. Pellets	Rating
Control	21	1.00
Annual Mix	105	5.00
Clover-small grain	41	1.95
Clover-fescue	9	0.43
Fescue	4	0.19
Mowing	8	0.38
Burning	38	1.81

firelanes. These reasonably high counts on the control areas are explained by the fact that these areas are composed of abandoned farms, and thereby are possessed of various cover types attractive to the rabbit.

Spring

The control areas yielded 9.44 per cent of all pellets counted in this phase of the study. The usage on the control areas was 2.63 times that of the mowed areas; 0.55 times that of the burned areas; 5.26 times that on the fescue firelanes; and 2.32 times that on the clover-fescue firelanes.

Annual Mix Pellet Count Results

Summer

The annual mix food patches, according to the pellet counts, received the greatest amount of summer use of any of the cultural treatment types. The count on the milacre quadrats showed a usage 4.05 times that of the control areas, while the count on the one-square-foot quadrats showed a usage 3.32 times that of the control areas. This was a usage 2.78 (milacre quadrats) and 1.18 (one-square-foot quadrats) times that of the nearest competitor, the clover-small grain food patches. Fifty-four and two-tenths per cent of all pellets counted were found on the annual mix cultural treatment type areas.

Spring

The annual mix food patches, according to the pellet counts, again received the greatest use of any of the cultural treatment types. The count showed a usage 5.00 times that of the control areas. This

was a usage 2.56 times that of the nearest competitor, the clover-small grain food patches. Forty-six and two-tenths per cent of all pellets counted were found on the annual mix cultural treatment type areas.

This high count was, however, due to the fact that 82.3 per cent of all the pellets found on these areas were located within a single quadrat. This is an unusual situation. Furthermore, cover in these food patches was severely depleted by winter weather. This resulted in the exposure and subsequent counting of many older pellets.

In the opinion of the investigator, this count did not give a true picture of annual mix food patch utilization by the cottontail rabbit in the spring season. Actual utilization is undoubtedly much lower.

Clover-small Grain Pellet Count Results

Summer

Second highest usage of all the land-cultural treatments was found on the clover-small grain management unit, where 22.2 per cent of all pellets found were counted. This was a usage 1.46 (milacre quadrats) and 2.82 (one-square-foot quadrats) times that on the controls, and was far above the usage as determined on any of the other cultural treatments with the exception of the annual mix plantings.

Spring

Second highest usage of all the land cultural treatments was again found on the clover-small grain food patch, where 18.3 per cent

of all pellets enumerated were located. This was a usage 1.95 times that of the controls.

Because the clover forms a dense ground-cover, only the most recently deposited pellets are found exposed for counting. This places a handicap on the clover-small grain food patches when they are compared with other land-cultural treatments such as the annual mix food patch, where sparse cover results in increased exposure of older pellets. Consequently, the count accorded the clover-small grain treatment is perhaps less than that deserved, at least in the spring season.

Clover-fescue Pellet Count Results

Summer

Results of pellet counts on firelanes planted to the clover-fescue combination were somewhat contradictory. Usage was 0.24 (milacre quadrats) and 1.18 (one-square-foot quadrats) times that of the controls. Because the clover-fescue firelanes are located in forested area it would seem that the lower figure would be the more correct, and it does fit in well with other data. Pellets counted on these areas represented 5.04 per cent of all pellets enumerated.

Spring

Data collected from spring pellet counts verify the low usage given the clover-fescue firelanes by the cottontail. Only 3.54 per cent of all pellets counted were found on this cultural treatment type. This was a usage 0.43 times that of the controls.

Fescue Pellet Count Results

Summer

Firelanes planted to fescue showed a usage 0.14 (both milacre quadrats and one-square-foot quadrats) times that of the controls. This represented 1.87 per cent of all counted pellets. Since the firelanes are located in forested area, this low count reflects the low rabbit population that one would normally expect in such a situation.

Spring

A low count was again obtained on the fescue firelanes. Usage was 0.19 times that of the controls. Of the total number of pellets counted, 1.92 per cent were located on this land-cultural treatment type.

Burned Area Pellet Count Results

Summer

Only 1.30 per cent of all pellets were encountered in the burned areas. Fortenbery (1959:78) found that burning produced new vegetation favorable to the cottontail. The investigator is at a loss to explain the low count on the burned areas, except that perhaps it was due to the small number of areas sampled. Another possibility is the fact that most of this burned area is covered by forest, an environment not particularly suited to the rabbit. The relatively short period of time that had elapsed since the area was burned may also be a factor. At any rate, the burned areas showed a usage only 0.06 (milacre quadrats) and 0.36 (one-

square-foot quadrats) times that of the control areas.

Spring

Usage of the burned areas was 1.81 times that of the controls. This figure is almost as high as that obtained for the clover-small grain food patch, and is perhaps more in line with what one might expect. Sixteen and seven-tenths of all pellets counted were found on the burned areas.

Mowed Area Pellet Count Results

Summer

Mowed areas gave up only 1.27 per cent of all pellets counted. This was only 0.06 (milacre quadrats) and 0.27 (one-square-foot quadrats) times the usage of the control areas, and represents the poorest showing of all the land-cultural treatments tested by the pellet counts. This apparent discrepancy can be explained by the fact that even though selected randomly, all three mowed areas on which pellet counts were conducted were located in predominantly forested land. Since the rabbit is primarily a farm-land species, one would not expect a high population in forest habitat.

Spring

A low count was again obtained on the mowed areas. Only 3.30 per cent of the total pellets counted were on this land-cultural treatment type. This was a usage 0.38 times that of the controls.

TRAPPING FOR CULTURAL TREATMENT EVALUATION

The 120 traps were opened on October 5, 1959. There were six traps on each of the 20 study areas, the latter being equally divided among the annual mix, clover-small grain, clover-fescue, fescue, and control types. The traps were operated through October 22, a total of 2,160 trap nights (120 traps operated for 18 days). Seventy-two rabbits were marked and 18 were recaptured. A total of 90 rabbits was handled in this phase of the study. The number of trap nights required for each capture was 24. Trapping by Fortenbery (1959:35) in September and October of the previous year yielded one rabbit capture per 28.8 trap nights. In both instances, the relatively high number of trap nights required for each capture was undoubtedly due to the comparatively mild weather encountered in this geographical section at this time of year. It is believed that the rabbits utilize the traps primarily for cover. Trapping results are enumerated in Table 10. As too few rabbits were handled on each of the study areas to obtain a population estimate by trap-retrap formulae, the number of rabbits marked was used as an index of abundance. This same situation was encountered by Fortenbery in his work (1959:36). In the case at hand the main difficulty was failure to realize a sufficient number of recaptures. Whether or not this indicates movement on the part of the rabbits is something that needs further study. According to Redd (1956:94) monthly population estimates cannot be made by live-trapping due to variability of trap response (especially during summer and early fall) and he stated that 40 per cent of the population must be handled before a reliable population estimate can be had.

Table 10. Live-trapping of rabbits, Camp Pickett, Va., Oct. 5-22, 1959

Site No.	Treatment Type	Captures	Recaptures	Total
1	Annual Mix	8	2	10
15	" "	3	1	4
19	" "	3	1	4
20	" "	3	1	4
	Total	17	5	22
2	Clover-small grain	11	3	14
3	" " "	9	2	11
17	" " "	2	1	3
18	" " "	13	2	15
	Total	35	8	43
4	Clover-fescue	2	0	2
5	" "	0	0	0
9	" "	1	0	1
16	" "	5	1	6
	Total	8	1	9
6	Fescue	1	0	1
7	"	0	0	0
8	"	0	0	0
10	"	0	0	0
	Total	1	0	1
11	Control	2	0	2
12	"	3	1	4
13	"	4	3	7
14	"	2	0	2
	Total	11	4	15
	Grand Total	72	18	90

During this period of trapping a sex ratio of 112 males to 100 females was found. Fortenbery (1959:36) found a ratio of 130 males to 100 females.

Traps on the control, annual mix, and clover-small grain areas were again opened on February 4, 1960. This period of trapping extended through April 8. Data are presented in Table 11.

Control Area Trapping Results

Fall

On the control areas a total of 11 rabbits were marked with four of these being recaptured. This was a 36.4 per cent rate of recapture. The average number of rabbits captured per control area was 3.74, and for purposes of comparison this value may be given a rating of 1. This represents 15.3 per cent of all rabbits marked in this phase of the study. The number of rabbits handled on the control area was 16.7 per cent of total.

Winter

During the winter period of trapping 26 rabbits were marked on the control areas, with six of these being recaptured. This was a 23.1 per cent rate of recapture. An average of eight rabbits were captured on each of the control areas. This accounts for 23.6 per cent of all rabbits marked in this phase of the study. The number of rabbits handled on the control areas was 24.6 per cent of total.

Table 11. Live-trapping of rabbits, Camp Pickett, Va., Feb. 5-April 8, 1960

Site No.	Treatment Type	Captures	Recaptures	Total
1	Annual Mix	4	0	4
15	" "	6	2	8
19	" "	4	0	4
20	" "	12	2	14
	Total	26	4	30
2	Clover-small grain	6	2	8
3	" " "	20	4	24
17	" " "	8	2	10
18	" " "	24	2	26
	Total	58	10	68
11	Control	6	0	6
12	"	6	2	8
13	"	10	4	14
14	"	4	0	4
	Total	26	6	32
	Grand Total	110	20	130

Clover-Small Grain Trapping Results

Fall

The four areas planted to the clover-small grain yielded a total of 35 rabbits marked and eight recaptured. This was a 22.8 rate of recapture, and contrary to what one might expect, less than the rate of recapture realized on the control areas. Compared with controls, these areas had a rating of 3.18, this being a usage of 2.05 times that of the nearest competitor, which in this case was the annual game bird mix. Rabbits marked on this treatment type comprised 48.6 per cent of the total number marked, and 47.7 per cent of all rabbits handled were accounted for here.

Winter

Fifty-eight rabbits were marked and 10 recaptured on the clover-small grain trapping sites. This was a 17.3 per cent rate of recapture. The usage by the cottontail of these food patches was 2.12 times that on the control areas. This was a usage 2.26 times that of the annual mix food patches. Of the total number of animals marked in this phase of the study, 52.7 per cent were tagged on the clover-small grain areas. Rabbits handled here represented 52.3 per cent of the total.

Annual Mix Trapping Results

Fall

Seventeen rabbits were marked and five were recaptured on the areas planted to annual game bird mixture. This was a recapture rate

of 29.4 per cent, and like that of the clover-small grain treatments, less than the rate of the control areas. When compared with the control areas, usage was found to be 1.55 times greater. A total of 23.6 per cent of all rabbits were marked on these areas, and 24.4 per cent of all rabbits were handled here.

Winter

On the annual game bird mix food patches, 26 cottontails were marked and four were recaptured, this being a 15.4 per cent rate of recapture. The usage of these areas was 0.94 times that of the controls, and only 0.44 times that of the clover-small grain food patches. There seems to be very little food left for the rabbit on these food patches by the time mid-winter arrives. Of the total number of rabbits marked in this phase of the study, 23.6 per cent were tagged at the annual mix trapping sites, while 23.0 per cent of all rabbits were handled here.

Clover-Fescue Trapping Results

Eight rabbits were marked on the firelanes planted to the clover-fescue combination, while only one rabbit was recaptured. This was a rate of recapture of 12.5 per cent, just 1/3 of the rate realized on the control areas. Usage of these firelanes by the rabbit was 91.0 per cent of that provided by the control areas (a rating of 0.91). This is a much higher figure than that which might be expected according to the results of the pellet counts that were conducted during the summer. However, the apparent discrepancy can be explained by the fact that five of the rabbits marked on the clover-fescue firelanes were trapped on a site which passed within 100 yards of an old farm field. The investigator's

observations led him to believe that rabbits were using this old farm field and were in fact doing a considerable amount of traveling between the field and the firelane. This brings to light again the fact that rabbits are primarily a farm game species, and would utilize the firelane plantings for food if their other requirements could be met by the surrounding habitat. The clover-fescue firelanes yielded 11.1 per cent of all rabbits marked, and 5.56 per cent of all rabbits handled.

Fescue Trapping Results

Only one rabbit was marked and only one rabbit was recaptured on the firelanes planted to fescue. This was the poorest response of all the land-cultural treatment types. The usage was 0.091 times that of the control areas, 0.125 times that of the clover-fescue combination, 0.027 times that of the clover-small grain plantings, and 0.059 times that of the annual game bird mixture plantings. The very low usage was obviously due to the fact that all firelanes sown to fescue had been bulldozed through solid stands of loblolly pine. A pure stand of loblolly pine provided few of the cottontail's requirements. The percentage of rabbits marked on the fescue firelanes was 1.39, while 5.55 was the percentage handled.

TESTING OF POPULATION ESTIMATION FORMULAE

Work was begun on this part of the project in July, 1959. At this time a one-half-acre annual game bird mix food patch was installed in the center of the five-acre rabbit pen. The pen, which had been built by Fortenbery in 1958, was repaired so that it was "rabbit proof."

In October, all woodchuck burrows within the enclosure were plugged

with burlap bags. This was done in order that a valid census of the rabbit population within the pen could be realized. The census was made by track counts, pellet counts, flush counts, and trapping.

Track counts done soon after a hard rain indicated that two rabbits were inhabiting the pen. Pellet counts on 20 one-square-foot quadrats selected randomly yielded 237 pellets. Normally this would indicate a rather high usage of an area, but in this case it must be remembered that any rabbits within the pen were confined to that area and must necessarily deposit all their droppings in that region. Two flush counts done with the aid of the investigator's German Shepherd turned up no rabbits whatsoever. Trapping was then carried on for seven days, and during this time only one rabbit was captured, a full-grown male. The remains of another rabbit were found in the pen. From the foregoing and from other observations the investigator reached the conclusion that just the one rabbit was then inhabiting the study area. Results of later trapping confirmed this opinion.

Nine permanent milacre quadrats for pellet counting were established. Initial counts made on these quadrats gave a total of 293 pellets. All these pellets were removed from the quadrats. It was the intention of the investigator to conduct pellet counts at regular intervals in the pen, and thus determine the number of pellets that a known population would deposit over a given period of time. However, this was prevented by various difficulties that were encountered during the course of the project.

Early in November, 11 cottontails were trapped elsewhere and stocked in the rabbit pen. All were sexed, aged and tagged before release. This made a total of 12 rabbits inhabiting a five-acre area. Following

the stocking the pen was left idle for ten days. During this time the pen was severely damaged by White-tailed Deer (Odocoileus v. virginianus), and all but two of the rabbits escaped. Several of these escapees were later trapped outside the pen and one was shot by a hunter during the open season which began November 16.

The pen was repaired and ten more rabbits were stocked, making the total population again 12. Trapping was resumed immediately for a period of 15 days. At this time it was discovered that poachers had killed ten of the rabbits present. Two dead rabbits were found inside the pen, both having been shotgunned. Many empty shotshell cases were also found inside the fence. This was done in spite of the fact that the pen was heavily posted. The investigator released beagles in the area, but not a single rabbit was jumped. Only two of the inhabitants were ever seen again, one of the survivors being the full-grown male that was living within the enclosure when the experiment began.

Eight more rabbits were stocked in the pen, making a population of ten. Trapping was resumed immediately. Three rabbits were killed by a fox that leaped over the fence during the night. The investigator attempted to call the fox into gun range early the next morning but had no success. A predator call of the type that imitates a rabbit's death scream was used.

These three victims were replaced with other rabbits. The replacements were considered not as new additions to the pen, but instead were regarded as replacements. This policy was followed whenever rabbits were found dead in the pen from whatever cause. The writer realizes that this method is open to a certain amount of criticism, as different rabbits have different trap responses. However, this is the only way in which a

"constant, known population" could be maintained for purposes of calculations with mathematical formulae.

During this period of trapping, rabbits were found dead in the pen of various causes, often unknown. Whenever possible, these animals were autopsied. Two of those autopsied were found to be dead of starvation.

The investigator was not able to determine the exact extent of avain predation on the pen population. During the course of the project only two rabbits that could be regarded as proven hawk or owl kills were found within the pen. However, various species of hawks were constantly coursing the area in which the pen was located. It is possible that more than a few cottontails became hawk dinners.

By January 16 only two rabbits were to be found inhabiting the pen. One of these was Number 298.[1] The investigator was unable to determine how most of the rabbits were lost. Some were undoubtedly lost when deer knocked down sections of the fence. Deer damage was a serious problem during the first three trapping periods, severe damage to the pen occurring on an average of twice a week. The pen was kept under constant surveilance and any damage done by deer was remedied as quickly as was feasible.

The problem of deer damage was solved by the installation of deer-frightening devices at the pen. Tin cans were relieved of their labels and tied to the metal fence posts with binder twine of sufficient length

---

[1]No. 298 tag was given to the cottontail originally inhabiting the five-acre enclosure. This rabbit became quite well-known to management personnel on the Camp Pickett area, and was referred to as "Old 298."

to allow them to swing freely. A half-dozen pebbles were added to each can. When a slight wind was blowing, considerable noise was produced. This noise, plus light reflection off the cans resulted in an efficient deer-frightening device. Damage to the pen was reduced from twice per week to only two times in about two months.

Following the addition of the deer-frightening devices, eight more rabbits were stocked into the pen. This made the total again 10. It was the opinion of the investigator at this time that the five acres within the pen could not possibly support more than 10 rabbits because of the depleted supply of food and cover. Very little green foods were available, and severe winter weather that included two snows had resulted in the destruction of most of the cover. In the hope of improving the cover situation, two brush piles were built inside the pen. Track counts made during a later snow showed both of these brush piles being utilized by the rabbits.

Trapping was immediately resumed and carried on until March 5, 1960. During this time numerous rabbits were found dead within the pen of unknown causes. All were replaced. One of these replacements, when released in the pen, ran in a large circle, crashed into the fence, and in a panic scrambled over it. A few days later, another rabbit was observed attempting to climb over the fence, but it was not successful. However, it appeared to the investigator that with a little practice success would be readily achieved.

One of the rabbits tagged by Fortenbery in 1958 was trapped just outside the fence. When released inside the pen, it loped to the fence and climbed over just like it had done it many times before. A few days later, this same rabbit was trapped again, this time inside the pen,

indicating that it had climbed the fence once more. These observations lead one to conclude that a cottontail can scale a 27" fence if the occasion demands. Undoubtedly, some of the rabbits stocked into the pen made good their escape in this manner.

During this phase of the study, a total of 49 cottontails were marked. Recaptures numbered 78, a recapture rate of 159 per cent. A total of 127 rabbits were thus handled. "Old 298" was recaptured 25 times. Another individual was recaptured 14 times.

The mathematical formulae that the investigator had hoped to evaluate through results obtained from this study are known as the Krumholz, the Lincoln, and the Shumacher and Eshmeyer. These formulae have been presented by Fortenbery (1959:44-45). Unfortunately, because of the various difficulties encountered during the course of the project, this investigator was not able to accomplish the desired task. He was, however, able to formulate a set of recommendations which will be of assistance to the next researcher attempting this experiment on the study area:

1) An annual game bird mix food patch should be installed within the rabbit pen during the summer months.

2) A clover-small grain food patch should be installed in the fall.

3) At least nine brush piles of the type described in this thesis should be constructed inside the pen before winter.

4) A furrow should be plowed against the base of the fence to prevent any rabbits from burrowing their way out of the enclosure.

5) An overhang, at least one foot in width, should be added to the fence. This overhang would be directed toward the interior of the pen. This should prevent rabbits from climbing over the fence.

6) Fox and hawk traps should be set on the area directly surrounding the pen. In the present study, the investigator was not able to make use of fox traps because of the fact that he was using his dog to make daily flush counts within the enclosure and to have had fox traps set in that vicinity would have exposed the dog to extra hazards.

The ideal method for preventing interference by predators would be to completely enclose the five-acre area by constructing a roof on the pen. This is not feasible because of the cost involved.

7) Post "Off-Limits" signs at least every 200 feet around the pen.

8) Space traps according to the previously described procedure.

9) Avoid trampling cover when running the trap line.

10) Maintain and reinforce the deer-frightening devices at the pen as previously described.

Although the foregoing recommendations will not cure all the ills of this experiment, they should be of considerable help.

PARASITES

Ticks

Infestation with ticks of cottontails handled during the course of this project was extremely limited. During the winter months, ticks were conspicuously absent. Of 414 rabbits handled in the study, only 37 had one or more ticks. This was 8.95 per cent. The low figure is due in part to the fact that no rabbits were handled in the summer, the season of greatest tick infestation.

Fleas

Infestation with fleas was also rather limited. None were encountered during the months of November, December, or January. However, fleas became abundant in February. Of 154 rabbits handled between February 1 and April 11, 1960, 71 had fleas. This was 46.1 per cent. Eighty, or 19.3 per cent, of the 414 rabbits handled in the study were infested.

Bot Fly Larvae

Bot fly larvae (Cuterebra bacatta), and/or scars caused by their infestation, were numerous. Forty-two per cent of all individuals handled either were or showed definite evidence of having been infested. These 174 rabbits each had an average of 1.32 larvae. No preference was shown for hosts of any one sex, with 84 females and 90 males being afflicted. In the fall, immature cottontails were more often infested than were adults.

The genital region was the most common anatomical site at which the lesions occurred. Sixty-five per cent of all lesions were found at this location. Other anatomical sites were the shoulder region (17 per cent), the side (10 per cent), the neck (4.0 per cent), the back (3.0 per cent), and the tail (1.0 per cent).

Fortenbery (1959:61) found 114 of 325 rabbits handled (35 per cent) on Camp Pickett to be infested with one or more Cuterebra fly larva. No preference for hosts of one particular sex existed, and immatures were more often infested than were adults. The most common anatomical site at which the lesions occurred was the genital region.

McGinnes (1958:50) found an average infestation of 15 per cent in two years of trapping at Blacksburg, Virginia. Bruna (1952:38) in Kentucky observed an infestation of 12.6 per cent, while Geis (1957:94) in Michigan observed 26 per cent infestation in the summer of 1956 and 11 per cent in the summer of 1957.

DISEASE AND INJURY

Eighteen rabbits were subjected to autopsy. One male presented

signs of death by starvation. Three females suffered death by freezing. None of the other individuals showed any gross pathology. No endoparasites were found. Rabbits autopsied were found dead in the field of unknown causes. Those killed by auto or predators were not autopsied.

Nine of the 414 rabbits that were handled in the study were afflicted with Shope's fibroma. This was 2.2 per cent, the same incidence reported by Fortenbery (1959:61). All of the lesions were located on the hind legs or feet. One individual had three fibromas on the left hind foot and two on the right hind leg.

Nine rabbits also were suffering from various lacerations. Three of these rabbits were recaptured at least once, and healing had occurred in all instances. One cottontail was recaptured several times, and the investigator was therefore able to observe the entire healing process of some rather extensive lacerations.

Minor cuts and contusions resulting from attempts to escape were common among live-trapped rabbits. Seven rabbits found dead in the traps established trap-mortality at 1.7 per cent.

FOX PREDATION

Fifty-six fox stools were subjected to gross examination in the field between July 1 and November 30, 1959. Fifty-five, or 99 per cent, of the stools contained seeds of the persimmon (Diospyros virginiana). Eighteen, or 32 per cent of the total, contained remains of small mammals (mostly hair of mice). Remains of rabbits were identified in only two of the stools.

It must be kept in mind that examination of these stools took place in the field, sometimes under adverse conditions. The results

obtained are therefore not nearly as reliable as would be data from examinations performed in the laboratory. However, the investigator believes that the low number of stools containing rabbit remains is significant, as is the large number of stools containing seeds of the persimmon. It seems obvious that fruits are making up the bulk of the fox diet in the summer and fall. Few rabbits are apparently taken. In all probability, rabbits eaten by foxes during these seasons are either carrion or ones caught by chance. Abundant cover in the summer and early fall gives these mammals good protection from predators. Fruits are plentiful and readily available to the fox during this time.

RESULTS OF COVER MANIPULATION

Live-trapping was conducted on the five-acre area selected for the cover manipulation study from November 1, 1959 to April 11, 1960. Construction of brush piles took place on February 3, 1960. Results are presented in Table 12. Too few rabbits were handled to get a population estimate.

It is obvious that the addition of the brush piles did not increase utilization of the area by the cottontail. The reason for this is probably the fact that the brush piles were not constructed until after the rabbits had disappeared from that area. When winter sets in, rabbits on Camp Pickett seem to disappear from the uplands, and are found in the lowlands, particularly the swamps.

The trapping results indicate that the addition of brush piles to an area after the rabbits disappear from it will not cause their return. In geographical areas where cottontail loss during the early winter months is significant, upland brush piles should be constructed

Table 12. Live-trapping of rabbits on cover manipulation site, Camp Pickett, Va., Nov. 1, 1959-April 11, 1960

Month	Captures	Recaptures	Total
November	7	1	8
December	5	1	6
January	0	0	0
February	1	0	1
March	2	0	2
April	1	0	1

in the fall if beneficial effects are to be derived from them. Brush piles built on lowlands may, however, be beneficial to wildlife regardless of the time of year that they are constructed.

McGinnes (1958:68) found that brush piles can and will attract rabbits, at least at distances less than 207 yards from the artificial cover. That investigator was able to make habitable an otherwise "rabbit barren" area by such artificial habitat alteration. However, that study was carried out on a 26.5-acre area on which existed an initial estimated rabbit population of 51 individuals. In the case at hand there were no rabbits inhabiting the five-acre area when the brush piles were constructed.

TRACK COUNTS

Attempts to evaluate the various land-cultural treatment types by track counts were not successful.

The first attempt to obtain data by use of track counts was made on December 19, 1959. This was the first snow of the winter season. However, much of the snow was melted before the investigator was able to complete the counts, and the result was insufficient data.

Track counts at all the land-cultural treatment trapping sites were completed on three occasions: February 14, March 3 and 4, 1960. In every instance only a very few rabbit tracks were observed. No evaluation could be made from the minute data that was obtained.

Few rabbits and/or rabbit signs were observed in the field during any of the snows at Camp Pickett this year. Apparently the cottontail population is, with few exceptions, "holed up" in this kind of weather, especially when the snow is accompanied by moderate to strong wind.

HIGHWAY KILL

Data pertaining to the number of Cottontail Rabbits observed dead on the highways in and around Camp Pickett are presented in Table 13. During the time of year when food and cover were abundant, the highway kill was negligible. When food and cover began to diminish the highway kill began to rise. The greater the winter depletion of food and cover, the greater the highway kill. This progressively increasing highway kill is undoubtedly due to the increased amount of movement required of the rabbits if they are to secure the necessary food and cover when these items are scarce.

The highest kills of all occurred in the months of March and April. Increased cottontail movement brought on by the breeding season was a contributing factor.

Table 13. Highway kill, Camp Pickett, Va., July, 1959-April, 1960

Month	No. killed	Miles per kill
July	1	1234
August	2	1153
September	1	888
October	2	693
November	5	200
December	7	171
January	17	58
February	20	50
March	20	33
April	25	31

RABBIT MANAGEMENT DISCUSSION AND RECOMMENDATIONS

SEASON LENGTH

Investigation carried on during the hunting season uncovered the fact that very few of the tags on rabbits killed by hunters were being turned in at the game checking station. It was therefore impossible to estimate the total cottontail population on Camp Pickett using data obtained from tag returns.

In spite of the above situation, the investigator estimates from other information and data that the 1959-60 kill was somewhere between 10 and 15 per cent of the total population.

Mosby[1] states that 50-70 per cent of the fall rabbit population on an area having good habitat can be harvested by hunters without depleting the breeding stock. This means that in all probability, at least twice as many cottontails could be safely harvested on the Camp Pickett management area as were harvested this season.

Two methods are available for increasing the percentage of rabbits taken by hunters in a single season. The first, an increase in the daily bag limit, is not recommended by the investigator at this time because it is doubtful that this would have any appreciable effect on the amount of recreation available to the hunter. The second, an increase in season length, is recommended. Adding at least two weeks to the beginning of the season would result in increased recreational

---

[1]Personal communication from H. S. Mosby, Virginia Polytechnic Institute, Blacksburg, Virginia.

opportunities for the hunter as well as an increase in the annual cottontail harvest. Both are desirable.

Extending the beginning of the season rather than the end is recommended because it is in the fall that many rabbits being lost to natural causes would be available to the hunter.

Hunting pressure is not self-regulatory on Camp Pickett. This is because of the widespread publicity being given the area by various individuals and organizations. It is conceivable that the annual cottontail kill might be increased by an increase in hunting pressure, but this is hardly under the control of management personnel.

PREDATOR CONTROL

Allen (1954:262-263) says:

> "Attempts to use predator control as a year-after-year force in the economy of a wildlife population seem to be almost universally unsound. In healthy wildlife habitats wildlife communities take care of themselves, and sustained excessive predation can in most cases be taken as a symptom of deficient cover or some other semi-permanent condition. The word 'sustained' is not to be passed over lightly, because temporary predation to excess is a valid reason to suspect such temporary population ills as disease, intolerable weather extremes, or lowered water levels (where these are important to such species as ducks or muskrats).
>
> The matter of harvesting the annual surplus of predators is a subject little understood but fraught with implications. . . . breeding stocks of animals are healthiest and most productive when the population is thinned out early in the season and competition among breeders is minimized. This undoubtedly holds true for carnivores as well as herbivores.
>
> In the early forties foxes became far too abundant over much of the nation. Many states were under public pressure for intensive control of foxes. It is almost universally the case that these programs do not get down through the annual surplus of animals and actually reduce the breeding stock; and if they did that the breeding stock might rise to the occasion and be even more productive.
>
> So what does control mean? Are we actually keeping the fox

> healthy by taking off excess numbers each year and thus creating favorable conditions for producing next year's crop? Are we delaying the reckoning that Nature has in store for the fox - such decimating agents as rabies, encephalitis, and distemper?
>
> It is likely that we are. . .
>
> Our best evidence indicates that in many cases the most effective way to control predators is to provide their prey with a better habitat in which to live.
>
> This sketchy appraisal of the carnivore menace indicates that an attitude of caution toward control programs is realistic. . . . . They are among our most costly wildlife management endeavors and are of concern to those who pay for them.
>
> De Vos pointed this out in discussing the wolf in Ontario: 'It should be realized that only two pups in a litter must survive to reach maturity and breed if the population is to remain constant. Normally the surplus is killed off by disease and other factors.'"

In a study of foxes in New York state, Sheldon (1950:33-42) found a population density averaging one gray and three red foxes per one-square-mile. Observations lead the investigator to believe that this is a reasonable figure for the breeding fox population on Camp Pickett, except that the ratio of grays to reds is about even. Certainly the Camp Pickett population is not less than three foxes per one-square-mile. Using the latter figure the number of foxes on Camp Pickett would total approximately 220. The entire range of Camp Pickett can be considered favorable as far as the foxes are concerned.

Assuming an equal sex ratio for the fox, there would be approximately 55 female gray foxes and 55 female red foxes on the area. According to Trippensee (1953:105-106), foxes breed at the age of one year, the average litter size for the red being between five and six, while the gray averages about three to four. Using the conservative figures, the spring population on Camp Pickett would be somewhere around 660. This means an annual surplus of 440 foxes. It seems likely that a fox population could stand an annual hunting or trapping kill of at least 40 per

cent of the fall population if one were entertaining hopes of reducing the breeding population. To accomplish this would require tremendous amounts of time and energy on the part of management personnel, to say nothing of the expense involved. It is quite obvious that fall trapping on Camp Pickett has not removed the annual surplus.

It would seem that the time to control foxes would be during the breeding season. However, removal of animals at this time would surely improve the chance of survival for those that remained. Spring trapping might even conceivably be an aid to the fox population, as the summer population would be healthier as a result of lessened competition. To reduce effectively the fox population by spring trapping would require a very sizeable catch. It is extremely doubtful that the number of spring-trapped foxes on Camp Pickett is large enough to accomplish the desired result.

Trapping was initiated in 1957. During that year 124 foxes were trapped, the highest annual total realized in the three years that trapping had been done.[1] In spite of this, the chances of a hunter making a fox kill during the open season were twice as great in 1957-58 as in 1956-57.[2] And at the end of three years of trapping, the chances of a hunter making a fox kill during the open season were still slightly better than before the trapping program began.[2] These figures tend to indicate that the trapping has acted merely as another of nature's limiting factors for the fox population.

Reducing the summer population of foxes on Camp Pickett may not

---

[1]See Appendix Table 1. Foxes trapped, Camp Pickett, Va., 1957-58-59.
[2]See Appendix Table 8. Index of hunter-man days per kill by species, Camp Pickett, Va., 1956-1957, 1957-1958, 1958-1959, 1959-1960 hunting seasons.

even be desirable from the standpoint of cottontail management. According to the data obtained from the summer road counts, there was a precipitous drop in the rabbit population in mid-August. This population decrease had all the earmarks of being caused by disease, and is most often the result of "too many animals on too little area for the prevailing conditions."

Accordingly, one may speculate that a higher population of foxes would have helped to hold the summer rabbit population in check and thereby reduced the chance of disease spreading through the cottontails.

In this discussion nothing has been said about the cost of the trapping program on Camp Pickett. The investigator does not have cost figures available, but there is no doubt the cost per fox caught is considerable.

In view of the foregoing, the investigator is forced to recommend cessation of fox trapping as a predator control program on the Camp Pickett area. The program should at least be suspended for a year or two and the effects evaluated.

Where fox trapping is carried on as a rabies control program the situation is somewhat different. Every effort must be made to protect people and domestic animals from contacting this disease. Where rabies is evident, trapping of foxes would be quite desirable. However, at the present time, to the best of the investigator's knowledge, rabies is not a problem on the study area.

LAND MANAGEMENT

Food Plantings

Research tends to indicate that the various food plantings on the Camp Pickett game management area are being utilized by cottontails. Fortenbery (1959:70) found a much higher usage (205 per cent by trapping and 172 per cent by pellet counts) of areas supplied with food plots over natural untreated areas. According to the results of his studies, areas planted to annual mix showed higher usage than plots sown to clover and winter grains (Fortenbery, 1959:40). The greater part of Fortenbery's data were collected in the early fall.

In the present study, results indicate that different food plantings receive the highest use in different seasons. In the summer, usage of the annual game bird mix food patches is higher by far than usage of the other types of plantings (Tables 6 and 7). During the fall season, usage of the clover-small grain food patches becomes predominant (Table 10). From that period on, the clover-small grain treatment holds the "limelight" (Table 11).

Because the clover-fescue and fescue firelane plantings were in forested areas, it is impossible to compare them fairly with the annual mix and clover-small grain plantings. The investigator believes that the firelane plantings would have received reasonably high usage by the rabbit had the firelanes been located in non-forested areas.

It is difficult to evaluate the various food plantings in terms of their actual effect on hunting kill. It may well be that they are over-rated. One wildlife biologist has termed the plantings "legalized baiting." Perhaps the food patches are "preferred food" and merely

attract the rabbits rather than support them. Seton (1929:789) says that to make a complete list of the plants that are cottontail foods would be to catalog 99 per cent of the flora of the United States. Madson (1959:17) says, "The diet of the cottontail is almost infinite; it will eat nearly every plant food that grows above ground, a greater variety than that eaten by any other North American creature. It is far easier to list the foods that the rabbit does not eat than the ones it does."

The aim of management is to increase on a sustained yearly basis the amount of game available to the hunter. Research is needed to determine the actual return of the various management procedures in terms of cost and feasibility. However, in spite of the above comments, the planting of wildlife food must still be accepted as good management until proved otherwise, or at least until something better is found by researchers.

In view of research findings and general observations, the investigator recommends the following with regard to the various food plantings:

1) Annual plantings should be abandoned in favor of perennials.

2) Plantings of rabbit food should be limited to areas suitable for the rabbit. It is impossible to raise farmland game in forest, unless the forest is changed into farmland by management procedures. The latter is rarely, if ever, feasible and is perhaps not even desirable.

3) Food patches should be limited to a size of 1/4 to 1/2 acre. They should be long and narrow in shape, and might even be made serpentine to advantage. The maximum edge effect is desirable.

Burning

In spite of the fact that results of this study did not demonstrate burning to be especially favorable to the rabbit, the investigator

believes that burning is a valuable management procedure under certain conditions. Burning as a game management practice seems to go in and out of "style" as the years go by. This is somewhat the case with a great many wildlife management practices.

On Camp Pickett, burning as a management technique can best be applied to the forested areas for clearing off the layer of pine needles smothering out the undergrowth which would be so valuable for wildlife. Selective lumbering would handle this problem better, but is costly where timber demand is low.

Burning should be done in late winter (January, February, and March). Small blocks should be treated rather than extensive areas. If burning is the only technique being applied to any given area, it must be repeated at approximately five-year intervals if effectiveness is to be maintained.

Mowing

This investigation failed to demonstrate the effectiveness of mowing as a game management technique. Nevertheless, the writer regards mowing as the most effective single management tool available to the game manager.

The most important limiting factor for the rabbit on Camp Pickett, as far as management is concerned, is not lack of food or cover but the often inefficient distribution of these two items. There are large, unbroken fields of broomsedge, adjacent to which often are large unbroken tracts of even-aged loblolly pine forest. These larger tracts need to be broken up into smaller units, the more the better. Use of

heavy duty mowing equipment will accomplish much along this line.

It is recommended that major emphasis be placed on mowing 50-75-foot-wide strips through broomsedge and other open field types. These same strips should be mowed two or three times during the summer in order that new succulent growth be continually available to wildlife. An additional reason for repeatedly mowing the same strips rather than new ones is that this method does not result in the destruction of nests and leaves adjacent cover intact. An aerial photograph of the area should resemble a checkerboard.

PROPOSED RESEARCH

1. Continuation of the summer roadside counts, with a study designed to determine the cause of the precipitous drop in the rabbit population that apparently occurred in mid-August.
2. Evaluation of the various land-cultural treatments, emphasizing utilization by game species other than the cottontail.
3. Evaluation of the various land-cultural treatments in terms of their actual effectiveness in increasing the game harvest; and in terms of the actual cost of the increased harvest, if any.
4. A study to determine the maximum numbers of the various game species extant on Camp Pickett that can be removed by the hunter each season without depleting the breeding stock.
5. A study to evaluate the effects of cessation of the fox trapping program being carried on at the present time by management personnel, should this program be eliminated in the future.
6. Another attempt to evaluate the various trap-retrap formulae for estimating rabbit populations by live-trapping a known cottontail population in a five-acre enclosure.

SUMMARY AND CONCLUSIONS

Cottontail Rabbit population fluctuations were measured by roadside counts during the summer months. These counts were conducted each evening during the months of July and August, and every Sunday, Tuesday, and Thursday evenings during the month of September. The road-count route, which was ten miles long, was adjoined by habitat favorable to the rabbit. Daily variation was great. A precipitous drop in the rabbit population occurred in mid-August. The average number of rabbits seen per road count decreased from twelve to three within one week. The suspected etiology of this population drop was disease, although no research data were collected to substantiate this theory. Morning roadside counts were not found to be a suitable tool for measuring population fluctuations.

Land-cultural treatments were evaluated by means of rabbit pellet counts and live-trapping of rabbits. The treatments extant on Camp Pickett are installation of annual game bird mix and clover-small grain food patches, seeding of firelanes in fescue and clover-fescue combination, burning and mowing.

Summer pellet counts were conducted on 21 sites, randomly selected and representing the six different treatment types as well as controls. Permanent milacre quadrats mechanically established and non-permanent one-square-foot quadrats randomly selected were utilized in this phase of the study. Highest utilization by the cottontail occurred on the annual mix management units, where 52.2 per cent of all pellets were counted. Next highest was the clover-small grain treatment, where 22.2 per cent of all pellets were located. Following these two types were

the clover-fescue firelanes with 5.04 per cent, the fescue firelanes with 1.87 per cent, the burned areas with 1.30 per cent, and the mowed areas with 1.27 per cent. The control areas provided 13.7 per cent of the total.

Fall trapping was conducted on 20 sites, equally divided among clover-small grain and annual mix food patches, fescue and clover-fescue firelanes, and controls. Six traps were placed at each site. As too few rabbits were handled on each of the study areas to obtain a population estimate by trap-retrap formulae, the number of rabbits marked was used as an index of abundance. Ninety rabbits were handled in this phase of the project, 72 being marked and 18 recaptured. Thirty-five cottontails were marked on the clover-small grain treatments, 17 on the annual mix, eight on the clover-fescue, one on the fescue, and 11 on the controls. Preference for the clover-small grain food patch seems clearly evident at this time of year.

Winter trapping was conducted on 12 sites, equally divided among clover-small grain and annual mix food patches and controls. A total of 130 rabbits was handled, with 110 being marked and 20 recaptured. Fifty-eight cottontails were marked on the clover-small grain treatments, 26 on the annual mix, and 26 on the control areas. These data seem to indicate that the annual food planting provides little for the rabbit during the winter season. The clover-small grain management unit continues to be of value.

Spring pellet counts were carried out in exactly the same manner as were the summer counts with the exception that only the one-square-foot quadrats were utilized. The greatest number of pellets, 46.2 per cent of the total enumerated, were found on annual mix food patches.

Only 18.3 per cent of the total was found on clover-small grain food patches. Counts on burned areas were considerably higher than those previously encountered, with 16.7 per cent of the total being found here. Clover-fescue firelanes yielded 3.54 per cent, fescue firelanes 1.92 per cent, mowed areas 3.30 per cent, and control areas 9.44 per cent. Apparent discrepancies between these spring pellet count data and the previously obtained trapping data are believed due to an accumulation of old pellets. A pellet durability study conducted from September through April showed winter loss of rabbit pellets to be minimal. It is quite probable that in the spring of the year the clover-small grain food patch is still receiving the highest utilization by the cottontail.

An attempt was made to evaluate various trap-retrap population estimation formulae by live-trapping a known Cottontail Rabbit population in a five-acre enclosure. The result was failure, however, when deer knocked down the fence, hunters poached, and rabbits were lost from various other, often unknown, causes.

A record was kept of all parasites, disease and injury encountered in the rabbit population during the study. The incidence of tick infestation among the cottontails was 8.95 per cent. Eighty of the 414 rabbits handled during the course of the project had fleas. Forty-two per cent of all rabbits handled either were or presented evidence of having been infested with bot fly larvae. An incidence of 2.2 per cent of Shope's fibroma was found.

Fifty-six fox scats were subjected to gross examination in the field between July 1 and November 30. Fifty-five, or 99 per cent, contained seeds of the persimmon. Eighteen, or 32 per cent, contained remains of small mammals. Remains of rabbits were identified in only two of the scats.

Track counts made in the snow did not prove to be a suitable method for evaluating the various land-cultural treatments. It was found that rabbits remain "holed-up" during moderate to heavy snows.

A record was kept of all cottontail deaths known to have been caused by motor vehicles. The number of deaths per mile of highway traveled became progressively higher through the months of July to April, even though the rabbit population became progressively lower. This increasing highway kill was apparently due to the increased movement required of the cottontail in the winter months when food and cover are scarce, and the increased movement that occurs among the rabbit population when the spring breeding season arrives.

LITERATURE CITED

Allen, D. L. 1939. Michigan cottontails in winter. J. Wildl. Mgmt., 3(4):307-322.

_____ 1954. Our wildlife legacy. Funk and Wagnalls Co., New York, N. Y., 422 pp.

_____ 1958. Rx for rabbits. Field and Stream Magazine, 63(1): 74-75, 137-139.

Bowers, G. L. 1954. An evaluation of cottontail rabbit management in Pennsylvania. Pa. Game Comm., Harrisburg. Mimeo, 16 pp.

_____ 1956. Recipe for rabbits. Pa. Game News, 27(4):24-30. Pa. Game Comm., Harrisburg.

Bruna, J. F. 1952. Kentucky rabbit investigations. Federal Aid Proj. W-26-R. Ky. Dept. of Fish and Wildl. Resources, Frankfort. 83 pp.

Buele, J. D. 1947. Pennsylvania's cottontail problem. Pa. Game News, 18(2):10-13, 34-37.

Cheatum, E. L. 1952. Disease and parasite investigations. Final rpt. Federal Aid Proj. 1-R, Supp. E. N. Y. Cons. Dept., Albany. 72 pp.

Craighead, F. C. and Craighead, J. J. 1950. The ecology of raptor predation. Trans. N. Amer. Wildl. Conf., 15:209-233.

Crunden, C. W. and Hendrickson, G. O. 1955. Evaluation of techniques in estimating a Mearns cottontail population. Proc. Iowa Acad. Sci., 62:498-501.

Dalke, P. D. 1937. A preliminary report of the New England cottontail study. Trans. N. Amer. Wildl. Conf., 2:542-548.

_____ 1942. The cottontail rabbits in Connecticut. State Geological and Nat'l Hist. Surv. Bul. 65, Hartford. 97 pp.

Dell, J. 1953. Experimental post-season liberation of imported cottontail rabbits. Final rpt., Federal Aid Proj. W-22-R, Job IV-A. N. Y. Cons. Dept., Albany.

Dusi, J. L. 1949. Methods for the determination of food habits by plant microtechniques and histology and their application to cottontail rabbit food habits. J. Wildl. Mgmt., 13(3):295-298.

Eberhard, T. 1954. Food habits of Pennsylvania housecats. J. Wildl. Mgmt., 18(2):284-286.

Ecke, D. H. and Yeatter, R. E. 1956. Notes on the parasites of cottontail rabbits in Illinois. Ill. Acad. of Sci. Trans., 48:208-214.

Errington, P. 1946. Predation and vertebrate populations. Quarterly Rev. of Biology, 21(2):144-147; 21(3):221-245.

Fay, F. H. and Chandler, E. H. 1955. The geographical and ecological distribution of cottontail rabbits in Massachusetts. J. Mammal., 36(3):415-424.

Fortenbery, D. K. 1959. An evaluation of some rabbit management procedures as applied in southeastern Virginia. M. S. Thesis, Va. Poly. Inst., Blacksburg, 95 pp.

Geis, A. D. 1957. Coprophagy in the cottontail rabbit. J. Mammal., 38(1):136.

_____ 1957. Incidence and effect of warbles on southern Michigan cottontails. J. Wildl. Mgmt., 21(11):94-95.

Handley, C. O. 1951. Two basic things in rabbit and quail management. W. Va. Conservation, 15(5):20-24. W. Va. Cons. Comm., Charleston.

Haugan, A. O. 1943. Management studies of the cottontail rabbit in southeastern Michigan. J. Wildl. Mgmt., 7(1):102-119.

Hendrickson, G. O. 1938. Winter food and cover of the Mearns cottontail. Trans. N. Amer. Wildl. Conf., 3:787-793.

_____ 1939. Inventory methods for the Mearns cottontail. Trans. N. Amer. Wildl. Conf., 4:209-215.

Herman, C. M., Kilham, L., and Warback, O. 1956. Incidence of Shope's rabbit fibroma in cottontails at the Patuxent research refuge. J. Wildl. Mgmt., 20(1):85-89.

Kirkpatrick, C. M. 1950. Crow predation on nestling cottontails. J. Mammal., 31(3):322-327.

_____ 1956. Coprophagy in the cottontail. J. Mammal., 37(2):300.

Kline, P. and Hendrickson, G. O. 1954. Autumnal decimation of Mearns cottontail, Decatur County, Iowa. Proc. Iowa Acad. Sci., 61:524-527.

Korschgen, L. J. 1957. Food habits of coyotes, foxes, housecats and bobcats in Missouri. Mo. Cons. Comm. P-R Series, 15.

Latham, R. M. 1952. So you want more rabbits? Pa. Game News, 23(9). Pa. Game Comm., Harrisburg.

Ledune, E. K. 1933. Parasites of the Ohio cottontail rabbit. Proc. Conf. Game, Fish and Cons. Commissioners. 27.

Lemke, C. W. 1952. How can we produce more cottontails? Wis. Cons. Bul., 17(7):22-25. Wis. Cons. Dept., Madison.

Linduska, J. P. 1947. The ferret as an aid to winter rabbit studies. J. Wildl. Mgmt., 11(3):252-255.

_____ 1949. Winter den studies of cottontails in Michigan. Ecology, 28(4).

Llewelyn, L. L. and Handley, C. O. 1945. The cottontail rabbit of Virginia. J. Mammal., 26(4):379-390.

Madson, J. 1959. The cottontail rabbit. Olin Mathieson Chemical Corp., East Alton, Ill., 56 pp.

Majors, E. 1955. Population and life history studies of the cottontail rabbit. M. S. Thesis, Ala. Poly. Inst., Auburn. 119 pp.

Makepiece, L. J. 1956. Rabbits, a subject bibliography. Biographical Center for Research, Rocky Mt. Reg., Spl. Biblio. No. 3, Denver Publ. Lib., Denver. 81 pp.

McDowell, R. D. 1955. Restocking with native cottontails. J. Wildl. Mgmt., 19(1):61-65.

McGinnes, B. S. 1958. Some factors in influencing the cottontail rabbit in southwestern Virginia. Ph. D. Thesis, Va. Poly. Inst., Blacksburg. 189 pp.

Myers, K. 1955. Coprophagy in the European rabbit (Oryctolagus cinículus) in Australia. Australian Jour. of Zool., 3(3):336-345.

Newman, D. E. 1959. Factors influencing the winter roadside count of cottontails. J. Wildl. Mgmt., 23(3):290-294.

Peterle, T. J. and Eberhardt, L. 1959. Is the Lincoln index reliable for cottontail censusing? Federal Aid Proj. W-40-R and W-96-R, Game Div., Mich. Dept. Cons., Lansing. 9 pp.

Petrides, G. A. 1951. The determination of sex and age ratios in the cottontail rabbit. Amer. Midl. Nat., 46(2):312-336.

Redd, J. B. 1956. Abundance and distribution of the cottontail rabbit as affected by land use. M. S. Thesis, Va. Poly. Inst., Blacksburg. 80 pp.

Seton, E. T. 1929. Lives of game animals. Doubleday Doran and Co., N. Y, N. Y., Vol. IV, Part II, pp. 441-949.

Sheldon, W. G. 1950. Denning habits and home range of red foxes in New York state. J. Wildl. Mgmt., 14(1):33-42.

Smith, R. H. and Cheatum, E. L. 1944. The role of ticks in the decline of an insular cottontail population. J. Wildl. Mgmt., 8(4):311-317.

Stannard, L. J. and Pietsch, L. R. 1958. Ectoparasites of the cottontail rabbit in Lee County, northern Illinois. Ill. Nat'l Hist. Surv. Div., Dept. Reg. Ed., Urbana. 19 pp.

Studholme, C. R. 1951. Plant succession and cottontails. Proc. Northeast Sect. Wildl. Soc., Wilmington, Del. March.

Trippensee, R. H. 1948. Wildlife management. McGraw Hill Book Co., Inc., N. Y., Vol. II, 572 pp.

Whitlock, S. C. and Gower, C. 1938. Tapeworms in rabbits. Mich. Cons., 8(2):8.

Yeatter, R. E. and Thompson, D. H. 1952. Tularemia, weather and rabbit populations. Ill. Nat'l Hist. Surv. Bul., 25(6):351-382, Urbana.

The vita has been removed from the scanned document

APPENDIX

Appendix Table 1. Foxes trapped, Camp Pickett, Va., 1957-58-59

Season	Species	Male	Female	Total
Spring of 1957	Red	—	—	—
	Gray	—	—	—
Total		—	—	67
Fall of 1957	Red	19	14	33
	Gray	14	10	24
Total		33	24	57
Spring of 1958	Red	18	31	49
	Gray	27	22	49
Total		45	53	98
Fall of 1958	Red	4	6	10
	Gray	4	10	14
Total		8	16	24
Spring of 1959[a]	Red	—	—	11
	Gray	—	—	10
Total		—	—	28[b]
Fall of 1959[c]	Red	—	—	—
	Gray	—	—	—
Total		—	—	45

[a]No data kept as to sex.
[b]Seven were trapped for which no data were kept as to either sex or species.
[c]No data kept as to sex or species.

Appendix Table 2. Land-cultural treatment, Camp Pickett, Va., 1957-58-59

Treatment type	Year	Extent of treatment
Annual Mix food patch	1957	296 one-quarter-acre plots
	1958	128 one-half-acre plots
	1959	138 one-half-acre plots
Total		207 acres
Clover-small grain food patch	1957	26 one-half-acre plots
	1958	48 one-half-acre plots
	1959	1 ten-acre plot
Total		47 acres
Experimental food patches	1959	1 one and one-half acre plot
		3 five-acre plots
		8 plots (total 35 acres)
		Various strips
Total		54 acres
Mowing	1957	200 acres
	1958	250 acres
	1959	250 acres
Total		700 acres
Burning	1958	680 acres
	1959	4,600 acres
Total		5,280 acres
Bulldozing and planting of firelanes	1958	5.2 miles (80 feet in width)
	1959	30 miles (80 feet in width)
Total		341 acres
Grand Total		6,600 acres

Appendix Table 3. Expenditures for wildlife management by Virginia Commission of Game and Inland Fisheries, Camp Pickett, Virginia, 1957

Item	Amount
Grain drill rental	$200.00
Tractor rental (includes driver)[1]	----
Commercial fertilizer (20 tons No. 2-12-12)	735.55
Seed	219.50
Labor[1]	----
Total	$1155.05

[1]Cost figures not available.

Appendix Table 4. Expenditures for wildlife management by The Virginia Commission of Game and Inland Fisheries, Camp Pickett, Virginia, 1958

Item	Amount
Equipment[1] Ford disc plows Ford flexo-hitch harrow Ford rotary mower Ford 861 tractor John Deere grain drill	$3422.91
Signs	4.38
Equipment for trapping program	157.20
Repairs to equipment	175.00
Bulldozer rental	4000.00
Agricultural limestone (160 tons)	1156.25
Commercial fertilizer (36 tons)	1150.20
Seed[2]	615.50
Labor[3]	1734.75
Grease, gas and oil	425.00
Total	$12841.19

[1]Does not include cost of hand tools.
[2]Does not include cost of 100# Sericea lespedeza, nor $4000 U. S. Army funds.
[3]Does not include cost of operating game checking station.

Appendix Table 5. Expenditures for wildlife management by The Virginia Commission of Game and Inland Fisheries, Camp Pickett, Virginia, 1959

Item	Amount
Equipment Dodge 3/4 ton truck	$1624.85
Repairs to equipment	175.00
Bulldozer rental (160 hours @ $12.50)	2000.00
Agricultural limestone (400 tons)	3100.00
Commercial fertilizer (120 tons No. 2-12-12)	3512.00
Seed[1]	1261.75
Labor[2]	1881.00
Gasoline	500.00
Total	$14054.60

[1]Does not include cost of 200# Kenland red clover.
[2]Does not include cost of operating game checking station.

Appendix Table 6. Annual harvest by species, Camp Pickett, Va., 1956-1957, 1957-1958, 1958-1959, 1959-1960 hunting seasons

Species	Year 1956-57	1957-58	1958-59	1959-60
Deer[1]	66	44	117	152
Turkey[2]	23	30	3	19
Quail	802	789	1722	1936
Rabbit	852	1904	2863	3474
Squirrel	50	285	563	1815
Raccoon	9	27	15	24
Duck	158	146	157	67
Fox	6	13	5	15
Snipe	6	9	10	18

[1]Antlered only.
[2]Males only.

Appendix Table 7. Hunter-man days, Camp Pickett, Va., 1956-1957, 1957-1958, 1958-1959, 1959-1960 hunting seasons

Month	Season 1956-57	1957-58	1958-59	1959-60
November	1317	1880	2499	4012
December	2362	2324	2660	4248
January	900	755	1466	2238
Totals	4579	4959	6625	10,498

Appendix Table 8. Index of hunter-man days per kill by species, Camp Pickett, Va., 1956-1957, 1957-1958, 1958-1959, 1959-1960 hunting seasons

Species	Season 1956-57	1957-58	1958-59	1959-60
Deer[1]	1.00	1.64	0.83	1.00
Turkey[2]	1.00	0.83	11.1	3.62
Quail	1.00	1.10	0.68	0.95
Rabbit	1.00	0.48	0.43	0.56
Squirrel	1.00	0.18	0.13	0.06
Raccoon	1.00	0.36	0.86	0.90
Duck	1.00	1.17	1.45	5.41
Fox	1.00	0.50	1.74	0.92
Snipe	1.00	0.71	0.87	0.76

[1]Antlered only.
[2]Males only.

Appendix Table 9. Total game killed at Camp Pickett during 1959-1960 hunting season by months

Month	Deer	Turkey	Quail	Rabbit	Squirrel	Raccoon	Duck	Fox	Snipe
Nov.	102	12	806	1508	498	7	41	12	11
Dec.	37	6	672	1032	705	13	24	1	7
Jan.	13	1	458	934	612	4	2	2	0
Totals	152	19	1936	3474	1815	24	67	15	18

ABSTRACT

of

EVALUATION OF INTENSIFIED RABBIT MANAGEMENT PROCEDURES

ON PUBLIC HUNTING AREA IN SOUTHCENTRAL VIRGINIA

by

Alan Scott Krug

Thesis submitted to the Graduate Faculty of the

Virginia Polytechnic Institute

in candidacy for the degree of

MASTER OF SCIENCE

in

BIOLOGY

Major

WILDLIFE MANAGEMENT

June 1960

Blacksburg, Virginia

This study, concerned with evaluation of Cottontail Rabbit management techniques, was conducted at Camp Pickett, Virginia, a 47,000-acre deactivated military reservation. This public hunting area is managed cooperatively by the U. S. Second Army and the Virginia Commission of Game and Inland Fisheries.

Cottontail Rabbit population fluctuations were measured by roadside counts during the summer months. It was found that a precipitous drop in the rabbit population occurred in mid-August. The suspected etiology of this population drop was disease, although no research data were collected to substantiate this theory.

Land-cultural treatments were evaluated by means of pellet counts and live-trapping. The treatments extant on Camp Pickett are installation of annual game bird mix and clover-small grain food patches, seeding of firelanes in fescue and clover-fescue combination, burning and mowing.

Summer pellet counts showed the rabbit to be utilizing the annual mix food patches more than any other treatment type. The clover-small grain food patch was next in preference. Utilization of the remaining treatment types, which were mostly located in forested area, was rather low.

Fall trapping data revealed a switch to the clover-small grain management unit, with the annual mix running second. Utilization of the other treatment types was again low.

Winter trapping data showed an even greater preference for the clover-small grain than was found in the fall.

Spring pellet count data resembled that obtained in the previous summer, with the exception of the burned areas, which received substantial usage by the rabbit. Differences between spring pellet count data and

winter trapping data are believed due to an accumulation of older pellets. A pellet durability study showed winter loss of pellets to be minimal.

An attempt to evaluate various population estimation formulae by live-trapping a known cottontail population in a five-acre enclosure met with failure when deer knocked down the fence, hunters poached, and rabbits were lost from various other causes, often unknown.

A record was kept of all parasites, disease and injury encountered in the rabbit population. Forty-two per cent of all rabbits handled either were or presented evidence of having been infested with bot fly larvae. An incidence of 2.2 per cent of Shope's fibroma was found.

A record was kept of all cottontail deaths known to have been caused by motor vehicles. The number of deaths per mile of highway traveled became progressively higher through the months of July to April, even though the rabbit population became progressively lower. This increasing highway kill was apparently due to the increased movement required of the rabbit in the winter months when food and cover are scarce, and the increased movement that occurs among the rabbit population when the spring breeding season arrives.