EVALUATION OF SOME COTTONTAIL RABBIT MANAGEMENT PROCEDURES AS APPLIED IN PIEDMONT VIRGINIA

by

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INTRODUCTION

Game management is faced with the problem of producing hunting recreation to an increasing number of sportsmen on lesser acreages of suitable land. Such a problem can be rectified only by increasing our knowledge of wildlife through research, and using this information to develop sound management practices.

Research is an all important tool which the game manager has at his disposal, but too often it has been forgotten or disregarded. Many management practices in use today have preceeded the research through which they should have been developed; this has resulted in a waste of valuable time and money.

The stimulus behind the development of management practices for the cottontail rabbit has been the increasing popularity of this game species. Over the years the interest in the sport of "beagling" and the popularity of rabbit hunting has induced game agencies and other private and public organizations to promote its management.

In order to gather data on the biology of the rabbit, determine management tools and to evaluate some rabbit management techniques being utilized in Virginia, a ten-year research program was initiated by the Virginia Cooperative Wildlife Research Unit. In 1955, J. B. Redd

undertook the first phase of this study. He was concerned with the distribution of the cottontail as affected by land use.

During the second phase of the study, B. S. McGinnes investigated various factors influencing the cottontail rabbit population in Southwestern Virginia.

The third and fourth phases of the study were concerned with evaluation of the rabbit management procedures as applied in Southeastern Virginia and were conducted by D. K. Fortenbery, in 1958, and A. S. Krug, in 1959.

The fifth phase of the study was also concerned with the evaluation of rabbit management procedures in Southeastern Virginia and had the following objectives:

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

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

3. Determine which wildlife management land-cultural treatments being used on Camp Pickett are most utilized by cottontails.

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

5. Prepare recommendations for improved rabbit Managements.

The field work for this study was conducted on Camp Pickett Military Reservation in Nottoway, Brunswick and Dinwiddie counties, Virginia, from July, 1960, through May, 1961. According to Llewellyn and Handley (1945:381), the species of rabbit found in this area is Sylvilagus floridanus mallurus (Thomas).

Evaluation was made of the habitat manipulation techniques undertaken on this reservation under the cooperative agreement between the Virginia Commission of Game and Inland Fisheries and the United States Second Army and of rabbit management techniques employed by the investigator.

LITERATURE REVIEW

The following section does not intend to present a complete bibliography on the cottontail rabbit. Such bibliographies have been compiled by Makepiece (1956) and by an anonymous author (undated rabbit bibliography from Connecticut).

A review of the literature concerning the cottontail, is a long and tedious undertaking. Much has been written and yet many questions are still unanswered.

This section intends to cover some of the highlights in cottontail investigations and includes many of the important papers from which data for this study were extracted.

Life history studies were made by Bruna (1952) in Kentucky, Majors (1955) in Alabama, Dalke (1937 and 1942) in Connecticut and MacNamara (1948) in New Jersey. In Virginia, life history studies were made by Llewelyn and Handley (1945), Redd (1956), and McGinnes (1958). A general coverage of the cottontail's life history and management was written by McDonough (1960) in Massachusetts and Madson (1959).

Cooley (1946) reported on cottontails breeding in their first summer and Lord (1958) reported on "The Importance of Juvenile Breeding to the Annual Cottontail

Crop". Instances of pregnancy of the cottontail rabbit in the winter were studied by Lord (1958).

Age determination by bone growth was developed by Thomsen and Mortensen (1946), and was studied and refined by Hale (1949). This aging method was used by Petrides (1951) in Michigan, Bruna (1952) in Kentucky, Dell (1955) in New York and Lord (1958) in Illinois. Lord (1959) presents a technique for aging cottontails based on the growth rate of the lens of the eye.

Elder and Sowls (1942) in Wisconsin and Petrides (1951) and Peterle (1957) in Michigan have published papers on the sex and/or age ratios of the cottontail.

Food habits of the cottontail were studied by Dalke (1942) in Connecticut, Allen (1939) in Michigan and Hendrickson (1938) in Iowa. A method of determining food habits by plant micro-techniques and histology is described by Dusi (1949).

Studholme (1951) in Pennsylvania and Byrd (1956) in Virginia wrote papers concerned with plant succession and cottontails.

Coprophagy in cottontails is described by Kirkpatrick (1956), Geis (1957) and Heisinger (1960).

The subject of cottontail predation is a highly controversial one and most authors have something to say

on it. An interesting paper on "Crow Predation Upon Nestling Cottontails" was written by Kirkpatrick (1950).

Little work has been done concerning the diseases of the cottontail. Most of the literature is concerned with domestic rabbits or with other species of mammals with only a mentioning of the cottontail. One such publication was written by Woodbury and Parker (1953) on tularemia. Papers directly concerned with cottontails were written by Yeatter and Thompson (1952) on tularemia and Herman, Kilham and Warbach (1956) on Shope's rabbit fibroma. McGinnes (1958) in Virginia reported on tularemia in an enclosed rabbit population.

A study of rabbit parasites was made by Ecke and Yeatter (1956) in Illinois, Herman and Jankiewich (1943) in California and Dalke (1937) in Connecticut. Gies (1957) in Michigan collected data on the incidence and effect of warbles. The role of ticks in the decline of an insular cottontail population was studied by Smith and Cheatum (1944).

Erickson (1947) studied and compiled a list of the helminth parasites of rabbits of the genus Sylvilagus. A study of the incidence and transmission of Sarcocytis in cottontails was made by Erickson (1946) and the species of Siphonaptera infesting wild hares and rabbits of North

America north of Mexico were studied by Kohls (1940).

Pirnie (1949) wrote an article titled "A Test of Hunting As Cottontail Control". Other control measures were published by Lantz (1929) and Garlough, Welch and Spencer (1942). A special feature appeared in the December, 1955 issue of Sports Afield Magazine titled "Rabbit Hunting".

Cottontail management recommendations were made by Bowers (1956) in Pennsylvania, Dell (undated) in New York, Bushong (1959) in Indiana, Handley (1951) in Virginia and Bruna (1952) in Kentucky. An evaluation of habitat development was made by Chambers (1959) in West Virginia.

Recommendations for food plantings for rabbits were made by Bowers (1956) in Pennsylvania and Hankla and Verts (1958) in North Carolina.

Cover preferences of Massachusetts' Cottontails were studied by Fay and Chandler (1955) and a study of winter dens in southern Michigan was made by Linduska (1947). The rearing cover used by the Mearns Cottontail was studied by Linder and Hendrickson (1956). Cover manipulation studies were made by McGinnes (1958) in Virginia and cover preference studies were carried out by Hendrickson (1938) in Iowa. Hendrickson (1940) studied the nesting cover used by the Mearns Cottontail.

A study regarding the relationship of soil fertility

and the size of cottontails was made by Denny (1943) in Missouri.

Rabbit propagation studies and experiments were conducted by Sheffer (1957) in Maryland.

The very controvertial subject of rabbit stocking was reported by Dell (1953) in New York, McDowell (1953), Bowers (1954) and Latham (1952) in Pennsylvania, and Sheffer (1957) in Maryland.

A partial evaluation and study of census methods was made by Redd (1956) in Virginia, Peterle and Eberhardt (1959) in Michigan, Crunden and Hendrickson (1955) in Iowa, and Fortenbery (1959) and Krug (1960) in Virginia. Linduska (1947) made use of the ferret for censusing cottontails in local areas of Michigan. Lord (1959) used a drive count to measure the winter mortality of cottontails. Schultz and Byrd (1957) presented an application of covariance to the study of cottontail rabbit population data. Lord (1959) compared early morning and spotlight roadside censuses for cottontails. Newman (1959) describes the factors that influence the winter roadside counts for cottontails.

Labisky and Lord (1959) described a flexible plastic ear tag for rabbits.

PROCEDURE AND TECHNIQUES

SELECTION AND DESCRIPTION OF STUDY AREA

The site of this study was primarily Camp Pickett Military Reservation. This 47,000 acre tract of land was selected and used by Fortenbery in 1958-1959 for the third phase of this field research project on the cottontail rabbit. In 1959-1960 Krug continued to use this area for the fourth phase of the study. For continuity this camp was again chosen for this present phase of the study.

Camp Pickett is located in southeastern Virginia near Blackstone. The reservation includes parts of Nottoway, Brunswick and Dinwiddie counties.

Fortenbery (1959: 9, 10 and 62-66) gave a physical description of the reservation, climatological data and a listing of some of the flora and fauna of the area.

Camp Pickett is managed for game under a four-year cooperative habitat improvement program between the Virginia Commission of Game and Inland Fisheries and The United States Second Army. Included in this agreement, which became effective in August of 1956, are wildlife management, administration and law enforcement.

Many management techniques are applied to this area including fox trapping, installation of food patches, seeding of fire lanes, bulldozing, mowing and burning. Hunting on the reservation is by permit only and all game is checked out at an official checking station and a complete record of the kill and hunting pressure is maintained.

Because of military activity, the area available to the investigator for most of the work was limited. In order to insure the least amount of military disturbance, the contonement area and the airfield of Camp Pickett were selected for the bulk of the study.

The contonement area and the airfield contain about five thousand acres and are closed to public hunting. Barracks and other camp buildings divide the area into many small units, and when not in use, provide excellent cover for the rabbit. Wooded areas, as well as the open fields, interspersed throughout this area, are all in the early stages of ecological succession.

RECORDS

All field data were recorded in a small notebook and later transfered to permanent record cards.

Permanent record cards were divided into three categories: (1) A dated log book containing daily activities, weather conditions, a road count record, field observations and daily trapping records. (2) A record book containing trapping information by areas, roadside count data, listing of animals seen and captured, trapping information by months, predation and miscellaneous field observations. (3) Individual record cards for trapping and pellet durability. Trapping record cards contained the date of capture, tag number, specimen number, tag color, plastic ribbon color, trapping location, sex, size, general condition, observations of parasites and diseases, release point, trap number, date of capture and date, place and trap number of any recaptures. Pellet durability records contained the date the pellets were put out, number of pellets put out, plot number, station number, number of pellets present at each counting, possible or known cause of loss, and condition of the remaining pellets.

TRAPPING

Description of Traps

Wooden live mammal traps of the type described by Redd (1956:10) were used.

Location of Traps

For Evaluation of Land-Cultural Treatments: In an effort to evaluate three land-cultural treatments in regard to utilization by the cottontail, 16 trap sites were arbitrarily selected. The sites included 4 annual mix plots, 4 clover-small grain fire lanes, 4 mowed roadside areas and 4 control areas.

Annual mix plots consisted of the following species in the following percentages: Soybeans (Glycine max) 20 per cent, cow peas (Vigna sinensis) 18 per cent, buckwheat (Fagopyrum sagittatum) 10 per cent, rape (Brassica rapa) 2 per cent, brown top millet (Panicum ramosum) 5 per cent, milo or grain sorghum (Sorgum vulgare) 19 per cent, Korean lespedeza (Lespedeza stipulacea) 19 per cent and German millet (Setaria italica) 5 per cent (Fortenbery, 1959:11).

Clover-small grain fire lanes were planted with white clover (Trifolium repens) and rye (Secale cereale) and/or fescue (Festuca spp.).

Two methods were used for the placement of the traps for this study. The method used in Location 1 was similar to the placement described by Fortenbery (1959:14) who used nine traps to cover a five-acre square area. This method was based on an assumption made by Redd (1956:10), that each trap had a 100-foot radius of influence. This assumption proved satisfactory for McGinnes (1958:15), Fortenbery (1959:13) and Krug (1960:23). Using the same assumption, the investigator used 10 traps to cover a rectangular area of five-acres (Figure 1). This modification, of trap placement, was made in order to get more of the cultural treatment into the effective radius of the traps, since most of the cultural treatments are rectangular in shape. The other method used was called a Four Corner Evaluation. Four traps were used and one was placed in each corner of the area in question. This method was used for Locations 2, 3 and 4.

Along the Roadside Route: One section of the roadside count route was selected for trapping and marking of the rabbits found in this area. Trapping was done in order to keep track of the population found along this segment of the route. The area that showed the highest population, according to the number of rabbits seen, was chosen and it was approximately .4 miles in length.

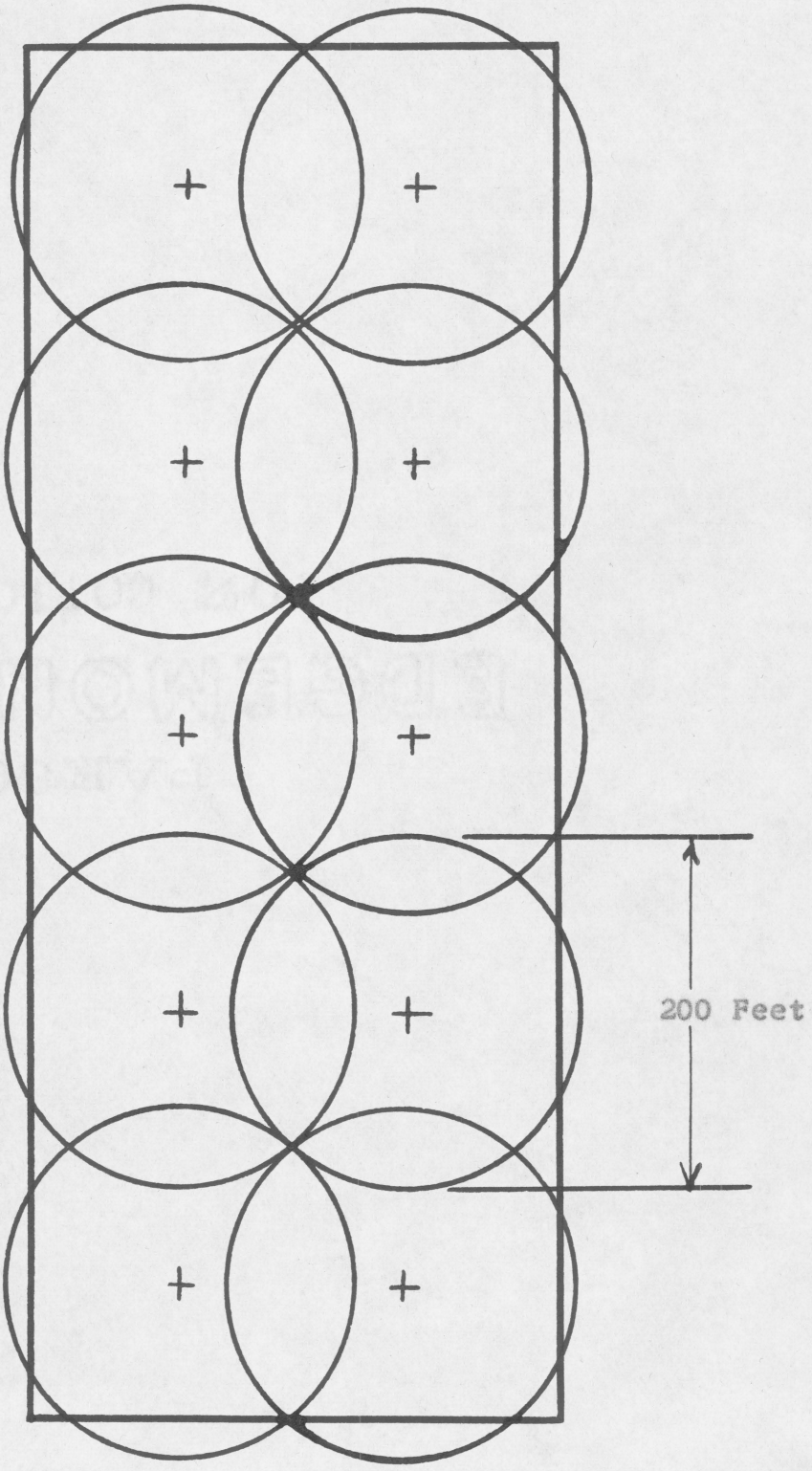

Figure 1. Location of traps on five-acre site.

Thirteen traps, spaced about 200 feet apart, were placed along one side of the road.

For Evaluation of Trap-Retrap Formulae: The spacing of traps was according to Fortenbery (1959:14).

For Natural Cover Evaluation: Natural cover utilization and degree of utilization was to be measured by means of trapping and track counts. Traps were placed about 200 feet apart along a predetermined transect line. Where cover was too thick or the way impassable the traps were placed on a line parallel to the transect line and tangent to the impassable area.

For Cover Manipulation Studies: One box trap was placed no more than 10 feet from the type cover being measured.

For Handling Rabbits: Traps were placed as close as 20 feet apart in areas supporting high rabbit populations.

Handling and Marking of Trapped Rabbits

Traps were checked each morning. Rabbits were removed from the trap using the funnel method described by Redd (1956:11). Redd used a wire funnel but this investigator employed a net funnel.

The net funnel was constructed using about the same dimensions Redd described for his wire funnel with the exception that 1-inch mesh fish net was used instead

of ½-inch hardware cloth. This type of funnel is quite flexible and allows for a thorough examination of the animal without having to hold it (Figure 2).

Other methods of handling rabbits are described by Petredes (1951:314), McGinnes (1958:15) and Krug (1960:25).

All rabbits handled were aged, sexed, examined for parasites, diseases and injuries, and tagged.

Types of tags and tagging methods used for all rabbits were those described by McGinnes (1958:15). The investigator used in addition to this method a plastic ribbon which was wrapped around the rabbit's ear and fastened in place by the tag (Figure 3).

Captured squirrels were marked with fish tags as described by Redd (1956:11).

Baits

No baits were used in this study. Both Fortenbery (1959:36) and McGinnes (1958:104) believed that rabbits enter traps in search of cover rather than in the pursuit of food. Redd (1956:32) and McGinnes (1958:104) found baited as well as unbaited traps equally effective in the capture of rabbits, therefore baits were not used in this study and all traps were considered to be equally effective.

In other rabbit investigations, Bruna (1952:6) in

Figure 2. Marked rabbit in net holding funnel.

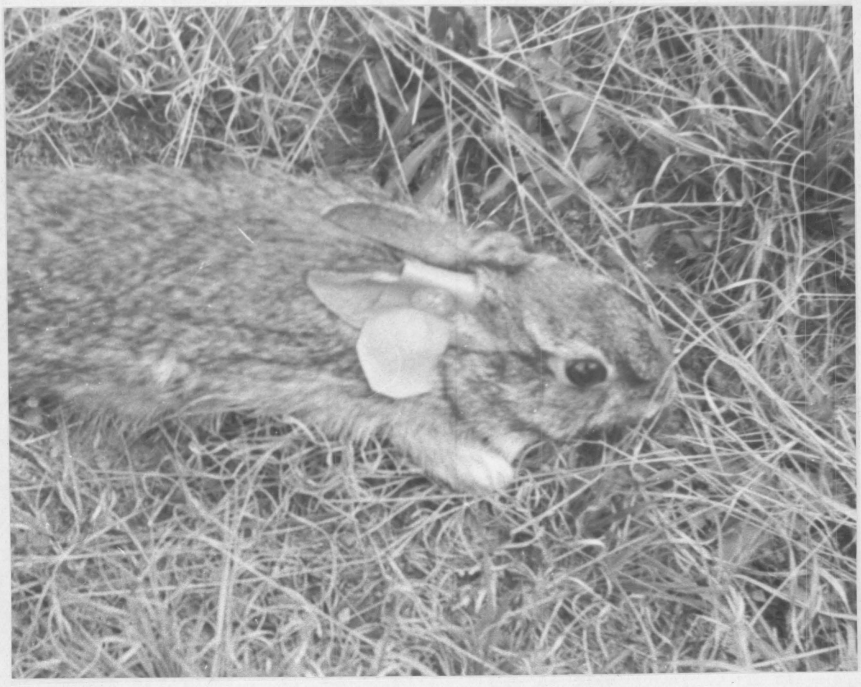

Figure 3. Method of attaching plastic ribbons and tags to cottontails' ears.

Kentucky found apples to be the best rabbit bait and corn second best; Dalke (1937:545) in Connecticut found carrots first in preference followed by parsnips; Redd (1956:11) in Virginia was of the opinion that shelled corn was better than cabbage, lettuce, celery or apples; McGinnes (1958:104) in Virginia used apples, onions, rabbit urine and unbaited traps with equal effectiveness. McGinnes (1958:105) states, "Effectiveness of baits and lures may be seasonal; the effectiveness of cover is universal".

SEX DETERMINATION

Examining the "external" genitalia as described by Petrides (1951:315-316) was the method used for determining the sex of rabbits. The presence of descended testes in the male and mammae in the female were other criteria used for sex determination.

AGE DETERMINATION

The development of the sex organs and body size were the criteria used for aging rabbits. Trapped animals were classed as immature or adult while rabbits seen in the field were classed by size (1/4 grown, 1/2 grown, 3/4 grown

or full grown). Techniques used for aging are described in Petrides (1951:327-333).

PARASITE EXAMINATION

A record was kept of all flea, tick and bot fly larva infestations. A collection was made of the fleas, ticks and bot fly larvae which were parasitizing those rabbits handled. Ticks and fleas were removed with the aid of tweezers and the bot fly larvae were removed by the manipulation method described by McGinnes (1958:54).

Ticks were sent to Walter Reed Hospital, Washington, D. C. in care of the Rocky Mountain Spotted Fever Project, Virginia State Department of Health.

DISEASE AND INJURY EXAMINATION

Rabbits were carefully examined for any signs of disease and/or injury.

A gross autopsy was made of any dead rabbits found in the field. Included in the autopsy was a careful macroscopic examination of the heart, lungs, liver, kidneys and spleen.

TRACK COUNTS

In an attempt to measure utilization of both natural and artificial cover, track counts were to be conducted 1 to 3 days after each snowfall, if conditions were suitable. The investigator circled the area in question and counted all rabbit tracks leading in and out.

ROADSIDE COUNTS

Selection of Route

The route used for roadside counts was the one employed by the previous investigator, Krug.

The following is a description of the route used:

1. The route is 10 miles long and is located in the cantonement area.
2. The cantonement area provides in the form of unused buildings and woodland, and fields, that are in the early stages of plant succession, ideal rabbit habitat.
3. Fresh succulent grasses are provided by infrequent mowing of the roadside and some of the areas adjacent to the buildings.
4. The mowed roadside provides a good view of rabbit activity for the observer.

5. Traffic is minimal.

Method of Operation

The procedures used on the roadside counts were the ones used by the previous investigator, Krug, with some additions.

Roadside counts were driven at the slowest speed possible in high gear and took approximately one-half hour. Most roadside counts were conducted one-half hour before sunset but some were made during other times of the day and night.

The data obtained on each of these counts were as follows: date; daily weather conditions; time (at the beginning and at the end of the count); light meter readings (taken before and after the count); traffic conditions (by street); number of rabbits seen (by street); size of rabbits seen (1/4, 1/2, 3/4 and full); and any other miscellaneous data the investigator thought pertinent. No distinction was made between rabbits seen on or off the road as was made by Newman (1959:290) in Iowa.

Roadside count data were recorded on 8½ by 11-inch sheets of paper especially prepared for this purpose. A separate sheet was used for each roadside count.

Most roadside counts were conducted in the evening

and in most cases only under optimum conditions. Rain was the main factor that determined whether or not a count would be made. Most road counts were cancelled or discontinued if rain fell just prior to or during the count.

The investigator's wife assisted on practically all counts; two observers probably gave more reliable results.

EVALUATION OF TRAP-RETRAP FORMULAE

The pen materials used by Fortenbery in 1958 and by Krug in 1959 and 1960 were used as a pen in this study. This "rabbit proof" pen enclosed 5-acres of suitable rabbit habitat and contained a known number of rabbits. An enclosed rabbit population was then subjected to trapping, tagging and retrapping.

The data obtained from this study were to be used in several trap-retrap mathematical formulae. The use of these data would enable the investigator to make an evaluation of these formulae and test their accuracy.

NATURAL COVER EVALUATION

An effort was made to evaluate natural cover preferences of the cottontail rabbit during the winter. The technique to be used for this investigation was as follows ; traps were placed 100 to 200 feet apart along a predetermined transect line running through an area supporting diverse forms of cover. A vegetative survey was to be made of the area surrounding each of these trapping sites and within a radius of 100-feet. Trapping would determine in which vegetative type and in what abundance rabbits were present.

The area selected for this study was 0.4 miles wide and 2.3 miles long. It was bounded and divided into four sections by roadways. The transect line was run lengthwise through the center of the area and the traps were placed approximately on this line. A note was made of where and when animals were jumped while running the trap line and track counts were made after a snowfall.

COVER MANIPULATION STUDIES

Selection of Sites

One of the areas used in this study was the one set up and described by Krug (1960:27-28). It was a five-acre field supporting an excellent growth of orchard grass (Dactylis glomerata), a few 1 to 3 year old loblolly pines (Pinus taeda) and numerous clumps of broom sedge (Andropogon virginicus) and in which 9 brush piles were constructed. According to Krug, this area supported a good rabbit population during the summer and early fall but when winter arrived rabbit utilization would be close to zero, because of the shortage of cover.

Four more areas were selected for this study. Two were similar to the areas selected by Krug and the others were open areas planted with an annual mix plot.

The investigator selected other areas where he planned to construct an assortment of artificial cover types, for example, tile pipes, rock piles, scrap metal piles, different types of brush piles and holes in the ground. Utilization of these forms of cover was to be measured by track counts in the sand placed in front of the openings to this cover. This endeavor was cancelled because of the shortage of rabbits.

Construction of Brush Piles

Brush piles were constructed according to the method described by Krug (1960:28).

Placement of Brush Piles

Krug (1960:28) located each of the nine brush piles constructed in the center of a circle having an area of 5/9-acre. The brush piles constructed during this project were located in the same manner but only in one-half of the area selected. The brush piles were to serve only half of the area and the other half was to serve as a control. Each area therefore was divided in half and the brush piles were placed in only one of the halves.

Utilization of brush piles was measured by trapping and/or track counts in the snow.

FOX PREDATION

An examination of fox stools encountered in the field was made and a gross stomach analysis was made of any foxes that the investigator was able to trap.

HIGHWAY KILL

All rabbits found dead on highways or roads were recorded and correlated with the number of miles traveled.

INTERVIEWS

Three types of interviews were conducted. Game Wardens, from 20 counties in Virginia, were questioned, before the hunting season, about the status of the rabbit in their respective counties. Toward the end of the season the wardens were asked the same question plus being asked about the rabbit hunting in the county and the possible cause for the fluctuation in rabbit numbers, if there was any.

In the field, quail hunters were asked about the abundance of rabbits according to the number of rabbits they jumped while hunting birds. Rabbit hunters were questioned about hunting success and the abundance of the rabbit.

PELLET DURABILITY

A study regarding the durability of rabbit pellets was made using fresh pellets obtained from trapped animals. These pellets came from two sources, caged animals being used for another part of this study and from animals found in traps being used for other studies. Since both traps and cages were checked and cleaned daily, all pellets used in this study were less than 24-hours old.

The number of pellets put out at any one time was not constant but any number over five was placed in as close to a natural habitat as possible.

Each rabbit pellet plot was at least one square foot in area and was marked with a numbered stake. Two plot stations were kept. One was located in a pine overstory and the other in an open area. Therefore each time pellets were put out, one set went into an open area and the other under a pine canopy. Thus, the investigator was able to compare the difference in durability between pellets dropped in open areas with those dropped in wooded areas.

One set of pellets required seven plots. A description of the plots is as follows:

1. Pellets placed on a wooden board.

2. Pellets placed on bare ground.
3. Pellets placed on bare ground with a vegetative covering (leaves and grass).
4. Pellets placed on bare ground with a pine limb covering.
5. Pellets placed on vegetative mat with no covering.
6. Pellets placed on vegetative mat with vegetative covering.
7. Pellets placed on vegetative mat with pine limb covering.

A comparison was made between plots in the same station and between stations. Most of the sets of pellets required only one plot.

The investigator used caged rabbits to count the number of pellets dropped by a single rabbit in 24 hours. Caged animals were also used to compare pellets produced on different diets.

All plots were checked at least once a week and in most cases more than once. An exception to this routine came during cold and snowy weather when the ground condition made accurate counting of the pellets impossible.

Pellets from plots that were blown or carried out of the plot boundaries were returned and those that could not be found were considered lost.

RESULTS

TRACK COUNTS

The investigator was unable to use snow track-counts for a population study due to the few tracks observed when such counts were possible. Insufficient snow during November and December made track counts impossible for the evaluation of land-cultural treatments.

During January and February the investigator was able to conduct three track counts. Two of these counts were conducted the first and second day after the snowfall on January 26, 1961. All cover manipulation sites were checked and one section of the transect line was walked. A total of six sets of rabbit tracks were found. Two of the sets were found on cover manipulation sites and only one of these was found entering and leaving a brush pile. The other four sets of tracks were observed crossing the 1/4 mile section of the transect line.

About ten miles of undisturbed roadway were driven on two occasions and only four sets of tracks were observed.

The second count was made February 4 and very similar findings were obtained.

The lack of success in the use of track counts can

be attributed either to the inactivity of the rabbits or to the shortage of rabbits.

TRAPPING FOR CULTURAL TREATMENT EVALUATION

Rabbit utilization of three land-cultural treatments extant on Camp Pickett was measured by live-trapping. The cultural treatments measured were annual mix, clover-small grain and mowing. Sixteen sites were selected and trapping commenced November 1 and continued until December 10. Forty-five rabbits were captured. The investigator tagged 40 rabbits and recaptured five. It required 1,264 trap nights, which was 27½ trap nights per capture. The trap nights required for each capture as experienced by Krug (1960:52) and Fortenbery (1959:35) were 24.0 and 28.8 respectively.

Table 1 shows the results of trapping on the three cultural treatments and the control areas. By the methods used and by basing utilization on the number of rabbits captured, it was found that during the months of November and December, a mowed roadside area was utilized more than the other two cultural treatments, annual mix was second and clover-small grain was next. The control areas showed utilization similar to clover-small grain.

Table 1. Comparison of cultural treatments by live-trapping, Camp Pickett, Va., November and December, 1960

	Annual Mix				Clover Small Grain				Mowing				Control			
	Location No.				Location No.				Location No.				Location No.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total rabbits captured	5	1	1	3	2	4	1	1	7	6	4	2	4	0	4	0
	10				8				19				8			
Per cent of total rabbits captured	22				18				42				18			

An effort was made to estimate the population on these areas using some of the trap-retrap formulae but not enough rabbits were handled to get a reliable population estimate. Both Fortenbery and Krug experienced this same difficulty.

The sex ratio obtained from this trapping period was 100 males to 100 females. Krug (1960:54) had a sex ratio of 112 males to 100 females and Fortenbery (1959:36) found a sex ratio of 130 males to 100 females.

ROADSIDE COUNTS

Evening Roadside Counts

Roadside counts commenced July 1 and continued throughout this study.

Krug (1960:29) found that 1/2 hour before sunset until sunset was the best time to carry on road counts, because it appeared to be the optimum time of rabbit activity. The investigator agrees with this conclusion, at least for the summer months.

Table 2 gives the number of counts conducted each month and the number of rabbits seen.

During the latter part of July a pronounced decline

Table 2. Rabbit roadside counts, 10 mile route, Camp Pickett, Va., 1960-61

Month	No. of counts	No. of rabbits seen	Average number of rabbits seen Per count by size 1/4	1/2	3/4	Full	By month
Jul	22	283	1.1	3.0	4.1	4.6	12.9
Aug	15	26	0.0	0.2	0.6	0.9	1.7
Sep	17	24	0.0	0.1	0.8	0.5	1.4
Oct	15	3	0.0	0.0	0.1	0.1	0.2
Nov	11	2	0.0	0.0	0.1	0.1	0.2
Dec	5	3	0.0	0.0	0.6	0.0	0.6
Jan	9	2	0.0	0.0	0.0	0.2	0.2
Feb	6	1	0.0	0.0	0.0	0.2	0.2
Mar	4	0	0.0	0.0	0.0	0.0	0.0
Apr	4	8	0.0	0.0	0.0	2.0	2.0

in the number of rabbits was noted during the roadside counts. This lesser number of rabbits was obvious throughout the study. The previous investigator experienced a similar drop but it occured in mid-August.

At first the investigator was of the opinion that a change in rabbit activity was the cause for this decline and not a drastic decline in population numbers. This assumption was made because last year's drop, as experienced by Krug (1960:29), was not real according to the hunting-kill records (In 1960 Camp Pickett recorded its highest rabbit kill). Appendix Table 1 gives the rabbit harvest at Camp Pickett for the hunting seasons from 1956-57 until 1960-61.

Krug (1960:34) checked his apparent decline with a brush-beating survey and a search for dead animals. No dead animals were found and not enough surveys were conducted to give any substantial results as to the reality of this drop in rabbit numbers. Krug gives no explanation for this decline.

This investigator and his beagle covered parts of the area along the road count route and rabbits seemed to be present wherever the dog was released. No concrete data was kept on these dog-surveys but it was noticed, that for every one dog release area needed to find a

rabbit during July and August, September required two and November at least three.

Another method of checking this decline was made by trapping and tagging along one portion of this route. Trapping began before the decline and continued until February, 1961. Very few rabbits from previous trapping periods were recaptured in subsequent trapping periods. This led the investigator to believe there was a continuous and rapid population turnover. This replacement plus the decrease in the number of rabbits captured could have been caused by the vacuum created by the decreasing population or was just the results of capturing transient rabbits. Table 3 gives some of the results of this trapping.

Krug (1960:35) found three factors influencing the daily count and these were rain, traffic and mowing. Krug states; "If a moderate to heavy rain was falling during the 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.". The investigator agrees with these findings.

Table 3. Live-trapping of rabbits along 0.4 mile section of 10 mile roadside count route, Camp Pickett, Va., July, 1960 - February, 1961

Month	Number of Rabbits Captured								Cpts.	Rcpts.	Totals	Trap Nights
	J u l	A u g	S e p	O c t	N o v	D e c	J a n	F e b				
Jul	17	-	-	-	-	-	-	-	11	6	17	312
Aug	1	3	-	-	-	-	-	-	3	1	4	26
Sep	2	0	15	-	-	-	-	-	11	6	17	377
Oct	0	0	1	3	-	-	-	-	3	1	4	209
Nov	-	-	-	-	-	-	-	-	-	-	-	-
Dec	0	0	2	0	0	1	-	-	1	2	3	130
Jan	1	1	1	0	0	0	3	-	3	3	6	75
Feb	0	0	0	0	0	0	0	0	0	0	0	118
Totals									32	19	51	1247

An attempt was made to associate other factors as the amount of light, temperature, phase of the moon, wind velocity, weather conditions following the count and humidity with the daily fluctuations in rabbit numbers but the drastic drop in rabbits made association impossible. However, Newman (1959:292) found that weather factors, including wind, do influence the number of cottontails observed on road counts.

Some of the information that can be derived from road count data is as follows; annual reproduction, reproductive periods and population trends. Continued road counts make data available for the comparison of years but it must be remembered that road counts can only be compared with counts carried on in the same areas.

Night Road Counts

About 24 night road counts were conducted during the months of November, December, January, February and March. The investigator speculated that perhaps a change in time might increase the total number of rabbits seen. Only 8 rabbits were seen during the 24 night road counts as compared with 0 rabbits seen during the 11 evening roadside counts conducted during the same time period.

Although more rabbits were seen during the night road counts, not enough were seen to give any conclusive data to the fact, that night counts are more reliable during the winter months than are evening roadside counts; the investigator is of the opinion they are.

No early morning or moon counts were conducted during this study. Krug (1960:38) conducted both morning and moon road counts and was not able to draw any conclusions as to their reliability.

EVALUATION OF TRAP-RETRAP FORMULAE

In preparation for this study, four strips of ladino-clover and one strip of rye were planted in the pen on October 4. The clover strips were placed in such a manner as to divide the pen into five equal sections. The purpose of this division was to create more edge and to enable the investigator to better observe cottontails on drive counts. The rye strip was planted in an area that was devoid of vegetation. All strips were approximately 12 feet wide and occupied at least 3/4 of an acre.

The pen was in dire need of repair and work on it was begun early in July. In addition to repairing the

original pen built by Fortenbery, a wire overhang was added as suggested by Krug (1960:63). Two feet wide galvanized poultry netting of one inch mesh was attached to the fence using pig rings. Part of the netting was used to increase the height of the fence while the remainder was left to hang down inside the enclosure.

Shortage of materials and military activity in and around the site of the five-acre rabbit enclosure delayed completion and operation of the pen until February 1.

Another stage in the preparation for this study was the trapping of mammalian predators. As suggested by Krug (1960:63), fox traps were set in the area directly surrounding the pen. Five traps were set September 28 and were operated until November 10. During this period, seven foxes were caught and destroyed (three red foxes and four gray foxes). Other animals caught during this trapping campaign were; three stray dogs, one raccoon, two opossums and one skunk. Trapping was discontinued because of the advent of the hunting season and the danger of catching hunting dogs.

Periodically during the summer and fall, tagged rabbits were placed in the pen. Although the pen was not completely repaired, the investigator believed the approximate carrying capacity of the pen could be determined.

Ten rabbits were stocked before November and periodic trapping was begun. By this time the original pen had been repaired and sections of the overhang were already completed. The investigator used 20 traps and three of the rabbits stocked during the summer were caught and placed outside the confines of the pen. Further trapping revealed that all three of these rabbits had climbed back into the pen and once again were released outside the enclosure. It was then decided to discontinue trapping as a means of removing animals from the pen and use intensive hunting. It was also decided to use a new population for this study and not animals accustomed to the pen or there with prior association with it.

When the enclosure was completed it was hunted and a total of 5 rabbits were removed. Three of the rabbits removed were the tagged rabbits stocked in the pen in the summer and taken out of the pen during the trapping period in the fall.

The pen was then stocked with two rabbits which had been captured some distance from the pen. The purpose of this stocking was to determine the length of time required for a rabbit to become accustomed to a new environment. This population was checked daily by the investigator and his beagle. After two days in the pen the rabbits,

when pursued by the dog, began to run in a natural manner and would avoid running into the fence. The investigator believes a minimum of two days is required for a rabbit to become acquainted with a new area, because it required two days for the rabbits to become accustomed to the enclosure wire. Admittedly this assumption was based on the observed actions of two rabbits thus is open to critisism. The pen was then hunted again and both remaining rabbits were removed.

For the first evaluation of some of the trap-retrap formulae, eight rabbits were placed in the pen. The rabbits used for this stocking were captured some distance from the pen and were ear marked with fish tags like those described by Redd (1956:11). The rabbits were marked in this manner only to permit future differentiation of stocked rabbits but for the purpose of this study they were considered as unmarked. When captured for the first time in the pen, these tags were replaced by reflective discs and plastic ribbons like those described on page 24. A different color combination of plastic ribbons was used for each rabbit to permit field identification of the individual rabbits.

More rabbits were stocked than the assumed carrying capacity of the pen to allow for any possible losses that

might occur before trapping commenced. The stocking period was from February 4 to February 11 and trapping commenced February 13. Trapping continued until February 23 when the traps were closed for four days. They were reopened February 27 and remained open until March 4. Results of the trapping appear in Table 4.

During the trapping period from February 13 to February 23, ten captures were made of six individuals. It required 90 trap nights or 9 trap nights per capture. From February 27 to March 4, five captures were made of three individuals that had been tagged in the previous trapping period. This trapping period required 45 trap nights or 9 trap nights per capture.

The data obtained from trapping the enclosed population was used in the Krumholz, the Lincoln Index and the Schumacher Eschmeyer mathematical formulae. These formulae were presented by Portenbery (1959:31-32) and Redd (1956: 14-16). Computations resulting in using these data in the before mentioned formulae appear in Tables 5, 6 and 7.

On March 9 the investigator with the help of his beagle began a check of the rabbits remaining in the pen. By March 11 all eight of the rabbits originally stocked were accounted for and by March 17 all had been handled

Table 4. Trapping record for an enclosed rabbit population used for evaluating trap-retrap formulae, Camp Pickett, Va., Feb. 13 - March 4, 1961

Tag Nos.	Sex	Dates of capture and recapture														
		Feb.										Mar.				
		14	15	16	17	18	19	20	21	22	23	28	1	2	3	4
523-524	F	X							X			X		X		
525-526	F		X													
527-528	M		X					X								X
529-530	M			X	X				X				X	X		
535-536	F							X								
537-538	M								X							

Table 5. Population estimation by use of Schnabel (Krumholz) formula based on an enclosed known number of rabbits, Camp Pickett, Va. *

Date	"A"	a	"B"	(A)(B)	∑(A)(B)	"C"	∑(C)	N
Feb. 14	1	1	0					
15	2	2	1	2				
16	1	1	3	3	5			
17	1	0	4	4	9	1		
18	0	0	4	0	9	0	1	9
19	0	0	4	0	9	0	1	9
20	2	1	4	8	17	1	2	8.5
21	3	1	5	15	32	2	4	8
22	0	0	6	0	32	2	4	8
23	0	0	6	0	32	2	4	8
28	1	0	6	6	38	1	5	7.6
Mar. 1	1	0	6	6	44	1	6	8.3
2	2	0	6	12	56	2	8	7
3	0	0	6	0	56	0	8	7
4	1	0	6	6	62	1	9	6.8

"A" Animals examined
"a" Animals marked
"B" Marked animals in area
"C" Recaptures
∑(C) Sum of recaptures

N Population Estimate

$$N = \frac{\sum(A)(B)}{\sum(C)}$$

* Data from Table 4.

Table 6. Population estimation by use of the Lincoln Index based on an enclosed known number of rabbits, Camp Pickett, Va. *

Date	M	m	n	N
Feb. 14	0		1	
15	1		2	
16	3		1	
17	4	1	1	4
18	4	0	0	
19	4	0	0	
20	4	1	2	8
21	5	2	3	7.5
22	6	0	0	
23	6	0	0	
28	6	1	1	6
Mar. 1	6	1	1	6
2	6	2	2	6
3	6	0	0	
4	6	1	1	6

M-number of marked animals in area
m-number of marked animals in sample
n-number of animals in each sample

N- Estimated Population

$$N = \frac{Mn}{m}$$

* Data from Table 4.

Table 7. Population estimation by use of Schumacher-Eschmeyer formula based on an enclosed known number of rabbits, Camp Pickett, Va. *

Date	k	M	M^2	m	n	M^2n	$\sum M^2n$	Mn	$\sum Mn$	N
Feb. 14		0		0	1					
15	1	1	1	0	2	2	2	0	0	
16	2	3	9	0	1	9	11	0	0	
17	3	4	16	1	1	16	27	4	4	6.75
18	4	4	16	0	0	0	27	0	4	6.75
19	5	4	16	0	0	0	27	0	4	6.75
20	6	4	16	1	2	32	59	4	8	7.36
21	7	5	25	2	3	75	134	10	18	7.44
22	8	6	36	0	0	0	134	0	18	7.44
23	9	6	36	0	0	0	134	0	18	7.44
28	10	6	36	1	1	36	170	6	24	7.09
Mar. 1	11	6	36	1	1	36	206	6	30	6.87
2	12	6	36	2	2	72	278	12	42	6.62
3	13	6	36	0	0	0	278	0	42	6.62
4	14	6	36	1	1	36	314	6	48	6.54

k- number of samples (passes)(k-1=degrees of freedom)
M- number of marked animals in area
m- number of recaptured animals in each sample
n- number of animals in each sample
N- total population summation $N = \frac{\sum M2(n)}{\sum Mm}$

* Data from Table 4.

and removed from the pen.

Rabbit 529-530 was found dead in the pen on March 9 but the cause of death could not be determined. From the condition of the carcass, predation was ruled out as a possible cause. The investigator felt certain that the animal died sometime after March 4, therefore it was considered an active part of the population until that time.

The total population of the pen during the whole trapping period proved to be eight rabbits.

The mean population estimate of the pen through the use of the formulae was found to be; the Krumholz, 7.93; the Schumacher-Eschmeyer, 6.97; and the Lincoln Index, 6.0 - 6.5. The investigator had difficulty in arriving at a population estimate using the Lincoln Index because of the short trapping period and the small sample population.

With the small population and the procedures used, it was found that the Krumholz formula was most accurate in the determination of the actual population but the Schumacher-Eschmeyer presented a more constant estimation.

NATURAL COVER EVALUATION

Early in January, 50 traps were placed along one segment of the transect line used for this study. After seven days of trapping only two rabbits were captured. The investigator was of the opinion that the apparent shortage of rabbits decreased the trap response and not enough rabbits would be handled to give any conclusive data about the natural cover preferences of the cottontail. The study was discontinued.

The length of the transect line required and the type of vegetative survey suitable for such a study was not determined.

COVER MANIPULATION

Trapping commenced on all cover manipulation sites in November. The purpose of this study was to determine if the establishment of artificial cover in areas lacking in cover or in areas that have a cover shortage in the winter, would draw and/or hold a rabbit population.

Before presenting the results of this study it should be mentioned once again that the rabbit population on Camp Pickett was very low, rabbits were not wanting

for cover and they did not require artificial cover.

The five-acre area established by Krug (1960:67) and provided with nine brush piles on February 3, 1960, supported a high rabbit population in November but lost this population before January. Special hunts were allowed in the wooded area adjacent to the study area during the hunting season and only one of the rabbits tagged on the area turned up in the hunters' bag. Table 8 gives the results of the trapping on this five-acre cover manipulation site.

Not enough rabbits were handled on the other areas provided with artificial cover to draw any conclusions. Only five rabbits were handled on the five-acre area where three brush piles were constructed and only five rabbits were captured on the $2\frac{1}{2}$ acre area on which two brush piles were built.

Tables 9 and 10 give the results of the trapping on these two areas.

Track counts made on these areas and on the other areas used for cover manipulation studies revealed little or no usage of the areas or the cover in question.

Because of the rabbit shortage no conclusions could be drawn nor could the value of artificial cover in rabbit management be measured.

Table 8. Live-trapping of rabbits on five-acre cover manipulation site 1, established by Krug (1960: 67), Nov. 19,1960-Feb. 9,1961 and a comparison with the total number of rabbits captured by Krug, Nov. 1, 1959- April 11, 1960, Camp Pickett, Virginia

Month	1960-1961				1959-1960
	Trap-Nights	Captures	Recaptures	Total	Total
November	153	11	3	14	8
December	99	0	0	0	6
January	108	1	0	1	0
February	63	0	0	0	1*
March					2
April					1

* Brush piles established by Krug, Feb. 3, 1960

Table 9. Live-trapping of rabbits on five-acre cover manipulation site 2, Nov. 7, 1960-Jan. 21, 1961, Camp Pickett, Va.

Month	Trap-Nights	Number of rabbits With Brush Piles		Without Brush Piles	
		Captures	Recaptures	Captures	Recaptures
November	120	2	0	2	0
December	100	1	0	0	0
January	120	0	1	0	0
Totals	340	3	1	2	0

Table 10. Live-trapping of rabbits on 2½-acre cover manipulation site 3, Nov. 7, 1960-Jan. 21, 1961, Camp Pickett, Va.

Month	Trap-Nights	Number of rabbits With Brush Piles		Without Brush Piles	
		Captures	Recaptures	Captures	Recaptures
November	72	1	0	2	0
December	60	0	0	1	0
January	72	0	1	0	0
Totals	204	1	1	3	0

PARASITES

Ticks

Ticks are known carriers of many diseases. Among the diseases spread by ticks are Tularemia and Rocky Mountain Spotted Fever. Both these diseases are transferable to humans and therefore are of great concern in the medical and wildlife fields.

A study has been started by the Virginia State Department of Health regarding the spotted fever disease and its modes of transmission. The investigator aided one of the field workers of this project by collecting ticks and supplying a few animals for labratory examination. The study was very much concerned with cottontails and the ticks parasitizing them, because early in the summer or late spring a young rabbit was caught by one of their field workers which was positive for spotted fever.

All the rabbits handled from July through April carried ticks in varying numbers. Infestation was quite heavy on some of the rabbits handled during the fall, summer and spring months. During December ticks became conspicuously scarse. In September the ticks parasitizing rabbits were primarily very small young ticks. Very few adult ticks were found after October but the investigator

found one adult tick firmly attached to a rabbit captured in February.

Table 11 compares monthly observations of tick parasitism on live trapped animals.

Fleas

Fleas were observed on rabbits in all months except July. Infestation by fleas was slight during the summer months but began to increase in the fall. By winter the degree of parasitism was very heavy.

The investigator noticed that flea activity on rabbits increased as soon as the animal was handled. The amount of fleas seen upon handling determined the degree of parasitism.

Table 11 compares monthly observations of tick parasitism.

Bot Fly Larvae

The larvae of the bot fly (Cuterebra sp.) is a common parasite of the cottontail. Other common names of this larva are warble, rabbit grub and wolf.

Cheatum (1952:20 original not seen) gives the following description and life history of Cuterebra: "This bot fly larva or grub is found under the skin and

Table 11. Comparison of monthly observations of ecto-parasitism on live trapped rabbits, Camp Pickett, Va., 1960-61

Months	Number of Rabbits	Percentage showing parasitism by; Ticks	Fleas	Bot Larvae
July	11	100.0%	0.0%	27.3%
August	16	100.0	6.3	25.3
September	27	100.0	7.4	40.7
October	24	100.0	29.2	62.5
November	53	100.0	43.4	58.5
December	18	100.0	94.4	22.2
January	10	50.0	100.0	10.0
February	11	27.3	66.6	00.0
March	2	100.0	100.0	00.0
April	3	100.0	100.0	00.0

is most commonly located in the neck region. A breathing hole is made in the skin and the larva grows to maturity. When fully grown these grubs may be over one inch long and an inch in diameter, dark in appearance, and covered by short, stout spines. During the latter part of the summer and in the fall, they force their way through the breathing apperature and fall to the ground where they burrow and enter the pupal state for the winter. In the spring, the adult bot fly emerges from the pupa, mates and searches for a rabbit on which to deposit her larvae, and the cycle is repeated." "There has been some speculation that the eggs may be laid on grass blades and other vegetation, and the newly-hatched maggots drop off on passing rabbits." (Madson, 1959:23 from Geis, 1953).

The adult bot fly resembles a small hairy bumble-bee (Madson, 1959:23). Figure 4 shows an adult Cuterebra which was hatched by the investigator.

The bot larvae always emerge and drop to the ground before cold weather, and are seldom of concern to mid-winter rabbit hunters (Madson, 1959:24 from Geis, 1953). "But ugly as warbles are, they are harmless to man. They may weaken a rabbit, or open the door for secondary infections or retard a young rabbit's growth, but they apparently never kill." (Madson, 1959:24). This parasite

Figure 4. Adult bot fly, Cuterebra sp.

has no effect on the edibility of the rabbit (Reilly and Dell, 1954-1955).

Of the 175 individual rabbits handled by the investigator, 40.2 per cent of the rabbits showed signs of having been infested by Cuterebra.

Krug (1960:65) found 42 per cent of the rabbits handled showed bot infestations and Fortenbery (1959:61) found 35 per cent. McGinnes (1958:50) found an average infestation of 15 per cent at Blacksburg, Virginia. Bruna (1952:38) in Kentucky found 12.6 per cent and Geis (1957:94) in Michigan found 26 per cent infestation in the summer of 1956 and 11 per cent in the summer of 1957.

Of the 75 rabbits showing infestations during the trapping period from July to December, 52 were juveniles while only 23 were adults, and 33 were males and 42 females. This agrees with the findings of other investigators, that juvenile rabbits are more often infested than are adults and there seems to be no preference as to sex of the host.

Practically all parts of the rabbits' body were attacked by this parasite but the most common site of infestation was the genital region. Bots were also found on the neck, legs and on all other regions of the body proper.

Rabbits encountered were hosts to as many as four bots at the same time. One individual had two larvae utilizing the same breathing hole.

The investigator found five rabbits carrying dead bot fly larvae. In two cases the larvae were in the process of being reabsorbed, while the other three were gradually being forced out through the breathing port. One of the desiccated bots, in the process of being forced out, was observed in February.

The exact time required for the development of the large larvae, following deposition, is unknown (Cheatum, 1952:24). McGinnes (1958:54) found that larvae apparently develop rapidly; a rabbit was examined and found to be free from bots and when recaptured 22 days later it was found to have five well developed larvae.

All larvae encountered were collected. Most were put into alcohol but 20 larvae were put into a glass jar containing damp soil. Two of the larvae were found in the floor of the rabbit trap. Apparently these larvae reached maturity after the host was captured and emerged to pupate.

As McGinnes (1958:54) mentioned, the change from larval to the pupal stage is rapid and in one instance only required 2½ hours. The larvae found in the trap

required only about four hours. Larvae taken from the host required much longer and in most cases never reached the pupal stage, this probably was do to the immuturity of the larvae.

Less than two months after the larvae pupated in the glass jar, one adult Cuterebra sp. emerged. The investigator did not mark the larvae as they were put into the jar, so the exact time it required to go from pupa to adult is not known. The hatching of the adult fly on October 13, led the investigator to believe that more than one generation of bot flies may be produced each year. Other flies emerged on the following dates; March 27, April 20, April 25, May 1, May 5 and May 6 which was approximately between seven and nine months after pupating.

All adult flies were sent to the Entomology Department at V. P. I. for identification and inclusion into the V. P. I. collection.

Endoparasites

No examination was made for endoparasites.

DISEASES

Ten rabbits were autopsied, all of which were sacrificed for this purpose. All rabbits were healthy and had no internal disorders.

A search for diseased or dead rabbits was made but none were found. Hunters reported finding a few but none were turned into the investigator.

Fibroma

A fairly common cottontail disease is Shope's fibroma. This is a virus disease spread through the bites of mosquitos and possibly fleas which attacks cottontails (McGinnes, 1958:48). The virus is so tiny it can pass through a porcelain filter and can be given to captive animals in the labratory (Madson, 1959:23). The disease is characterized by wart-like protuberances on the skin that are usually soft and pinkish in color, and mostly occur on the feet and face (Reilly and Dell, 1954-55). The tumors are usually found only on the skin except in cases where it becomes cancerous and spreads through the animal's body (Madson, 1958:23).

"There is no evidence of transfer of the infection to man either through handling or eating rabbits which

have been infected with these tumors" (Herman et al., 1956:86).

In this study only three rabbits of the 175 handled showed the gross lesion of Shope's fibroma. All infected rabbits had tumors just above the nose.

Krug (1960:66) reported nine of the 414 rabbits handled were afflicted, Fortenbery (1959:41) found four of the 179 rabbits handled had tumors, and McGinnes (1958:71) found fibroma in only one rabbit of 973 handled.

Mange

The only other disease encountered on the area was mange, which was identified by a pathologist. Two of the animals handled showed this affliction.

Rocky Mountain Spotted Fever

Three rabbits were sent to the Department of Rickettsial Diseases, Walter Reed Army Institute of Research, Washington, D. C. for labratory examination. Two of the three rabbits sent in gave a positive titer for spotted fever antibodies but all isolation attempts of the spotted fever ricketsiae were negative. Rabbits with a positive titer possible had a prior infection of the disease. No labratory rabbits were used in the tests but previous

studies of the disease have shown that the spotted fever infection in rabbits is not fatal.

TRAP FATALITIES

The investigator experienced seven trap fatalities. Three rabbits died of injuries acquired in the trap. The others were lost to predators. A cat was suspected in two cases and a dog or a fox was responsible for the others.

FOX PREDATION

About 50 fox scats were examined in the field between July 1 and November 30. Gross examination of these scats was made and in only one could the investigator identify rabbit remains. Krug (1960:66) found rabbit remains in two of the 56 scats examined during the same period of time the previous year.

All the scats examined contained either the seeds of the persimon (Diospyros virginia) or blackberries (Rubus spp.). The investigator found hair and/or feathers in 14 of the 50 scats examined. As well as could be determined,

all the hair found was from mice. Examination of scats were made in the field and only roughly examined, hence, the reliability of the above information is open to question.

HIGHWAY KILL

The number of rabbits found dead on the highways and roads in and around Camp Pickett is presented in Table 12. This table also contains the data obtained by Krug (1960:71).

INTERVIEWS

Prior to the 1960-61 hunting season, game wardens from 20 southeastern Virginia counties were asked the following question, "Are the rabbits on the increase or on the decrease in your county?". Just before the end of the season the wardens were again asked the same question plus, "How was the rabbit hunting in your county?" and "To what do you attribute this change in the number of rabbits in your county?". The answers received from these interviews appear in Table 13.

Two other types of interviews were conducted during

Table 12. Highway kill data, Camp Pickett, Va., July, 1958-April, 1960* and July, 1960-April, 1961

Month	1959-1960 No. killed	1959-1960 Mi. / kill	1960-1961 No. killed	1960-1961 Mi. / kill
July	1	1234	5	265
August	2	1153	0	(1576)**
September	1	888	4	375
October	2	693	0	(1392)**
November	5	200	6	241
December	7	171	0	(729)**
January	17	58	4	258
February	20	50	0	(907)**
March	20	33	4	188
April	25	31	5	190

* Data obtained from Krug (1960:71)
** This is the total number of miles traveled

Table 13. Response to questions asked game wardens from twenty southeastern Virginia counties, 1960-61

QUESTIONS:
(1) "Are the rabbits on the increase or on the decrease in your county?"
(2) "How was the rabbit hunting in your county?"
(3) "To what do you attribute this change in the number of rabbits in your county?"

County	Response to Questions Nov. 7, 1960	Jan. 18, 1961		
	1	1	2	3
Amelia	Up	Normal	Normal	Dry Weather
Appomattox	Up	Down	Good	?
Brunswick	Up	Same	Good	Same
Buckingham	Up	Down	Poor	Weather ?
Charles City	Down	Down	Spotty	Dry Weather
Charlotte	Down	Down	Spotty	Disease
Chesterfield	Up	Down	Fair	Dry Weather
Cumberland	Up			
Dinwiddie	Up	Down	Spotty	?
Fluvanna	Up	Normal	Good	No Change
Goochland	Up	Normal	Fair	No Change
Greensville	Up	Up	Good	Fox die out
Henrico	Up	Down	Normal	?
Lunenberg	Down	Down	Spotty	?
Mecklenburg	Down	Down	Spotty	?
New Kent	Up	Down	?	Less Hunting
Nottoway	Up	Normal	Spotty	Dry Weather
Powhatan	Up	Normal	Good	?
Prince Edward	Up	?	?	?
Prince George	Up	Normal	Good	?

the hunting season. Interviews were conducted at the checking station and since all hunters had to check out of this checking station, both successful and unsuccessful hunters were contacted. About 200 quail and rabbit hunters were asked their opinion about the abundance of rabbits on Camp Pickett. All quail hunters replied with approximately the same answer, "We just didn't jump as many rabbits as we did in the previous years". The rabbit hunters on the other hand were divided in their opinion. About 50 per cent felt the number of rabbits normal, while the other 50 per cent felt the rabbits were scarse. When asked about rabbit hunting, the rabbit hunters responded in the following ways; hunting was poor because there doesn't seem to be as many rabbits; hunting was very good, we jumped most of the rabbits in a small area; and hunting was poor because there were too many rabbits in an area and the dogs couldn't stay on a trail.

The investigator found rabbit hunting spotty; fair to good hunting in some areas but in most areas rabbit hunting was poor.

PELLET DURABILITY

The study of rabbit pellet deterioration was continued by this investigator. Krug (1960:39) found that winter

loss of pellets was practically nil and with the advent of warmer weather disintegration of pellets became rapid. Krug believed that this may have great significance on the use of pellet counts in the management of the cottontail rabbit.

The purpose of this phase of the study was to determine some of the factors that influence the "persist ability" of rabbit pellets and attempt to determine pellet losses during the various seasons of the year.

Summer-Early Fall

During July, 69 pellets were placed in plots located on bare ground. These plots were checked daily and the pellets were counted. The results of the pellet counts conducted on these plots appear in Figure 5. Loss of pellets in all plots was greatest during the first forty-eight hours. Cause for the initial loss of pellets was attributed to earthworms and ants because of earthworm casts in the plots and the activity of ants near the pellets. In Illinois (Anonymous, 11:1959), a study revealed that earthworms were responsible for consuming rabbit pellets. The following appeared in the Survey of Pittman-Robertson Activities-1959;

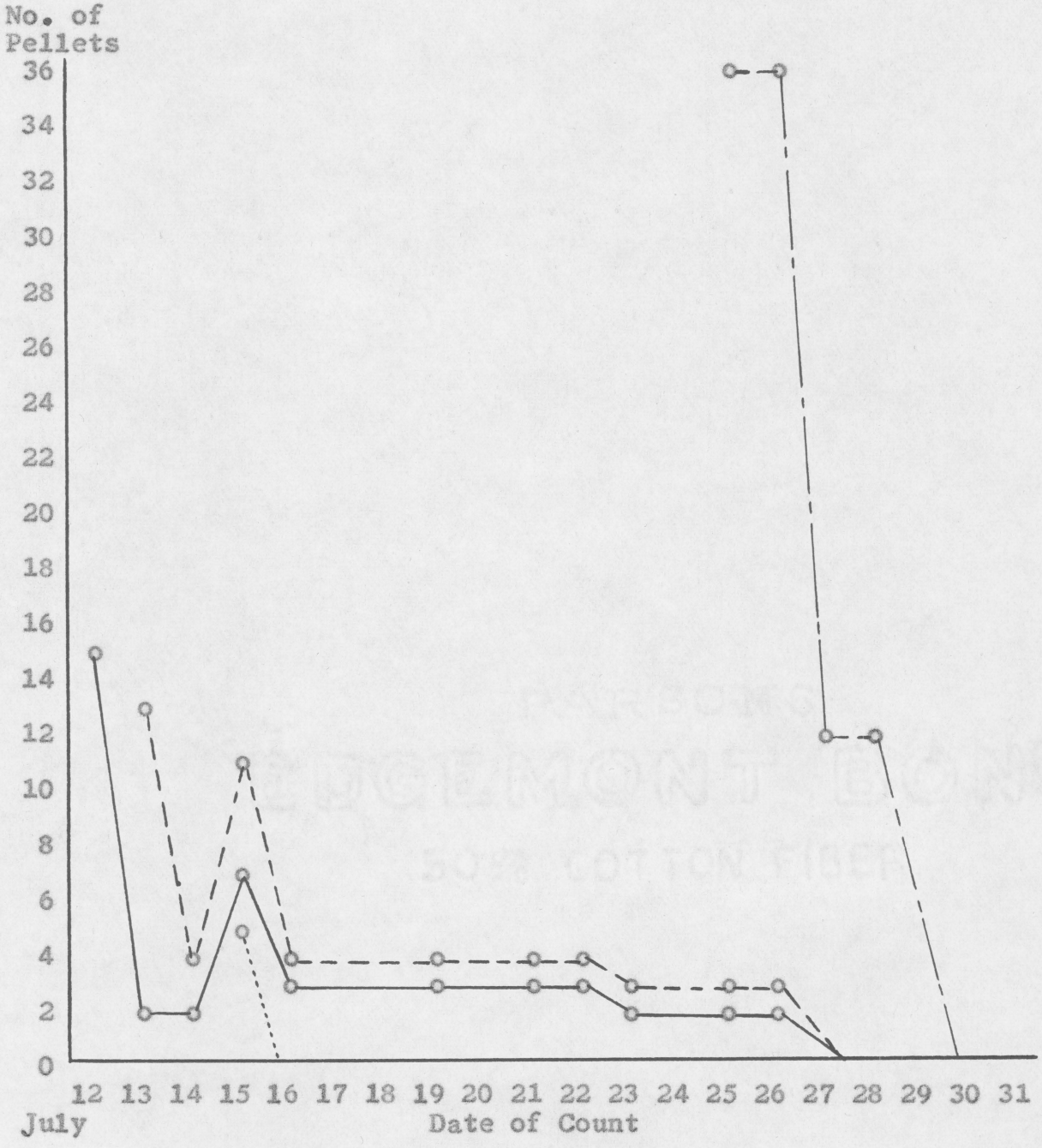

Figure 5. Observations on the durability of four groups of rabbit pellets during July, 1960, Camp Pickett, Va.

Earthworms consume rabbit pellets: Investigations in Illinois of the decay rate of rabbit fecal pellets disclosed that they lasted much longer in the winter than they did in the summer and that rainy periods in the summer caused rapid disappearance. Because daily observations of pellets did not reveal the expected gradual breakdown with fragments persisting for a while, another agent was suspected. Many pellets were present one day and gone the next. In addition, when pellets were arranged in regular pattern on the ground to facilitate counting the next day, the arrangement was much disturbed in spite of being protected by a cage of quarter-inch mesh wire over the pellets. The presence of earthworm casts around the remaining pellets gave the necessary clue. On a warm evening in April a large number of pellets were scattered on some bare ground which showed, by the number of earthworm casts, that there were many worms on this area. A red floodlight which apparently did not affect the activity of the worms was used for observations during the night. The worms were observed to come out of their holes, search for a pellet, grasp the pellet in their mouths and pull it back to their holes. If the diameter of the worm was larger than the pellet, the pellet was pulled down into the hole. If the worm was a small one, the pellet was pulled to the entrance of the hole and eaten there. In 30 minutes of observations approximately 20 worms were seen to devour 29 pellets.

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Observations in this study revealed that earthworms are responsible for most pellet losses by devouring and/or burying them. Mounds of earth containing pellets were believed to be made by ants and in some cases ants were observed moving pellets from the plot site. After 48 hours further loss of pellets to these causes was slight, until a rainfall would again make the pellets available and desirable to the earthworms. It appeared that dried pellets

could not be utilized by earthworms.

The investigator believes that pellets become desiccated after two or three days in the open, and this was the reason for persistence of the remainder of the pellets. Moisture in the form of rain would make pellets once again available to the earthworms.

Rainfall also played a role in changing the number of pellets in a plot. Buried pellets would be uncovered by rain and would increase the number of pellets to be counted while the washing action of heavy rains would mechanically remove pellets from the area or bury them in silt and decrease the number of pellets to be counted.

Referring to Figure 5, the increase in the number of pellets noted on July 15 was attributed to the thunderstorm that occured on the evening of July 14 and the moisture caused the decrease in the number of pellets recorded on July 16. Other decreases in pellets occured on July 28 and July 30 which was attributed to the rainfalls that occured on July 27 and July 29.

Very little decomposition of pellets was noted during this time period. The investigator believes that decomposition is goverened by air and ground moisture. Because pellets become rapidly desiccated, decomposition has little effect on the durability of pellets. Desiccated

pellets could last indefinitely, if the humidity remained low.

For the rest of the pellet studies two plot stations were maintained. One was located in a pine woods and the other in an open field. Therefore, each time pellets were put out, one set went into an open area and the other under a pine canopy. Thus the investigator made it possible to compare the difference in durability between pellets dropped in fields with those dropped in wooded areas.

The wooded area station is refered to as Station A and the open area station is refered to as Station B.

In order to determine the effect of desiccation on the persistence of pellets, 60 pellets were left to dry in the sun for several days but taken indoors in the evening and during inclement weather. On September 6, 60 fresh pellets were collected and placed along with the dried pellets in plots located in the pine woods and the open field. A weekly check was made on these pellets. The results of these observations and counts on these plots appear in Figure 6. Very little difference was noted between the fate of the dried and fresh pellets. Dried pellets, however, remained longer on the ground after placement than did the fresh ones. Dried pellets apparently absorb whatever moisture is available and

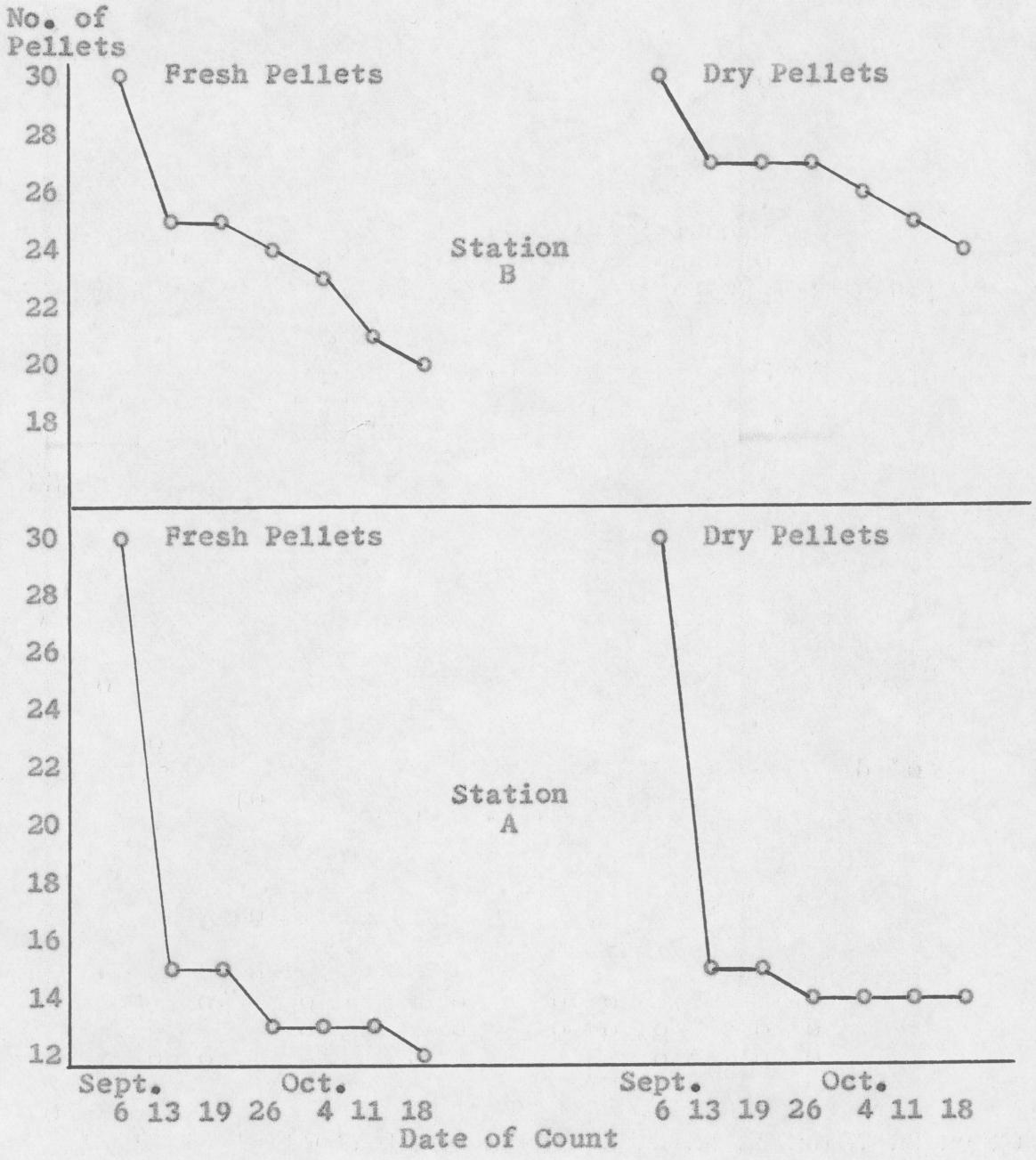

Figure 6. Pellet durability studies, comparison of dry and fresh pellets when placed under similar conditions, September and October, 1960, Camp Pickett, Va.

return to the state of fresh pellets. Several rainfalls occured between the day the pellets were first put out and the day they were first counted. However, it was noted that pellets placed in wooded areas disappeared more rapidly and more completely than did the pellets located in the open field. The reason for the slower loss of pellets in the open areas can be attributed to the lower humidity found in open areas while in wooded areas the humidity is generally higher for longer periods of time.

The investigator also tried to determine if the micro-environmental conditions, in which pellets were dropped, had any influence on their persistence. Fresh pellets were placed in artificial conditions comparable to various types of natural conditions in which rabbits might drop pellets and where pellet counts might be carried out. Examples of the conditions in which pellets were placed were as follows: pellets placed on wooden board (Plot 1), pellets placed on bare ground (Plot 2), pellets placed on bare ground with vegetative covering (Plot 3), pellets placed on bare ground with pine limb covering (Plot 4), pellets placed on vegetative mat with no covering (Plot 5), pellets placed on vegetative mat with vegetative covering (Plot 6) and pellets placed on vegetative mat with pine limb covering (Plot 7). Seventy

fresh pellets were used in this study. The weekly tallies of these pellets appear in Figure 7.

No loss occured of the pellets placed on the wooden board and no visible decomposition was noted.

The pellets placed on bare ground, with and without any type of covering, resulted in complete loss of all pellets except those that were placed in Station B - Plot 4. Very little loss was experienced by this plot and no definite explanation for this persistence could be found except for the possibility of little earthworm activity in that particular area.

The fate of pellets placed on vegetative mats varied considerably between plots and the two stations. Pellets placed on vegetative mats resulted in a lower loss except for the pellets in Station A - Plot 7, where complete loss occured the first week. No definite explanation could be found except for the fact that a great deal of earthworm activity was observed in this particular area.

Earthworm activity was the primary cause of all pellet losses. Conditions where humidity remained high seemed to encourage their activity and also permit pellets to remain moist and desirable. This seemed to be the reason why pellets in wooded areas and areas supporting some vegetation disappeared more rapidly than those in open areas. In open areas earthworm activity is limited

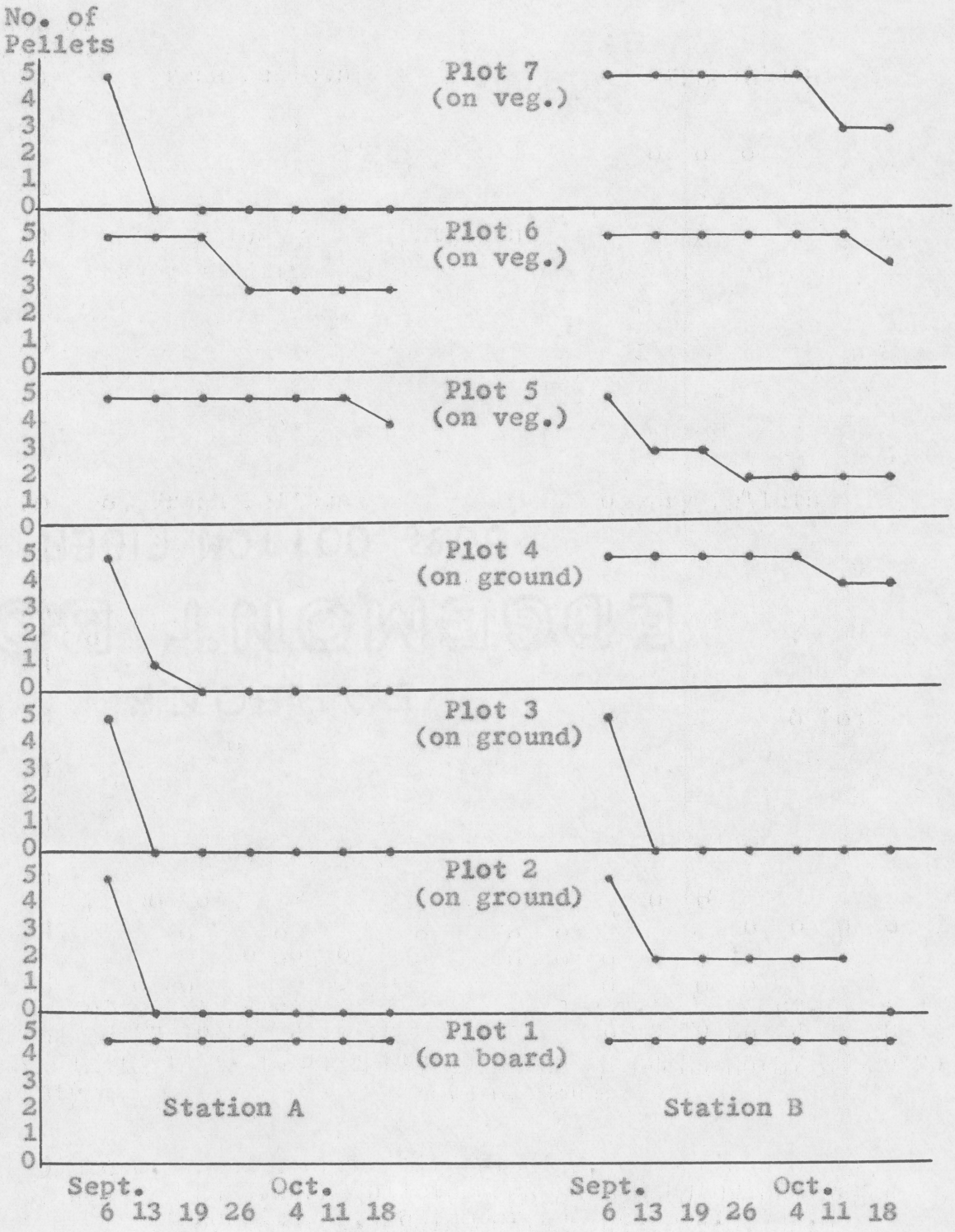

Figure 7. Pellet durability studies, comparison of pellets placed under different environmental conditions, Sept. and Oct., 1960, Camp Pickett, Va.

by the available moisture and pellets rapidly become desiccated and remain desiccated until a rainfall provides moisture.

Ants may be responsible for some pellet losses but the amount of loss was not determined.

Decomposition played no important role in pellet durability during this part of the study.

Late Fall-Winter-Early Spring

All the following pellet studies were made using bare ground plots. Although previous studies revealed that a difference in persistence did occur between pellets dropped on bare ground and those dropped in vegetation, it was felt that sufficient information could be derived from using only the bare ground plots.

The purpose of the following studies was not to determine the amount of pellet loss contributed by various environmental factors, only to determine the degree of pellet losses occuring during the late fall, winter and early spring and attempt to find what gross environmental factors contribute to that loss.

An attempt was made to count the pellets once a week but snow, frost and heavy rains made many of these counts incomplete or inaccurate, therefore, only the counts made

of all plots in both stations on the same day were recorded. Daily counts would have provided the exact amount of loss caused by various factors but on many occasions it would have required the disturbance of some of the plots.

Only pellets similar in size, shape and color to the ones in the study plots were counted, all others were considered foreign pellets and were removed from the area. Many of these foreign pellets were found in the areas surrounding the plots but only one was ever found in a study plot. Pellets belonging within the plot and found near the perimeter were returned to the plot and included in the talley.

The final phase of this pellet study ran from October 16 until April 30. A total of 360 pellets were used in this study and were placed under different enviromental conditions. The following is the number of pellets put out by months; 110 in October, 82 in November, 64 in December, 50 in January, 54 in February, 0 in March and 0 in April. The pellet counts by plots for the study appear in Table 14, for Station A in the pine woods, and Table 15, for Station B in the open field. Plot 2 in both stations contained pellets left over from the previous study, so were considered to be pellets dropped in September.

Table 14. Pellet durability study; pellets placed under pine canopy, over six month period, October, 1960 to April, 1961, Camp Pickett, Va.

Date	Pellet counts by plot Plot Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Oct. 18	20	10												
21	14	9	20											
23	15	10	18											
24	15	10	18											
27	15	10	18											
31	16	10	18	5										
Nov. 3	15	10	16	0										
5	14	9	17	0										
7					13									
8	15	9	17	0	13	10								
12	15	9	18	1	13	10								
14	15	9	18	1	12	9	9							
16	15	9	18	1	12	9	9	9						
19	14	9	18	1	13	9	8	8						
28	13	8	18	1	11	8	5	8						
Dec. 1	17	9	18	1	13	10	5	0						
5	17	9	18	1	13	10	5	0						
7	17	9	18	1	13	10	5	0	16					
10										16				
Jan. 4	12	0	10	0	12	0	0	0	6	13				
7	13	0	10	0	12	0	0	0	6	13				
14	13	1	12	1	13	5	1	0	15	14				
19											5			
21												20		
Feb. 5													25	
11														12
14	14	1	12	1	13	4	1	0	16	0	5	20	25	12
27	15	5	11	1	13	1	1	0	13	0	4	18	23	12
Mar. 4	15	6	11	1	13	5	1	0	15	0	3	19	22	11
14	13	6	13	1	13	3	1	0	15	0	3	20	21	11
21	13	5	10	0	11	1	2	0	15	0	0	18	20	12
25	14	4	10	0	12	1	0	0	15	0	3	19	20	10
Apr. 3	11	7	8	0	12	1	1	0	12	0	4	18	20	12
24	11	7	8	0	13	1	1	0	12	0	4	18	19	12

Table 15. Pellet durability study; pellets placed in open field, over six month period, October, 1960 to April, 1961, Camp Pickett, Va.

Date	Pellet counts by plot Plot Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Oct. 18	20	10												
21	19	10	20											
23	20	10	20											
24	15	9	20											
27	16	9	19											
31	16	9	19	5										
Nov. 3	19	9	20	5										
5	20	9	19	5										
7					13									
8	19	7	16	5	12	10								
12	20	8	14	5	13	10								
14	19	7	15	5	13	10	9							
16	18	8	16	5	13	10	9	9						
19	18	8	16	5	13	9	8	9						
28	19	8	17	5	12	9	7	9						
Dec. 1	17	8	16	4	13	10	7	7						
5	16	7	15	3	13	10	7	7						
7	16	7	15	3	13	10	7	7	16					
10										16				
Jan. 4	13	4	0	0	0	0	4	5	16	0				
7	13	5	0	0	0	0	5	5	16	0				
14	16	7	0	2	7	9	7	6	16	3				
19											5			
21												20		
Feb. 5													25	
11														12
14	16	6	0	0	7	9	7	6	16	3	2	20	25	12
27	7	4	0	0	0	1	7	5	12	3	4	14	23	10
Mar. 4	8	4	0	0	0	2	7	5	12	4	0	16	25	10
14	9	3	0	0	0	2	7	5	12	3	0	16	21	10
21	15	0	0	0	0	0	7	4	13	2	3	17	23	10
25	15	0	0	0	0	0	7	3	12	2	3	17	23	10
Apr. 3	14	0	3	1	0	0	6	4	12	2	3	17	24	10
24	13	0	2	1	0	0	6	4	11	1	3	17	24	10

During the late fall, winter and early spring it was difficult to attribute much of the pellet losses to any particular cause. By the end of October, earthworm activity had ceased and other factors became responsible for pellet losses. As a check on the possible causes of pellet losses, the pellets were arranged in some regular pattern in every plot. Each count revealed that the pellets were slightly to completely disarranged. Most of the pellets were moved from the center of the plots to the edge and even into the vegetation surrounding the plots. This movement of pellets seemed to be the reason for most of the pellet losses. Further observations revealed that not only were pellets taken from the plots but in some cases they were even returned. The investigator suspected wind, rain and possibly animal activity to be responsible for pellet count fluctuations and for the mechanical removal of the pellets from the study plot area.

With the advent of freezing weather, another factor was suspected of causing pellet count fluctuations and pellet losses; this was frost-heave. Observations revealed that the freezing and the thawing of the soil would bury pellets and/or uncover buried ones.

The first freezing date recorded during this investi-

gation was November 6, and the last was March 18. Between December 10 and January 4, some abnormally high and low temperatures were recorded which may have been responsible for the greater loss of pellets and between January 7 and January 14; abnormally high temperatures were considered responsible for the uncovering of many pellets lost during previous periods. Very little rain occured during these periods, so rain could not be considered an important factor in these losses and returns.

Snowfalls covering the ground occured January 26 and February 4.

Pellets in Plots 5, 10, 11, 12 and 14 were established when the ground was in a frost-heaved condition and Plot 13 was established when the ground was covered with snow. The purpose of these plots was to compare the persistence of pellets dropped in these conditions with those dropped under more normal conditions. There was no difference in persistence noticed.

It seemed that all environmental factors effecting the persistence of rabbit pellets played both a positive and a negative role with an overall gradual decrease in the number of pellets dropped in an area.

Deterioration of the pellets was negligible and not a factor during this part of the study. Rapid deterio-

ration of pellets was noticed in Plots 13 and 14 soon after the plots were established. This breakdown could be attributed only to high temperatures and composition of the pellets because the other pellets experienced no visible signs of deterioration. Although deterioration was rapid during the first week, it soon slackened and never reached completion and the pellets remained recognizable.

Pellets From Caged Rabbits

Several wild-trapped cottontails were held in cages from two to three days in order to obtain some idea of the number of pellets dropped by a rabbit during a 24-hour period. Although these rabbits were provided with sufficient amounts of food material, many of them refused to defecate. One rabbit in particular was held for three days and utilized most of the food provided but did not leave a single pellet. Coprophagy might have been an explanation for this peculiarity. Three rabbits did produce pellets during the first 24-hours. The number of pellets produced by each of these rabbits was 96, 109, and 120 respectively.

The rabbits held in captivity were fed different food materials such as natural greens, lettuce, cabbage, apples, celery and woody materials such as apple prunings and sumac.

Pellets produced on the diet of woody materials were lighter and grainy in appearance as compared to the dark homogeneous appearance of the pellets produced on the other diets. This difference was also noted in the field. Pellets found in grassy areas and areas containing some green herbaceous vegetation were darker and homogeneous while those found on the snow, when greens were not available, were lighter in color and grainy in appearance.

The pellets produced off a rough woody diet seemed to deteriorate more rapidly than those produced on a green diet.

Conclusions

This study revealed considerable variation in the durability or "persistability" of rabbit pellets from season to season. Because of this variation and the difficulty in aging rabbit pellets, it is felt, that only very unreliable data can be derived from using pellet counts in cottontail rabbit management. This unreliability can only be rectified by considerable refinement of the technique.

RABBIT MANAGEMENT DISCUSSION AND RECOMMENDATIONS

During this study the investigator experienced one of the most complex of all problems facing cottontail rabbit management; this is the cyclic tendency of the rabbit. Trippensee (1948:387) states, that fluctuations in numbers of an animal population in any locality that reaches such proportions as to attract attention because of excessive numbers followed by a noticeable scarcity of the same species is said to be cyclic. "The rabbit is generally regarded as being cyclic but it is probable that inasmuch as the rabbit has a high breeding potential it could be irruptive during a very favorable breeding season." (MacNamara, 1949:15).

The sharp fluctuations in cottontail numbers from season to season and from year to year are not clearly understood at this time and until we obtain more information as to the causes and effects, a control of the ups and downs in a rabbit population is impossible.

Many theories have been proposed as to the probable causes of population cycles but none of them presents a complete answer. "Cycles of abundance in various species,

the mechanism of which is still far from being cleared up, would seem, therefore, to be more and more clearly the result of multiple and complex phenomena, giving expression on the quantitative plane to interactions between population and environment." (Bourlière, 1956:319).

A general recommendation for managing a cyclic specie has been made by Trippensee (1948:395): "The cycle reduces the entire population, but in the case of the ruffed grouse, varying hare, Hungarian partridge, sharp-tail, and cottontail the reduction is mainly a decrease in the current crop of young animals. The population is still further reduced by hunting, which probably removes a considerable proportion of the individuals that otherwise survive and serve as the breeding reserve. If hunting of these cyclic species could be entirely eliminated during the years of low numbers, it would probably accelerate the "build-up." Likewise, the improvement in amount and quality of food and the reduction of predatory and other losses also should assist a low wildlife population in making a more rapid recovery.

It should be remembered that such practices may not influence the length of the cycle or in any way reduce the extent to which the population curve declines. It should, however, make the curve of recovery steeper and perhaps

thereby increase the number of shootable individuals during the period of recovery."

This investigator recommends that a study of the recovery of this rabbit population be initiated because only after such a study can management practices during population lows be recommended.

General Management

The only practicle answer to cottontail rabbit management is the improvement of food and cover conditions both naturally and artificially. Habitat manipulation and supplemental food and cover plantings have helped establish and increase rabbit populations without the expence of predator control or restocking efforts. It must be remembered, however, that management of the cottontail is dependent on the situation; food and cover should be provided when and where it is needed and it must not conflict with the present usage of the land.

No attempt has been made to present any detailed discussion of rabbit management because such a discussion has been handled admirably by Fortenbery (1959:43-50) and Krug (1960:72-81).

Recommendations

1. Continued research to determine the causes of population cycles.

2. Further evaluation of cottontail management techniques and procedures and the development of better methods that will increase our understanding of the species.

3. A standardization of management procedures which would make possible the pooling of research information from data cumulated by all investigators.

SUMMARY

Seasonal population fluctuations of the cottontail rabbit were measured by evening roadside counts and trapping. During the latter part of July, roadside counts showed a rather marked and drastic decline in the number of rabbits. This decline was forecast by the low number of rabbits seen in the field and the low number of rabbits the investigator was able to trap. Further confirmation of this decline came during the first week of the 1960-61 hunting season. A 42 per cent decrease in the number of rabbits killed occured in spite of a 10 per cent increase in hunting pressure. By the end of the hunting season a 60 per cent decrease in the rabbit harvest was recorded.

Trapping and tagging along one portion of the roadside route was used to check the population decline. Trapping began before the decline and continued throughout the study. It was noted, that very few rabbits from previous trapping periods were captured in subsequent trapping periods. A continuous and rapid population turnover plus the severity of the decline was suspected of influencing the trapping results.

Rabbit utilization of three land-cultural treatments

extant on Camp Pickett was measured by live-trapping. It was found that during the months of November and December, a mowed roadside area was utilized more than the other two cultural treatments, annual mix was second and clover-small grain was next. The control areas showed utilization similar to clover-small grain.

Trap-retrap formulae were evaluated by using data obtained from trapping an enclosed population and comparing the population estimates arrived at with the known number of rabbits. With a small population and the procedures used, it was found that the Krumholz formula was most accurate in the determination of the actual population but the Schumacher and Eschmeyer gave a more constant estimate.

The study of natural and artificial cover was discontinued because of the shortage of rabbits in the study areas. The investigator was of the opinion that the shortage would make any type of proposed evaluation impossible.

A record was maintained of the ectoparasites infesting the rabbits encountered on the study area. Forty per cent of the 175 rabbits handled showed evidence of parasitism by bot fly larvae, 42 per cent were parasitized by fleas and 95 per cent were parasitized by ticks. The investigator

was capable of hatching seven adult bot flies. All adult flies were sent to the Entomology Department at V. P. I. for identification and inclusion into the V. P. I. collection.

No examinations were made for endoparasites.

The only diseases encountered on the study area were Shope's Fibroma and mange. Three of the rabbits handled showed the gross lesion of the fibroma. Two of the animals handled showed the affliction of mange.

Ticks and rabbits were sent to the Department of Rickettsial Diseases, Walter Reed Army Institute of Research, Washington, D. C. Two of the three rabbits sent in gave a positive titer for spotted fever antibodies. No labratory rabbits were used in the tests but previous studies of the disease have shown that the spotted fever infection in rabbits is not fatal.

About 50 fox scats were examined in the field between July 1 and November 30. Gross examination of these scats was made and in only one could the investigator identify rabbit remains. All the scats examined contained either the seeds of persimon or blackberries.

A record was kept of the number of rabbits found dead on the highways and roads in and around Camp Pickett. The number of dead rabbits per mile varied from month to month.

Pellet durability studies revealed that loss of pellets during the summer and fall months was primarily due to earthworms and decomposition was negligible. During the winter and spring, all environmental factors, especially wind, rain and frost-heave, effected the persistence of rabbit pellets and they played both a positive and negative role with an overall gradual decrease in the number of pellets dropped in an area. The reliability of pellet counts as a technique in cottontail management is questioned.

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APPENDIX

Appendix Table 1. Rabbit harvest by season and month, Camp Pickett, Va., Nov., 1956 - Jan., 1961

Season	Number of rabbits harvested				Percent Increase
	November	December	January	Totals	
1956-57	195	401	256	852	
1957-58	503	745	656	1904	123.5
1958-59	1102	1085	676	2863	50.4
1959-60	1508	1032	934	3474	21.4
1960-61	562	339	489	1388	-60.1

Appendix Table 2. Hunter days by season and month Camp Pickett, Va., Nov., 1956 - Jan., 1961

Season	November	December	January	Totals
1956-57	1317	2362	900	4579
1957-58	1880	2324	755	4959
1958-59	2499	2660	1466	6625
1959-60	4012	4248	2238	10498
1960-61	2489	2512	1081	6082

Appendix Table 3. Total game killed, Camp Pickett, Va., 1960-61 hunting season by months

Month	Deer	Quail	Rabbit	Squirrel	Raccoon	Duck	Fox	Snipe
Nov.	75	695	562	394	12	17	3	8
Dec.	34	883	339	253	14	25	3	7
Jan.	7	843	489	146	1	5	1	0
Total	116	2421	1388	793	27	47	7	15

Appendix Table 4. Annual harvest by species, Camp Pickett, Va., 1956-57, 1957-58, 1958-59, 1959-60 and 1960-61 hunting seasons

Species	Year 1956-57	1957-58	1958-59	1959-60	1960-61
Deer[1]	66	44	117	152	116
Turkey[2]	23	30	3	19	**
Quail	802	789	1722	1936	2421
Rabbit	852	1904	2863	3474	1388
Squirrel	50	285	563	1815	793
Raccoon	9	27	15	24	27
Duck	158	146	157	67	47
Fox	6	13	5	15	7
Snipe	6	9	10	18	15

[1]Antlered only
[2]Males only
**Spring gobbler season

Appendix Table 5. Foxes trapped, Camp Pickett, Va., 1957-58-59-60-61

Season	Species	Male	Female	Total	
Spring-1957	Red	--	--	---	
	Gray	--	--	---	
Total		--	--	67	
Fall-1957	Red	19	14	33	
	Gray	14	10	24	
Total		33	24	57	
1957-Total					124
Spring-1958	Red	18	31	49	
	Gray	27	22	49	
Total		45	53	98	
Fall-1958	Red	4	6	10	
	Gray	4	10	14	
Total		8	16	24	
1958-Total					123
Spring-1959	Red	--	--	11	
	Gray	--	--	10	
Total		--	--	28*	
Fall-1959	Red	--	--	--	
	Gray	--	--	--	
Total		--	--	45	
1959-Total					73
Spring-1960				--	
Fall-1960	Red	14	11	25	
	Gray	28	20	48	
Total		42	31	73	
1960-Total					73
Spring-1961	Red	0	1	1	
	Gray	0	0	0	
Total		0	1	1	

* Seven were trapped and no data was kept as to sex or age.

ABSTRACT

of

EVALUATION OF SOME COTTONTAIL RABBIT MANAGEMENT PROCEDURES AS APPLIED IN PIEDMONT VIRGINIA

by

Paul Peter Woronecki

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ABSTRACT

The primary aim of this investigation was to evaluate various rabbit management techniques as applied in Piedmont, Virginia. This study was conducted at Camp Pickett, a deactivated military reservation managed cooperatively for game by the U. S. Second Army and the Virginia Commission of Game and Inland Fisheries.

Seasonal population fluctuations of the cottontail rabbit were measured by roadside counts and trapping. During the latter part of July, roadside counts showed a rather marked and drastic decline in the number of rabbits. This decline was confirmed by the low number of rabbits seen in the field and by the low number of rabbits the investigator was able to trap. Further confirmation of this decline came during the first week of the hunting season. Comparing the first weeks of the 1959-60 and the 1960-61 seasons, 376 less rabbits were killed during the 1960-61 season, which was 42 per cent of the 1959-60 kill. This occured in spite of a 10 per cent increase in hunting pressure. By the end of the hunting season a 60 per cent decrease in the rabbit harvest was recorded.

Rabbit utilization of three land-cultural treatments extant on Camp Pickett was measured by live-trapping. The treatments measured were annual mix, clover-small grain

and mowing. By basing utilization on the number of rabbits captured, it was found that during the months of November and December, a mowed roadside area was utilized more than the other two cultural treatments, annual mix was second and clover-small grain was next. The control areas showed a degree of utilization similar to clover-small grain.

Trap-retrap formulae evaluation was made by using data obtained from trapping an enclosed population. By comparing the population estimates with the known population, the Krumholz formula proned to be the most accurate in determining the actual population but the Schumacher and Eschmeyer formula gave a more constant estimate. With the procedures used it was difficult to reach an accurate population estimate by using the Lincoln Index.

Evaluation of natural and artificial cover was attempted but was discontinued because of the scarcity of rabbits on the study area. It was the investigator's opinion, that the shortage of rabbits would make any type of proposed evaluation impossible.

A record was maintained of the ectoparasites infesting the rabbits encountered on the study area. Forty per cent of the rabbits handled showed evidence of parasitism by bot fly larvae, 42 per cent were parasitized by fleas and 95 per cent were parasitized by ticks.

The only diseases encountered on the area were Shope's Fibroma and mange.

Pellet durability studies revealed that loss of pellets during the summer months was primarily due to earthworms and decomposition was negligible. Decomposition was governed by air and ground moisture. Dessicated pellets seem to last indefinitely. Deterioration of pellets slackened during cold weather and loss of pellets was caused by many environmental factors.