THE ABERT SQUIRREL (*SCIURUS ABERTI ABERTI*) AND ITS RELATIONSHIP TO THE FORESTS OF ARIZONA

by

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INTRODUCTION

The Status of the Squirrel

The Abert squirrel (*Sciurus aberti aberti*) is often described as one of the most beautiful squirrels in North America. Since the animal was first described by Woodhouse in 1853 it has held the fascination of the zoologist, the naturalist, and the tourist.

Naturalists who treked through the Southwest in the early days valued this animal for meat, for sport, and for esthetical reasons. Many have continued to find enjoyment in these qualities through the years.

It is surprising, therefore, that despite the great interest shown in this animal, few facts concerning its life history and ecology were recorded. The early naturalists added much to our knowledge of many animals in the Southwest, but their accounts of individual species were brief.

There has already been published a great deal of information about the squirrels of the eastern United States. Their popularity as game species has undoubtedly stimulated inquiring research. Although the states in the Southwest have an abundance of game animals, the human population is low and for this reason intensive research and management of squirrels has not been undertaken.

Only three people have worked with the Abert squirrel in recent years. Leon Lawson, a biologist for the Arizona Game and Fish Department, and Albert Trowbridge, a Fish and Wildlife Service biologist, began a trapping and transplanting project in 1941. Their accomplishments and observations are recorded in a report submitted to the Fish and Wildlife Service in 1942. O.N. Arrington of the Arizona Game and Fish Department carried on this project in 1943, 1944 and 1945. The work was instigated largely by G.A. Pearson of the Fort Valley Experiment Station in Flagstaff, Arizona who felt the squirrels were influencing costly studies on the growth and reproduction of the ponderosa pine. These workers were all mainly concerned with the problem in which they were involved and were not able to gather extensive data on the life history of the squirrel.

The squirrel hunting season has been alternately opened and closed by the game departments of the states where this squirrel occurs. In recent years the tendency has been to prohibit the shooting of the species because of low populations. The squirrel season has been opened for approximately two weeks in Arizona each fall during recent years, but the squirrel is not hunted in Colorado, New Mexico, and Utah.

The need is apparent for more information on the general life history of the squirrel. I feel that the other states have refused to open the season on the squirrel as a result of inadequate knowledge of the animal.

The Present Study

The author resided at the Fort Valley Experiment Station nine miles northwest of Flagstaff, Arizona from October, 1953 until September, 1954. This period was spent in full-time investigation of the habits of the squirrel.

Three study areas of 80 acres each were established in the Fort Valley Experiment Forest. Trapping and observations were made at all seasons of the year in these areas. Investigations of a more limited scope were made throughout the Coconino National Forest.

The period of study occurred during a low population of squirrels. It was deemed natural, therefore, to express the results of the study in general terms, giving a background for future work in such a way as to perhaps prevent future unproductive work.

Scientific names of the birds mentioned in this paper were taken from Peterson (1941). The scientific names of the mammals were taken from Burt and Grossenheider (1952). Kearney and Peebles (1951) was used as a source for the scientific names of trees mentioned in this paper.

Figure 1. Abert Squirrel Habitat in Summer.
Photo by C.R. Hungerford.

Figure 2. Abert Squirrel Habitat in Winter.
Photo by C.R. Hungerford.

CHARACTERISTICS OF THE SQUIRREL

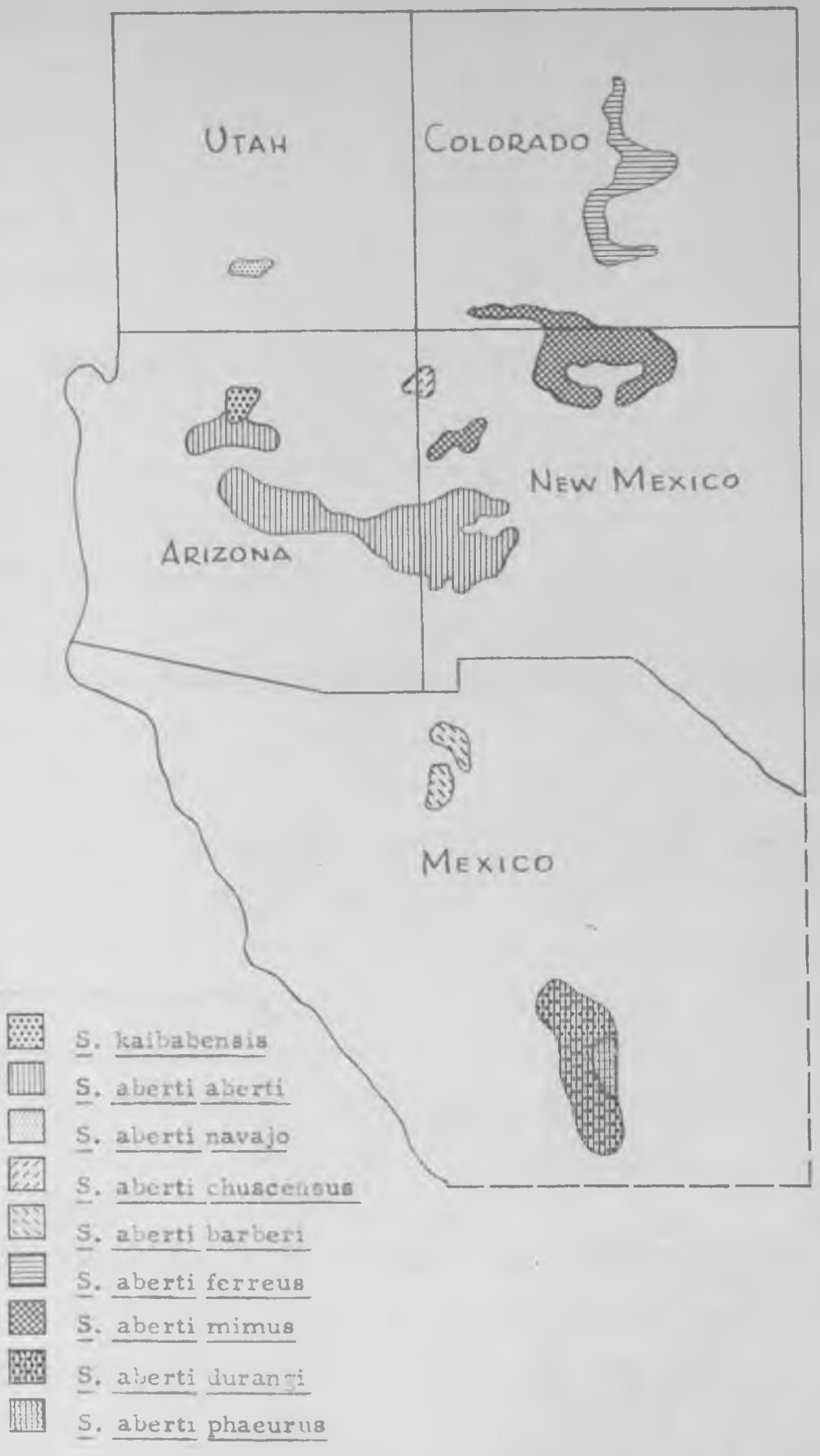
Range of the Squirrel

Original Distribution: The Abert squirrel belongs to the subgenus Otosciurus (Nelson, 1918) in which two species have been described. One species, Sciurus aberti, has been divided into eight subspecies; while the other, Sciurus kaibabensis or the Kaibab squirrel, is monotypic (Miller and Kellogg, 1955). Squirrels of this subgenus are found in Arizona, Colorado, New Mexico, and Utah in the United States, and in Chihuahua and Durango in Mexico. Figure 3 shows the range of the nine named forms. The map is taken in part from McKee (1941) and from a description of the range of S. aberti navajo by Durrant and Kelson (1947).

The squirrel is confined to the southern part of the Rocky Mountains and the Colorado Plateau in the United States. It is also found in the Sierra Madre Mountains in Mexico. It is found in very close association with the cool, dry forests of the interior ponderosa pine (Pinus ponderosa) and hardly ever wanders far from the pine (Bailey, 1931; Cary, 1911; Figs. 1 and 2).

They do venture up into the fir and down into the pinyon-juniper on occasion. The elevational distribution of the squirrel varies with latitude. In Mexico they are found as high as 11,000 feet while in Colorado they may be seen as low

Figure 3. Range of the Nine Forms of the Aberti Complex.



as 4,500 feet (Warren, 1910).

In Arizona the Abert squirrel (S. aberti abèrti) was found originally in the isolated stand of ponderosa pine on the south rim of the Grand Canyon, and in the pine which extends from the San Francisco Mountains near Flagstaff across the Mogollon Plateau southeastwardly into New Mexico.

Transplants: In 1941 a transplanting program was ininiated in Arizona by the Arizona Game and Fish Department and the U.S. Fish and Wildlife Service. This program was continued in 1943, 1944 and 1945 by the Arizona Game and Fish Department. The following areas were stocked with Abert squirrels during this period: the Pinal Mountains south of Globe, the Granite Basin Recreational Area in the Bradshaw Mountains northwest of Prescott, Horsethief Recreational Area six miles west of Crown King, the Santa Catalina Mountains near Tucson, the Hualpai Mountains south of Kingman, Mount Graham east of Tucson, and an area near Greer.

During the present study it was possible to examine only one of these release sites, the Santa Catalina Mountains. The squirrels were liberated near Winterhaven in 1941 and now are found over the Catalinas wherever ponderosa pine exists. This transplant, which consisted of 58 squirrels, was very successful.

These transplants have undoubtedly increased the hunting value of the squirrel by making this game animal more accessible to residents of southern Arizona.

Pelage

The Abert squirrel is the only North American squirrel which exhibits the full ear tufts throughout most of the year. In this way the group resembles the tree squirrels of northern Europe and Asia, S. vulgaris (McKee, 1941).

The tufts remain on the squirrel from early October until the following June. It is during only the months of July, August and September that most of the squirrels are without tufts. A few squirrels will maintain their tufts until late in July, and the young of the year have tufts present shortly after birth. Table 1 shows the variation in the length of the tufts during the months of the year. This information was gathered from collections and trapping.

The color of the pelage is also unique among the squirrels of North America. The body is a grizzled-grey dorsally with a variable rusty band along the middle of the back. A thin black line is present laterally, separating the dorsal fur from the white ventral fur. The tail is greyish dorsally and white underneath.

Two molts occur each year. Beginning in late spring, spots of new hair were found in the coats of the squirrels. The molt was first evidenced by a loss of hair under the forelegs. The molt of the ventral fur was usually almost complete before the dorsal molt began. During the spring molt the squirrels had a ragged appearance. The long, dull, winter pelage was in sharp contrast to the short, brilliant,

Table 1. Average Length, in Millimeters, of the Ear Tufts on the Abert Squirrel during 1954

Month	Length	No. of squirrels measured	Month	Length	No. of squirrels measured
Jan.	35	7	July	5	4
Feb.	40	6	Aug.	0	8
March	40	4	Sept.	5	2
April	32	8	Oct.	25	6
May	25	12	Nov.	30	3
June	20	6	Dec.	32	8

summer fur. Figure 4 shows the advance of the spring molt over the body of the squirrel.

By the end of July most of the squirrels had completed the spring molt, including the complete loss of the ear tufts. The pelage at this time was short, and the general coloring was much lighter than during the winter. The grizzled grey of the dorsal pelage contained many more white hairs, and the ventral pelage was a pure white. The rusty band down the middle of the back was larger in the summer pelage. The fall molt was less conspicuous. A gradual replacement of the hairs took place, with additional hairs coming in to form the thick winter pelage.

In the young there was a continuous development of the winter pelage from the time they first obtain their fur. For

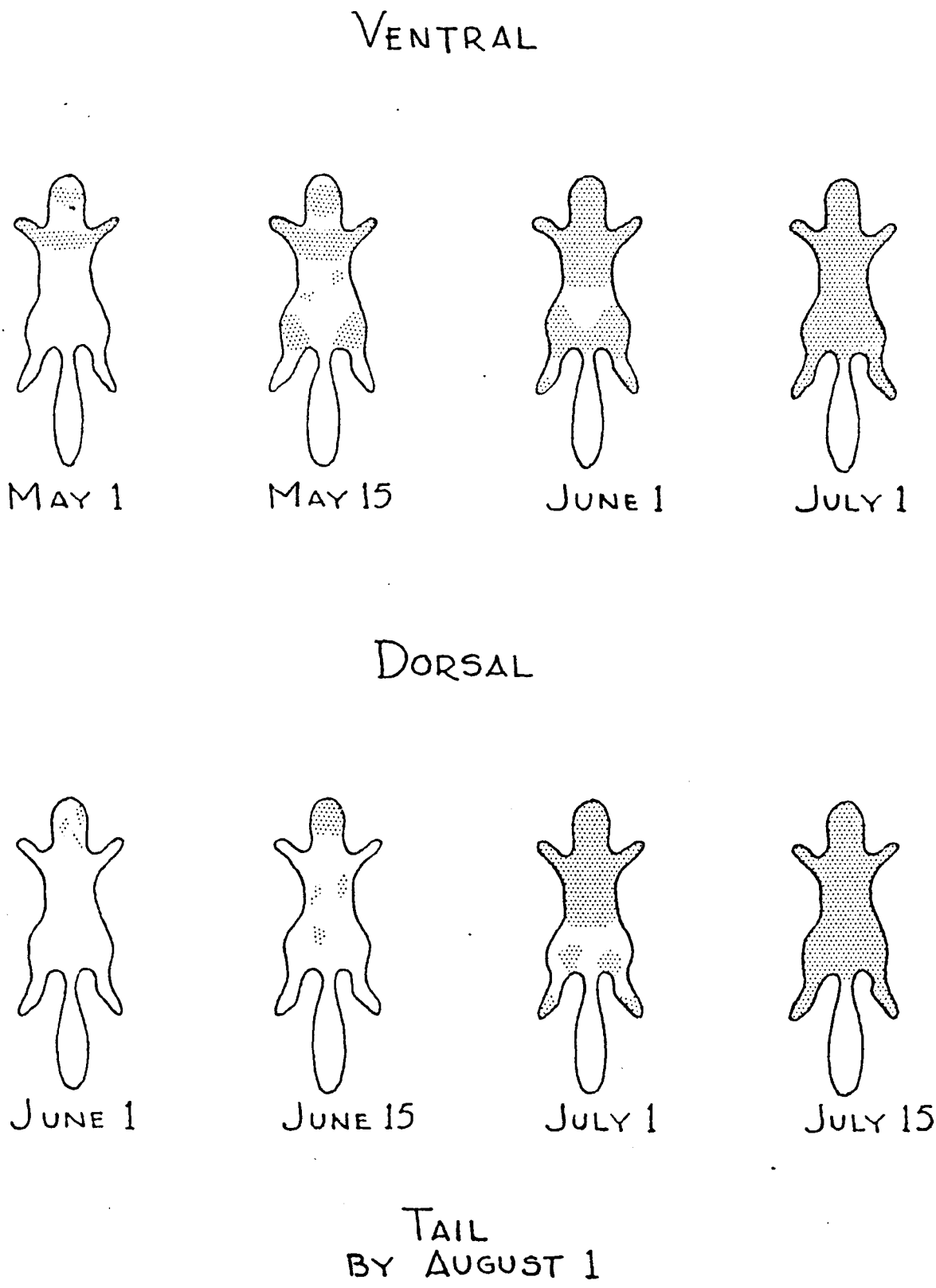


Figure 4. Progress of the Spring Molt over the Body of the Abert Squirrel.

this reason the young completed their winter pelage several weeks ahead of the adults. For a period of three weeks, therefore, the young of the year exhibited the full-tufted ears while the tufts in the adults were short and thin. The young could be distinguished from the adults by the length and fullness of their tufts during this period.

Melanistic specimens have been reported frequently, usually from the northern part of the range of the species (Cahalane, 1947). Cary (1911) refers to the squirrel as "... the most striking example of extreme melanism among mammals." He mentions 24 specimens, of which 19 showed strong melanistic characters. No melanistic squirrels were found during the term of this study.

Body Size

The weights of 300 squirrels obtained by different workers are given in Table 2. Only squirrels weighed from March to October of any year are included in the summary. Thus the weights are for only mature, full-grown animals.

The heaviest squirrel examined in this study was shot by L.K. Sowls in May, 1952. It was a female which weighed 824 grams. The lightest squirrel, a male, was collected by the author in June, 1954 and weighed 488 grams.

Not enough squirrels were collected during this study to depict weight changes throughout the year. The other investigators worked for short periods, usually during the

Table 2. Weights, in Grams, of Mature Abert Squirrels as Recorded by Various Investigators

Investigator	Year	Range of weights		Average weight	
		Lightest	Heaviest	Male	Female
Arrington	1943	562#	811#	609 (40)*	622 (34)
Arrington	1944	499#	796#	631 (89)	611 (46)
Arrington	1945	655#	811#	718 (19)	674 (15)
Sowls	1952	595	824	653 (11)	720 (16)
Keith	1954	488	748	620 (23)	632 (7)
		Total average		635	638

#Converted to grams by Keith
*Number of squirrels weighed

summer months.

Measurements of 98 squirrels taken during this study are given in Table 3.

Table 3. Measurements, in Millimeters, of Mature Abert Squirrels, with Range and Average

Investigator	Sex of squirrels	Measurements				No. in sample
		Total Length	Tail	Hind foot	Ear	
Sowls	Females	494	226	69	35	9
	Males	486	211	70	36	9
Keith	Females	476	215	71	44	9
	Males	476	204	69	44	22
AVERAGE	Females	485	220	70	39	18
	Males	479	206	70	41	31
RANGE	Females	451	203	65	32	
			to			
		512	252	77	49	
	Males	450	185	65	32	
			to			
		510	240	75	45	

FEEDING HABITS

Since the Abert squirrel is so closely associated with ponderosa pine, it is not surprising that they depend largely upon this tree for their food. They have developed feeding habits which enable them to use the tree as a food source during every season of the year.

The squirrel, in contrast to most animal species, is restricted to a climax vegetation and finds its best habitat in the older, undisturbed stands of ponderosa pine. The first requirement of any good tree squirrel habitat, regardless of the species, is the food supply (Layne, 1943; Allen, 1943).

Martin et al (1951:8) states, "There is no such thing as a constantly available food supply for wild creatures." Goldman (1928), however, in referring to the squirrel points out that the inner bark of the pine is a never-failing food source. It appears that both authors are correct to a certain extent when considering the Abert squirrel.

The inner bark of the pine is always available to the squirrels, but it appears that this food will not keep them in good condition over long periods. The squirrels are probably dependent upon the yearly seed crop of the pine to breed successfully and maintain good general condition. Caches of pine cones are not made, although some single

cones are buried in the fall (Bailey, 1913 and 1931; Cahalane, 1947; Goldman, 1928). The squirrels may be affected, therefore, by the yearly fluctuations in the cone crops of the pine. The food habits of the squirrel as determined by observations are given in Figure 5.

Seed of Ponderosa Pine

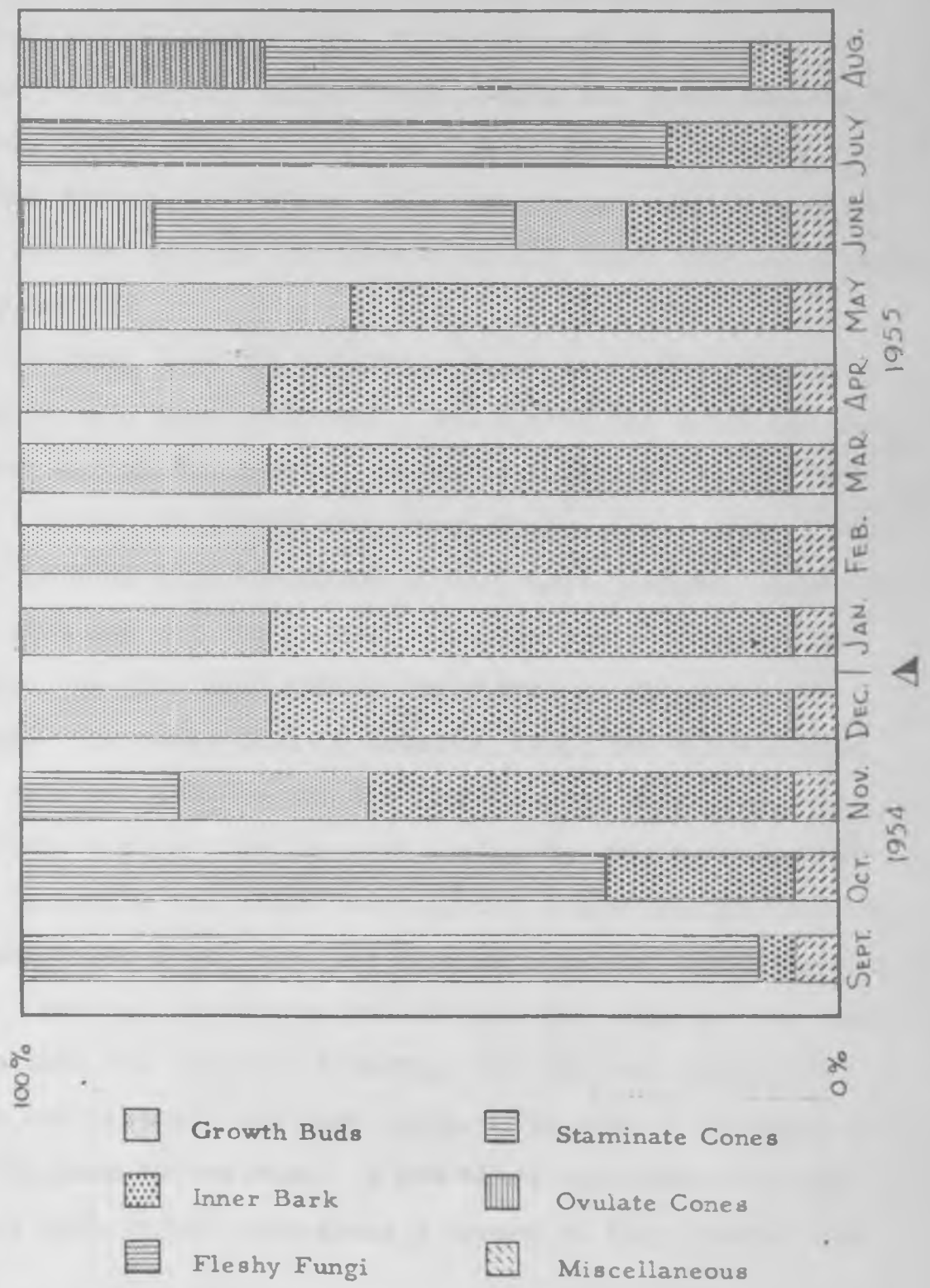
The seed of ponderosa pine is undoubtedly the highest quality food taken by the squirrels. Martin et al (1951) state that pine seed contains 25 percent protein and 25 percent fat.

Bailey (1913) lists the cones of Engelmann spruce (Picea Engelmanni) douglas fir (Pseudotsuga taxifolia), cork-bark fir (Abies lasiocarpa var. arizonica), and ponderosa pine as food sources. In the present study the squirrels were not observed to take seeds other than those of ponderosa pine. L.K. Sowls found acorns to be the main item in the stomach of squirrels collected in the spring of 1952.

Goldman (1928) points out that the squirrels must depend largely on other foods, for good seed years in ponderosa pine are not frequent. The cone crop varies from area to area and from year to year throughout the range of the pine. This erratic production of seed in variable areas is not completely understood, but it may be related to the erratic rainfall pattern present in the higher mountains of Arizona.

At the beginning of this study in September, 1953, the

Figure 5. Foods of the Abert Squirrel at Different Months of the Year.



squirrels were eating the near-mature cones of ponderosa pine. The cones opened, disseminating their seed, in late September and October. The squirrels continued to eat the seed of late maturing cones but spent more time on the ground foraging for single seeds. When the snows came in November, this source of food was unobtainable. On several occasions during the winter, holes were found where the squirrels had dug through the snow to obtain cones they had previously buried.

In June, 1954 the squirrels began to feed on the cones which at this time were small, but growth had begun and continued through the summer. Numerous "squirrel cones" less than 2 inches in length were found during June. The minute seeds at this time consisted of only soft tissues, since the seed coat had not yet formed. The squirrels continued to utilize the pine seed during the summer as the cones enlarged. The seeds fell in October, 1954; but since a good seed crop was present and the winter snows were late, the squirrels foraged for the seed during the month of December.

In eating the seeds the squirrel holds the cone between its two front feet, with the base of the cone towards its body. Several bracts are pulled from the cone and the seeds taken into the squirrel's mouth. The squirrel hulls the seeds and discards the seed coats. The cone is stripped from the tip back to the base. A few times squirrels were observed rolling the cone along a branch as they removed the

bracts. When feeding intensively, the squirrels average about one cone every 4 minutes and eat about 75 cones a day.

Inner Bark of Ponderosa Pine

The inner bark of the twigs of ponderosa pine is the most dependable source of food available to the squirrels. Martin et al (1951:12) state: "Inner bark, in spite of its unsavory appearance to us, is quite nutritious. In carbohydrate content it is at least the equivalent of leaves." This food, however, is taken only during periods when other foods are not present in sufficient quantity to sustain the squirrels. Goldman (1928) states that the inner bark is utilized at all seasons, but especially during the winter. Bailey (1931) and Cahalane (1947) both claim that the inner bark makes up the main part of the squirrel's diet. The inner bark of the pine is utilized in varying degrees from year to year, depending upon the fluctuating supply of other foods. If a good cone crop is present, it is doubtful that the squirrels will eat inner bark during the summer. Conversely, if a poor cone crop is present, the squirrels must supplement their diets during the summer with the inner bark. The growth buds of the pine are also a staple food, but they do not appear to be as palatable to the squirrels as the inner bark.

To secure the inner bark the squirrel clips a twig from a branch of the tree several inches behind the terminal pine needles. The group of needles is then clipped from the twig

Figure 6. Twigs Clipped from Ponderosa Pine in Obtaining the Inner Bark for Food.
Photo by C.R. Hungerford.

and a portion of the twig is retained. The squirrel then removes the rough outer bark from the twig with its teeth while rotating the "stick" in its front paws. The thin layer of inner bark is carefully scraped from the twig and eaten. The remainder of the twig is then dropped to the ground. These sticks are from one-half inch to 14 inches in length.

Only three years growth of needles remains on the ponderosa pine twigs during the winter. Since the section of the twig bearing the needles is usually discarded (Fig. 6), the squirrel is eating the inner bark from the four- and five-year-old portion of the twig. Many times, however, evidence under the pines showed that squirrels had stripped the needles from the one-, two- and three-year-old portion of the twig and had eaten the inner bark from these sections. This latter type of feeding is a habit with only certain individuals. The inner bark of the younger tissues is more succulent, but it does require more time to strip the needles from the twig.

The squirrels show a preference for certain trees in feeding on the inner bark (Goldman, 1928; Trowbridge, 1941). Some trees receive a much greater use than others which are comparable in form and vigor. These preferred trees do not have any anatomical characteristics by which they may be grouped. F.R. Herman of the Rocky Mountain Forest and Range Experiment Station took records of squirrel use on 300 acres of trees in the Coulter Ranch area in 1953 and 1954. His records indicate that there is no preference for any

particular size of tree. My observations also backed up these data. Twigs were found under saplings three inches in diameter and 15 feet tall, and under trees about 250 years old and 36 inches in diameter.

Martin et al (1951:11) state: "The nutritional needs of the animal may unconsciously make it select foods to meet its deficiencies." They go on to state (p. 12): "The nutritive value of plant food varies in different parts of the same plant and also from plant to plant." It seems logical that preference would lie in the variation in the nutritive value of the inner bark of the various trees. It was observed that many trees had only several twigs clipped, suggesting that their bark had been sampled by the squirrels and rejected. During the winter of 1953 and 1954, one tree had 1,256 twigs removed by the squirrels. During the following winter only 13 twigs were cut from this tree while an adjacent tree, with a completely different growth form, had 1,203 twigs removed. The first tree was definitely not as palatable during the second winter, indicating some physiological change in the tree.

In November, 1953 collections of the twigs which were cut by the squirrels on a 10-acre plot were begun. The collections were taken to define the period of use of this food source. Figure 7 presents the data obtained from these collections. Weekly collections were made under each of the 262 trees on this plot when snow cover permitted a complete

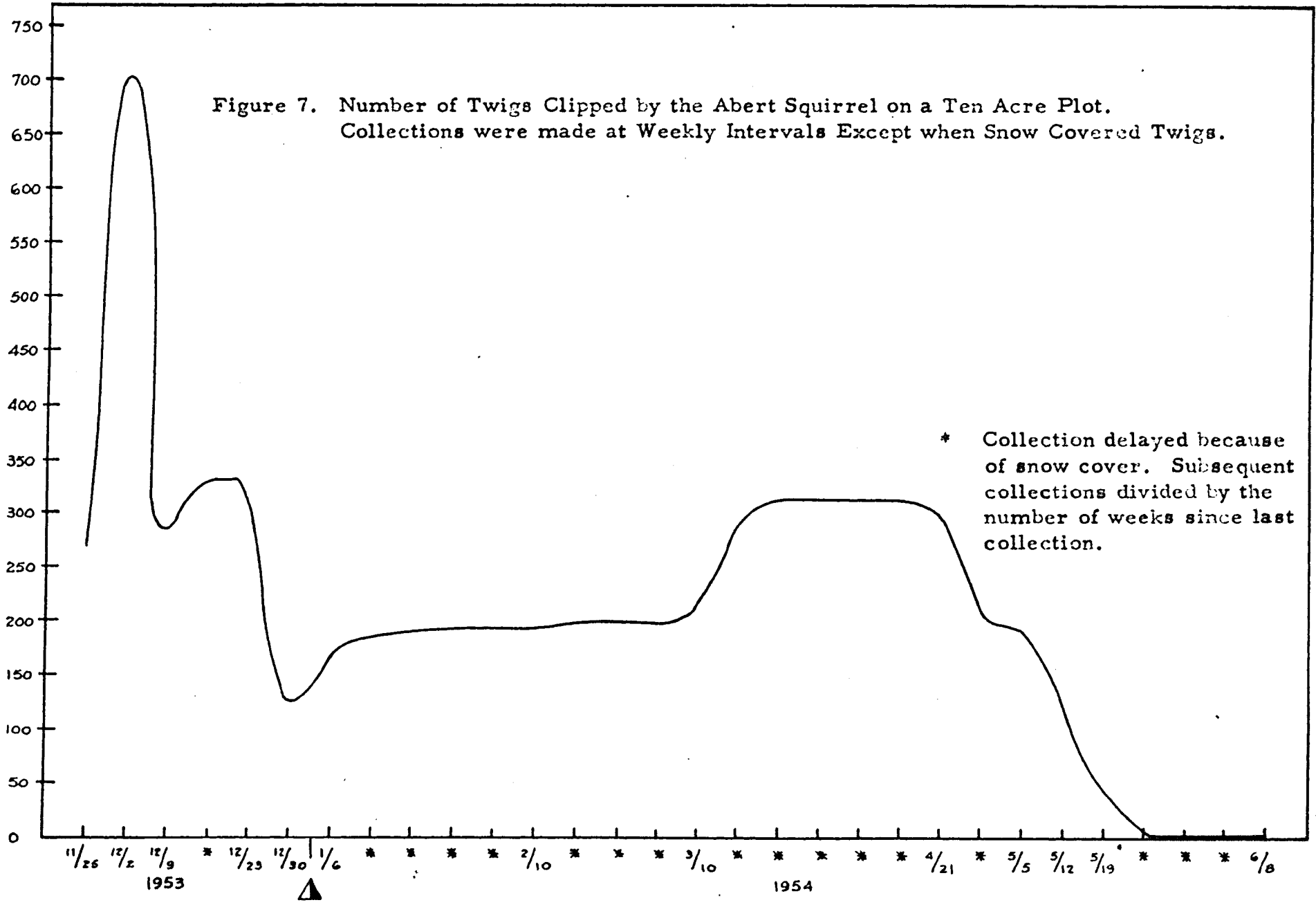


Figure 7. Number of Twigs Clipped by the Abert Squirrel on a Ten Acre Plot. Collections were made at Weekly Intervals Except when Snow Covered Twigs.

Figure 8. Limb on Ponderosa Pine Showing Results of Squirrel Bark Feeding.

collection. Several times snow fell between collections and the twigs were buried. If snow cover was present, the collection was delayed and then divided by the number of weeks since the last collection. The number of twigs varied considerably from week to week, indicating that the squirrels moved on and off the area and were not sedentary. When snow delayed the collections, it was shown that the squirrels used the area consistently throughout the winter.

In the fall of 1953 the squirrels began feeding on inner bark in October after the seeds had fallen from the cones. By late November they were depending almost entirely on the inner bark. In the spring of 1954 a decrease in the number of fresh twigs was evident in late May. At this time the squirrels began to feed on the ovulate and staminate cones of the pines.

From observation, it takes about three minutes for a squirrel to eat the inner bark from a twig. From counts made in fresh snow, the squirrels average about 45 twigs a day during the winter. This, of course, varied with the amount of other food eaten during a day's time and the period since the squirrels had last fed. A maximum of 95 twigs was eaten by one squirrel in a day's time.

Bark Feeding on Ponderosa Pine

The dwarf mistletoe (Arceuthobium vaginatum) which is common on ponderosa pine often occurs on the small branches

of the tree. The affected area of the pine is swollen and the inner bark is thick and succulent. In appearance this mass resembles the material obtained by the squirrels in feeding on the inner bark of the twigs. Squirrels were observed several times feeding on inner bark from limbs infected with mistletoe.

Many trees which appear to be damaged by porcupine will be found, upon close inspection, to have been utilized by the squirrel for this food (Fig. 8).

When feeding, the squirrel knocks the external parts of the mistletoe from the limb and removes a small portion of the outer bark. He then eats the succulent material from the bark. The mass formed by the tree in mistletoe infections remains with the outer bark when it is removed. The roots or "sinkers" of the mistletoe are also eaten with the inner bark. Coughlin (1938) refers to this type of feeding, but does not mention the presence of mistletoe infections. Several times in the present study it was hard to determine if the limb fed upon was infected with mistletoe; but in all cases where the tree was actually climbed and examined, mistletoe infections were present.

Barking of the pine takes place at all seasons of the year, but is most pronounced in the winter.

Growth Buds of Ponderosa Pine

The apical buds of the ponderosa pine twigs consist of

meristematic tissues which are quite succulent, rather sweet, and deep green in color. These tissues are protected by numerous small bracts which overlap to form a protective casing. The squirrels eat the entire bud after removing these coarse bracts.

While feeding on buds the squirrels work slowly and methodically over areas of the crown, pulling branches to them as they break off the buds.

Growth buds were eaten from January through May, 1954. Squirrels were observed to feed alternately on twigs and tips in the same tree, but often only tip remains were found under certain trees. Stomach analysis, observations, and feeding remains indicate that tips are not taken in as great a proportion as the twigs.

Because of the small size of the bracts dropped to the ground by squirrels in feeding, it was impossible to obtain an average daily figure for bud use. On several occasions squirrels were observed to take as many as 30 tips in an hour's time.

Staminate Cones of Ponderosa Pine

In early May the staminate cones form on the tips of the twigs of ponderosa pine. When newly formed and succulent, the entire staminate cone is eaten by the squirrel. As they dry in preparation for pollen dispersal, it appears the squirrels merely lick the surfaces of the cones to obtain the dry

pollen. At this time many squirrels are seen with yellow lips and whiskers, which shows that they have fed on the pollen. In early June the pollen began to disseminate.

This food source is undoubtedly of high quality, but is present for only a short period each spring. Many staminate cones are produced on each tree each year, and it is doubtful that the squirrels are able to affect the pollen crop by their feeding activities.

During May the squirrels were feeding on the staminate and small ovulate cones (Fig. 9). These two foods were taken in about equal amounts during this period.

Fleshy Fungi

In 1954 the fleshy fungi appeared on the forest floor in the middle of July (Fig. 10). A wide variety of forms were present, and many forms occurred in large numbers. The squirrels relished the fungi and fed extensively on them. Many of the fungi were parasitized by the larval forms of insects, and these appeared to be even more palatable to the squirrels.

At Fort Valley it was found by observation that the squirrels ate fungi of the following genera: Lycoperdon (puffballs), Tuber (truffles), Russula, Hypholoma, Boletus, Lepiota, Agaricus, and Aminita. Three forms which are extremely poisonous to man were relished by the squirrels. These were: Aminita vaginata, Aminita muscaria, and a member of the genus Russula. Dr. Paul D. Keener of the Department

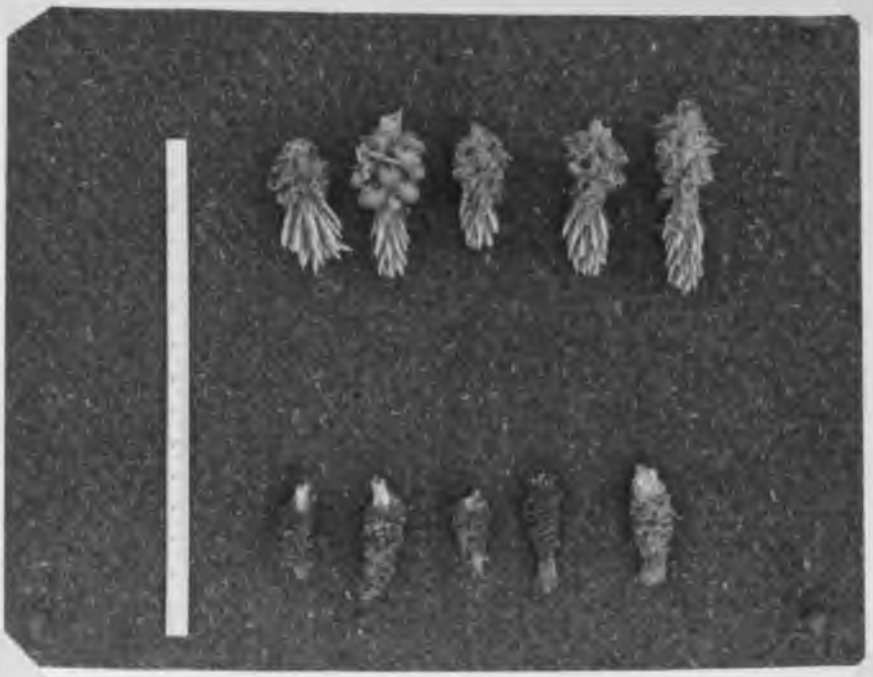


Figure 9 Remains of Staminate and Ovulate Cones Used as food by the Abert Squirrel. Photo by L.K. Sowls.

Figure 10. Boletus edulis, a Common Fungus in the pines Used by the Abert Squirrel for Food. Photo by L.K. Sowls.

of Plant Pathology at the University of Arizona spent a day in the field with me and identified the species of fungi which I had observed the squirrels taking for food.

In eating the fungi, the squirrels seldom ate an entire plant at one time but preferred to feed alternately on the many forms present.

Some fungi are taken later in the fall when they are dry, but most forms disintegrate quickly.

Miscellaneous Foods

On several occasions the squirrels were known to have fed on carrion. A captive squirrel ate the meat from a leg bone of a jackrabbit (Lepus californicus) after the meat had dried thoroughly. In the field, leg bones of rabbits were found on limbs in trees and by squirrel nests. Once a squirrel was observed feeding on the meat from a leg bone.

Squirrel tracks were found in the snow around several porcupines (Erethizon dorsatum) which were shot. It appeared that the squirrels had removed parts of these animals. Carrion was usually obtained from the remains of predator kills. The squirrels fed on carrion only at intervals, and did not depend on it as a major food source.

Throughout the course of the study the bones of rabbits, deer, cows, and other animals were found in odd places in the woods. Definite teeth marks were seen on these bones. Squirrels kept in captivity were observed to gnaw on bones and

readily consumed deer antlers. These probably furnished the squirrels with valuable minerals which they could not obtain from their other foods (Fig. 11).

Only pure stands of ponderosa pine exist on the Fort Valley area where the present study was undertaken. In some of the areas over the range of the squirrel, Gambel oak (Quercus Gambelii) is interspersed with the pine. It is known that the squirrels utilize the acorn crop from these trees.

Many times squirrels were observed feeding on an unknown food while on the ground. They undoubtedly take seeds of other plants and perhaps the foliage of a few. They could take the eggs of passerine birds, insects of various types, and lizards for food. The analysis of squirrel stomachs was found too time consuming to give satisfactory results in this study. Examination of the contents from 30 squirrel stomachs showed that field observations identified the major food items taken.

Water

The squirrels are able to live without available open water. In fact, open water is not present over the greatest part of their range. However, squirrels apparently take open water since tracks were found in the mud at water tanks. Several tanks constructed for cattle are scattered through the pine country of northern Arizona.

Figure 11. Antler, Jaw and Section of Pelvis from Deer Showing Teeth Marks of Abert Squirrel. Photo by L.K. Sowls.

In winter the squirrels ate snow, and after the summer rains they drank from standing water in rocks or on roads. I did not observe the squirrels taking dew from the vegetation and do not know to what extent it may be used.

In captivity the squirrels took water daily.

ACTIVITY

Movements and Home Range

During the winter of 1953-1954, maps of the activity of several squirrels in the study areas were recorded after each fresh snow. These maps portrayed the actual distances traveled, the feeding activities, travel routes, preferred areas, and nesting sites of each squirrel. From this information, sketches of the home ranges of several squirrels were drawn and the areas calculated. The area used by any one squirrel varied from day to day, of course, with the snow cover and the climatic conditions. The average size of the home range during the winter with a snow cover is about five acres. Perhaps under the pressure of higher populations the size of home range will vary, or perhaps the availability of food affects the size of their range.

The home range of a squirrel is limited to an area which contains food trees, nesting sites, and wandering areas (Allen, 1943; Baumgartner, 1938; Layne, 1954). In the fall a gradual shifting of the home ranges of the squirrels was very pronounced. Squirrels caught in a trap once were never recaptured or seen on the area again. The home range of squirrels living on the study area shifted through larger areas.

During the winter the squirrels were more sedentary and were always found in a certain area. The size of this area varied with the snow cover, contracting with fresh fluffy snow and enlarging with crusted old snow, regardless of the actual depth of the snow. During the breeding season the squirrel's home range was extensive. Trapping showed that movements were accentuated and squirrels moved great distances within short periods of time. In summer the squirrels used an area comparable to that used in the fall, but the home range was stable and did not shift.

Trapping was begun in September, 1954 on a logged area of 80 acres in the Fort Valley Experiment Forest (Fig. 12). Only two squirrels were caught a sufficient number of times to permit calculation of their home range with any degree of accuracy. In November, trapping was begun on an adjacent area of 80 acres which had not been logged. On this virgin area only three squirrels were caught enough times to permit calculation of their home ranges.

From the available information the average home range of the squirrel in the fall and early winter of the year is about 18 acres. This figure is an average of the ranges calculated for five individuals. The ranges were constructed and measured using a method described by Blair (1940). The pattern of these five ranges is shown in the appendix. Blair (op. cit.) points out, however, that the home range of at least 10 individuals should be calculated to obtain an

Figure 12. Ear Tagging of Abert Squirrel after Capture in Box Trap.

Photo by C.R. Hungerford.

average home range for a species.

The literature on squirrels shows that most species defend territories (Gordon, 1936; Layne, 1954; Hatt, 1929). No indications of territorial behavior were observed in the Abert squirrel. It could be that under the stresses of higher populations the squirrels would be forced to defend a territory.

Hours of Activity

In an attempt to delimit the hours of activity of the squirrels, a series of areas were chosen in which spot counts as described by Hicks (1947) were undertaken. After nearly 60 hours of such counts, only three squirrels were seen and the counts were discontinued. Apparently a larger population existed in the Fort Valley area in 1941, for Trowbridge and Lawson (1941) state that an average of 2.55 squirrels per hour were seen in spot counts. In areas with low population densities this method does not give satisfactory results.

From direct observation of known individuals, however, information is available on the hours of activity. Squirrels left the nest in the morning as soon as the first rays of the sun hit the trees. In the evening they entered the nest as the rays of the sun left the tops of the trees.

The squirrels were observed feeding at all hours of the day. In the morning they fed intensively for several hours.

Among the young in the fall this feeding period was sometimes interrupted by short periods of play. After four or five hours of intensive feeding, the squirrels spent more time resting or traveling on the ground.

Cahalane (1947) and Trowbridge and Lawson (1941) both speak of the lack of activity during long periods of inclement weather. Cahalane (op. cit.) states that the squirrels will remain in their nests for seven to ten days at a time. Squirrels were observed feeding, however, during severe snow storms, high winds and the rainfalls of the summer. Every day spent in the woods during the winter showed some evidence of fresh squirrel activity. The winter of 1953-1954 was not severe, and the storms did not last more than several days.

The only time that the squirrels were observed using their nests as refuges during daylight hours was after a heavy snowfall. The snow piled up on the branches of the trees during the storm and fell after the sun appeared. The falling snow could have knocked a squirrel from the tree, and perhaps the squirrels had learned to seek shelter during this period.

Other Activity

Escape and Alert: The squirrels sometimes called when disturbed, but usually remained perfectly silent. This was noticed most definitely when comparing summer and winter

activity. In the winter the squirrels seldom called when disturbed, but in the summer they frequently voiced their alert. When the source of disturbance was not seen, the squirrels became nervous and often began calling or moving.

Cary (1911) states that the squirrels use the nest tree for escape, while Hill (1942) claims they prefer to escape by running on the ground. I did not see squirrels seek refuge in a nest or in a nest tree when they were pursued. In winter the closest tree was sought for refuge. In summer they sometimes traveled a long distance on the ground if not pressed too hard, but immediately went up a tree if followed too closely.

In climbing the tree they circled to stay on the opposite side of the tree from the observer. Sometimes they went to the very top of a tree and were hidden from sight by the top branches. At other times they only climbed to the branches of the tree and remained in sight.

Noises coming from a distance or even harsh noises that were familiar to the squirrels caused little excitement. The slamming of car doors or the motors of cars on the road did not disturb them.

Cary (1911) and Coughlin (1938) agree that the squirrels are extremely quiet and hard to observe. Still other authors speak of the familiarity of the squirrels and of their morning awakenings by the animals (Mearns, 1907; Warren, 1910). This contradiction is probably a result of observing

different population numbers. It appears that, when plentiful, the squirrels become more active and tame and that, when scarce, they are shy and hard to see (Nelson, 1918).

Voice: In the literature, various opinions are expressed regarding the voice of the squirrel. Warren (1910) states that they could always be heard in the early morning as one walked through the woods, and that they chattered noisily if approached. Cary (1911), however, claims "... not a single sound was heard that could be attributed to the squirrels." Bailey (1913) agrees that their call is not often heard. In the present study, squirrels were seen at least as often as they were heard. Occasionally they were heard in the distance in the woods, but most of the time they were heard only after they were frightened.

The squirrels never called while on the ground, but only from a perch in the trees. When the call was uttered it was usually accompanied by the stomp of a foot and often by the quick waving of the tail.

The common call is a soft "chuff-chuff" that can be heard for some distance. Bailey (1913) believes that the bark is mainly a warning cry. Squirrels, on being removed from traps, uttered a squeal of fright, and after being seized uttered a soft growl. Other types of calls were heard only during the mating season.

A male defending his rights to a female uttered a

continuous "cluck-cluck" much as a chicken does. The female uttered a call similar to that of a fighting cat. This was used to discourage the males during the breeding activity. A call of fright was given by the more docile males when chased by the dominant male of a breeding group. The squirrels also uttered this call when attacked by dogs or hawks.

Cleanliness: The squirrels were continuously cleaning themselves, and their pelage showed the results of this habit. The pitch which was present in almost all of their foods stained their paws and faces. Squirrels stopped eating to clean themselves between parcels of food. They licked their paws and scrubbed their faces, or merely scraped their cheeks along the limb upon which they were sitting. All squirrels were infested with ectoparasites, and they often bit and scratched to relieve this irritation. They also combed their tail and fur with their teeth and claws.

Motion: The squirrels were very graceful in all their motions. On the ground they walked, hopped, and ran. All gaits were smooth, with the tail arched above the back. When running, a squirrel could quickly outdistance a man in dense cover or where debris was present.

When traveling in the trees the squirrels often looked awkward and apparently off balance. Their grace was still appreciated, however, when they traveled in the upper frail branches of the trees. At times they traveled at rapid

speeds in the trees. While chasing during courtship, the males jumped four or five feet straight down the bole of the tree. While playing, the young traveled rapidly with short steps down the bole, out branches and circling between branches, seemingly with careless abandon.

In tree-to-tree travel, the squirrels were capable of eight-foot jumps.

Signs Indicating the Presence of Squirrels

By one of several signs the presence of squirrels in an area could always be noted. These signs were mostly associated with their feeding habits.

From early winter until well into spring the presence of the terminal needle groups on the ground showed that squirrels were in an area (Fig. 6). Also, in winter the small bracts torn from the terminal buds were seen when there were squirrels in the vicinity. The fragments of ovulate cones were found during the summer in areas inhabited by the squirrel, and numerous "squirrel cones" (Fig. 9) were found under trees with a good cone crop. When eating the seeds of ponderosa pine after they had fallen from the cones, the squirrels dug through the litter on the ground to obtain the seed. These holes remained for some time as "pock marks" in the duff. Nests, although harder to see, indicated that squirrels had lived in an area.

Tracks of the squirrels in snow and dust, of course,

indicated their presence. In a more general way, squirrel damage to trees indicated squirrel use at some time in the past (Fig. 15).

Social Activity

As stated earlier, no signs of territorial behavior were observed in the Abert squirrel. On several occasions, however, actions indicated that they were aware of the presence of other squirrels. They were often seen to sniff at branches in the trees. This action was more frequently observed before and during the breeding season.

During the study, single squirrels and pairs were most commonly observed. From trapping it was determined that pairs sometimes remained together during the winter. These pairs always consisted of an old female and a young animal. This suggests that a mother allowed one of her young to remain with her during its first winter. By late spring all the squirrels were living alone.

Several times squirrels were observed to examine cautiously the nests used by other squirrels. In a pen study, a strange female was placed in the pen with a male in early spring. The female dominated the single nest in the pen. The male attempted to gain entrance but was repulsed each time. The female died from unknown causes three days after the male was released in the pen.

During the breeding season the height of social activity

took place. Squirrels were seen in groups of from two to eight. Chasing by adults was first observed at this time.

Relationships with Other Animals

Several relationships exist between the activities of squirrels and those of other animals. During the nesting season of the Western Bluebird (Sialia mexicana) the squirrels were kept from climbing the tree in which the bird's nests were located. If a squirrel started up a nest tree it was harassed until forced to leave. Bailey (1913) speaks of the Mearn's Woodpecker (Balanosphyra formicivora) attacking the squirrels as they rob the bird's food cache.

Hill (1942) claims that the Abert squirrel is often chased by the spruce squirrel (Tamiasciurus hudsonicus). This seems peculiar because the spruce squirrel is less than half as large as the Abert squirrel. However, E.C. Martin of the Rocky Mountain Forest and Range Experiment Station told me he had observed the smaller squirrel chasing the Abert squirrel.

Porcupines use old nests of squirrels as resting platforms. Chipmunks (Eutamias cinericollis) take over abandoned nests and raise their young in such shelter.

Jackrabbits feed on the needles of the twigs cut from the trees by the squirrels. This food source is utilized by the rabbits when deep snow covers the other vegetation.

NESTING

Location and Construction

Nests of the Abert squirrel were usually found in the branches of the ponderosa pine. Nests were found also in the hollows of large Gambel oaks and in the branches of cottonwoods (Populus Fremontii).

Cary (1911) states that the squirrels live primarily in hollow trees. However, pines, being very resistant to rot because of their high rosin content, seldom have hollows of a size suitable for a nest. The other trees which will rot and form cavities for nests are not found over the entire range of the animal and are not present in numbers to offer nesting sites for all the squirrels.

Goldman (1928) states that he has never seen a squirrel enter a hole in a ponderosa pine. Warren (1910), Bailey (1931), and Cahalane (1947) all agree that the desired location for the nests is in the branches of the pine.

The nests were constructed of twigs from the pine which varied in length from 6 to 24 inches and were never more than one-half inch in diameter. The squirrels gathered a large number of these twigs and piled them on a crotch in the tree. After numerous twigs were placed in the crotch, the squirrel forced its way into the center of the pile and

weaved a nest around its body. Later the outside of the nest was woven to prohibit wind and moisture from entering.

The bottom of the nest was lined with any type of soft material which was available or which could be made from the materials present. Lining materials found in the nests included the following: shredded grass, juniper bark, pine bark, cloth, string, cotton, rope strands, and newspapers. There was usually only one opening to a nest, but many times two openings were present. On several occasions nests were found which had three openings.

The inside diameter of the nests varied from four to ten inches, but most of them were approximately six inches across and rather oblong. The outside diameters varied from one to three feet, but averaged approximately one and one-half feet. The nests were found from 16 to 90 feet from the ground in the nest trees. Most were found on the south side of the tree, and were built to withstand the prevailing southerly winds of this country.

The nests of the squirrel appeared quite suitable as shelter against the elements. The squirrels did not suffer losses because of the inadequacy of their nests since they were secure in the trees, even in high winds, and effectively excluded wind and moisture.

Data were secured on the construction and location of 97 nests. The squirrels showed little selectivity as to where they placed the nests in the tree. Nests were found

in trees with a height of from 20 to 110 feet. These trees were of all age classes and varied in diameter (breast high) from 12 to 41 inches. The nest trees often showed the results of past feeding use by the squirrel.

On an 80-acre area which had been logged a total of 14 nests were counted. On an adjacent area of the same general size 29 nests were counted. Since these areas were visited frequently during the study, it is believed that a complete count was made. Several of these nests showed use during the winter, but only a few were kept in repair. Old, unused nests remain for some time in the trees.

Some of the old nests collapse and form a flat, thick mat of decaying material which will remain in the trees indefinitely, in some cases forming the base on which a new nest is built. Such a platform gives a nest more stability than if it is built in the crotch of a tree.

Pregnant females and females with young were observed building new nests. These two groups of females showed a strong nest-building instinct. On several occasions females were watched for long periods during which they began the construction of many nests. For each one actually completed, probably 20 were left unfinished. Females interrupted their feeding and gathered twigs for a nest. After a while, however, they returned to feeding and moved off through the woods. On one occasion a female spent nearly two hours building a completely new nest after her young were taken

from her.

The nest-building activity was one of the most confused actions observed in the squirrels.

The new nests built by pregnant females were well constructed, had but a single opening, and were lined entirely on the inside. The cavity of these nests was smaller than that of an ordinary nest, and averaged about four inches in diameter. When the young were first born they were restricted in a depression in the floor of the nest. By the time the young were six weeks old the mother had moved them to a new nest which was lined only on the bottom. These second nests had a greater depth than most, perhaps to restrict the young to the nest.

Use of Nest

The nest was used as a sleeping place during the night and to shelter the young. Other than that it appeared to have little use. It was not used as a haven for escaping danger, nor as a resting place during the day. Mature squirrels did not share their nests with other adults.

In the fall the squirrels added material to their nests in preparation for colder weather. In the winter, several nests only short distances apart were used at intervals, so that from two to four nests were kept in good repair by each squirrel. Even during the winter the nests were lined only on the bottom. In summer the roof of the nest was manipulated

for the comfort of the squirrel. On warm, sultry nights the roof was thrown back and the squirrel slept in an open nest. When rain fell, the roof was replaced on the nest and woven to exclude water.

The presence of fleas in a nest indicates that a nest is currently in use or has been in relatively recent time. Fleas do remain in the nests for some time after a squirrel has left.

The nests were usually cluttered with assorted bones, sticks, mushrooms, string, cloth, or carrion. The squirrels defecated outside the entrance to the nest, and a thick layer of feces was usually present there.

Many times nests were found in groups. As many as three were found in one tree, and often four to five were found within a radius of 300 feet. During the summer it was more difficult to tell the location of an individual squirrel, but they apparently used more nests as they traveled greater distances.

BREEDING AND MORTALITY

The breeding habits of the Abert squirrel have never been thoroughly investigated. There are some references to breeding in the literature, and some keen observations were made by men spending only a short time in observing the squirrel.

Hill (1942) reports young one-third to one-half grown on August 5 in New Mexico. Bailey (1931) saw the first young on May 24 in New Mexico and observed that farther north the young were about one-half grown in October. Cary (1911), however, claims that one-half of the squirrels seen in Colorado during the last week in May were immature.

Goldman (1931) tells of E.R. Hall's report of a suckling female on June 28. Cahalane (1947) states that the squirrels have three to four young in May, but scattered litters are found from April to October. Merriam (1890) was not certain of the breeding habits but guessed that there were one or two young.

Mearns (1907) observed that the squirrels breed in May with troops of males chasing females, and that the young are born from May to August, depending upon the altitude. Even though this naturalist spent only a limited time in the country inhabited by the squirrel, he appears to have gathered

more facts on their life history which are correct than any other investigator before or since. Using his writings as a guide, the present study verified many of his observations.

Breeding Season

Observations related to breeding which were gathered in the present study are given in Table 4. Beginning in March, it was noticed that the squirrels often paused while feeding or traveling and carefully smelled objects near to them. This activity became more noticeable as the squirrels came into breeding condition. It is thought that the females emitted an odor which attracted the males.

The first signs of oestrum in a female were observed on March 28. The vaginal slit was somewhat enlarged and the lips of the vulva were swollen. As the season advanced the females exhibited a more pronounced swelling of the vulva and the vaginal slit became enlarged, in some cases to one-fourth of an inch. At this time the vulva was a deep pinkish color in contrast to its normal, fleshy white color. The condition of oestrum in the females was identical to that described by Sollberger (1943) for the eastern flying squirrel (Glaucomys volans). The females did not all reach oestrum at the same time. The breeding season was over a month long, due to the staggered occurrence of oestrum in the females.

In the fall of the year the testis in the males were

Table 4. Activity Associated with the Breeding Season in the Abert Squirrel

Source of data	Date	Activity or condition
Collection	3-28	Oestrum (first observed)
Field observation	4- 5	Close association of pair
Collection	4- 7	In oestrum
Collection	4-20	In oestrum
Collection	4-26	In oestrum
Field observation	4-27	Close association of pair
Trapping	4-27	In oestrum
Collection	4-28	In oestrum
Field observation	5- 6	Close association of pair
Pen study	5- 6	In oestrum
Trapping	5-13	In oestrum
Field observation	5-14	Close association of pair
Field observation	5-16	Close association of pair
Pen study	5-16	In oestrum
Field observation	5-17	Breeding activity
Field observation	5-20	Breeding activity
Field observation*	5-21	Breeding activity
Trapping	5-24	Female, had bred
Collection	6-14	Pregnant
Pen study	6-16	Pregnant
Nest examination	7- 1	Young found, 1 week old
Pen study	7- 1	Young born
Pen study	7- 8	Young born
Nest examination	7-13	Young found, 1 week old
Nest examination	7-27	Young found, 4 weeks old
Trapping	7-28	Lactating

*Reported by F.R. Herman of the Fort Valley Experiment Station

abdominal and the skin of the scrotum was taut against the ventral surface of their bodies. In February the scrotum began to fill out as the testis descended. By the middle of March the testis had fully descended in most of the male animals. From then until the end of the breeding season, an excrement could be squeezed from the penis of the males.

In April the Cowper's gland enlarged, and the males appeared to be in full breeding condition. It appeared that the males, as a group, were prepared to breed as the first female reached oestrum.

Table 5 gives the volumes of the right testis from the male squirrels collected during the study.

In April field observations showed a closer association between members of pairs. Peculiar antics were observed, with the males expressing their first interest in the females.

In one observation a single male joined a male and female in a tree. The pair was feeding and paid little attention to the newcomer. As he worked his way up the tree, however, the male above became more observant. After a short period of feeding together, he chased the newcomer from the tree. On another occasion a male and female were observed feeding together in a tree. The male tried to approach the female several times. She retreated, and a wild chase ensued through the upper branches of the tree. The male finally left the tree, alone.

Males were often observed in the company of females, and

Table 5. Testis Volumes of Male Abert Squirrels Collected during 1954 and 1955

Date	Length	Width	Volume	Cowper's gland
	mm.	mm.	cu. mm.	
1954				
2-16	22	--	--	
2- 3	22	--	--	
2-23	Large			
3-12	21	12	1,584.0	
4- 5	23	12	1,734.1	
4- 6	29	17	4,389.2	
4-22	30	--	--	Enlarged
4-22	25	14	2,565.7	Enlarged
4-26	30-	16	4,021.2	
4-28	24	14	2,464.7	Enlarged
4-28	28	15	3,298.5	
5- 7	25	14	2,565.7	Enlarged
5-12	28	16	3,753.0	Enlarged
5-19	25	14	2,565.7	
5-20	25	13	2,212.2	
5-20	24	13	2,123.5	
5-20	26	14	2,668.0	
5-20	25	14	2,565.7	
6-14	29	16	3,887.4	Enlarged
6-26	23	14	2,340.3	
6-28	Testis ascending		--	
8- 9	18	7	460.7	
8-26	16	6	301.6	
10-20	19	8	636.6	
1955				
5-20	22	10	1,252.0	
5-20	32	16	4,289.3	
5-20	19	7	487.4	

they followed the female quite closely as she fed or traveled on the ground.

Breeding Activity

On May 17 I observed breeding activity for three hours on the study area. I first saw eight squirrels in a stand of young pines. It soon was evident that one was a female and the others were males. The female remained quietly feeding at the top of the trees with one of the males. This dominant male had been trapped and ear tagged, and thereby could be identified from the other males. He remained close to the female, both on the ground and in trees, constantly on guard for the advance of the other males. As the other males came up the trees, the dominant male would chase them back to the ground and quickly return to the female. As six males were alternately working their way up the trees, the male was kept busy maintaining his dominance.

The chases through the trees were very fast and careless. The squirrels jumped long distances through the trees and down the trunks, crashing through dead branches. The male constantly uttered a soft, clucking noise throughout the afternoon, and when chasing one of the other males this call became accentuated. The other males squealed with fright when chased.

Bodily contact was not made between the squirrels, and it was not apparent what character enabled the one male to

assume dominance. The group was not found until early afternoon, however, and actual fighting may have taken place earlier in the day.

During the afternoon the dominant male and the female copulated four times. The female finally repulsed the male from further contact. Copulation took place in the trees, with the male mounting the female as they clung to the side of the trees.

While on the ground the female led the way at a slow pace. The males flanked her as they traveled, with the dominant male following close behind. If another male came too close, the dominant one quickly chased him back. The female also repelled the other males with a call much like an angry cat. She used this same call to repel the dominant male from further copulation later in the afternoon.

Throughout the afternoon, male squirrels joined and departed from the group. The total number was quite impressive, but it was not possible to count the number of individuals seen. More squirrels were seen this day, however, than at any other time during the study.

On May 21 F.R. Herman of the Rocky Mountain Forest and Range Experiment Station saw a pair of squirrels copulate after a single other male had been chased away. On May 20 one female and four males were shot from a single tree. The female had bred, and these squirrels were classified as a breeding group.

After copulation the semen of the male solidifies in the vagina of the female. The presence of this "vaginal plug" indicated that a female had bred.

Gestation Period

None of the captive squirrels bred, and since copulation was observed only with an untagged female no accurate figures on the length of the gestation period are available.

The average date of observed breeding was May 19, and the average day of the birth of the young was June 28--an elapsed time of 40 days.

A female caught on May 16 was in oestrum but had not bred. When next caught, on May 24, she showed the vaginal plug indicating that she had bred. If May 20 is assumed as the day she bred, the gestation period was 42 days since she bore young on July 1 while in captivity.

During the gestation period the females were extremely wary and eluded the observer every time they were followed. As described in the section on the construction of nests, pregnant females spent most of the daylight hours building nests. Although only a few were completed for occupancy, many nests were started.

Birth of Young

The first young were found in the field on July 1 and appeared to be about one week old. On this same day a captive female was found with three young. The dates of birth

for these and other young are given in Table 6. Dates of birth were estimated for all the young found in the field.

The number of young per litter in the litters observed ranged from two to five and averaged 3.4 (Table 7). More records are needed before the average litter size can be stated with any degree of confidence.

Development of Young

At birth the young were completely without fur and their eyes and ears were covered by thin membranes. The only external features which were developed were the vibrissae of the face and the claws on the toes. The skin showed a pinkish coloration. They averaged 60 mm. in length and 12 grams in weight. Tables 8 and 9 show the increase in weight and measurements in the young.

At two weeks of age the young had thin, short hair on their tails, sides and dorsal surface, while on the ventral surface they were bare. They grasped firmly with their claws as they were picked up, and squealed loudly when handled. Their eyes were still closed and their ears, which laid close to their heads, had only small openings.

At six weeks of age the squirrels were fully furred and appeared as the adults in the summer pelage, except for the presence of full ear tufts (Fig. 13). The legs and tail still appeared out of proportion to the rest of the body. The hairs of the tail laid flat, giving the tail a terete

Table 6. Estimated Dates of Birth of Young Abert Squirrels

Date	No. of litters	Conditions
6-10 to 6-15	1	Field
6-25 to 6-30	2	Field
6-29 to 6-31	1	Captivity
7- 8 to 7-12	1	Captivity

Table 7. Age, Sex, and Number of Young in Litters of Abert Squirrels

Date	Female	Male	Total	Observation
6-24-52			4*	Collection#
6-14-54			5*	Collection
5-20-55			2*	Collection
7- 1-54	2	1	3	Captivity
7- 1-54	1	1	2	Field
7-12-54	3	1	4	Captivity
7-13-54	3	1	4	Field
7-27-54	2	1	3	Field
Totals	11	5	27	8 litters

*Embryos
#Collected by Dr. L.K. Sowls

Figure 13. Young Abert Squirrels at about Six Weeks of Age.
Photo by L.K. Sowls.

Table 8. Changes in Weights in Young Abert Squirrels

Age	Grams		Sample	
	Females	Males	Females	Males
At birth	11.4	12.7	5	2
2 days	13	13	2	1
5 days	12	14	2	1
8 days	10	13	2	1
11 days	11	12	2	1
5 weeks	169	170	2	2
6 weeks	197	192	5	3
7 weeks	241	244	5	3
9 weeks	343	365	2	1
Avg. adult	638	635		

shape. The ears tended to hang relaxed over the sides of their face, but were held upright when the squirrels were attentive.

As the young became older they spent less time sleeping and became more active. They played continually and gnawed on any object available. At seven weeks of age the tail broadened and was carried erect over their backs. The ears were always held in an erect position. They scratched and sat on their haunches as an adult. They ceased to need only milk in their diet; they ate mushrooms and chewed on the

Table 9. Measurements, in Millimeters, at Birth and at Six Weeks as Compared with Average Adult Measurements

Age	Sex	Total length	Tail	Hind foot	Ears	Tufts
At birth	Both	60				
6 weeks	Female	360	150	62	29	8
	Male	360	150	63	30	7
Avg. adult	Female	485	220	70	39	-
	Male	479	206	70	41	-

cambium of the twigs. At 10 weeks of age the young were capable of caring for themselves.

The only records of development are from young in captivity, and the exact age of independency in the wild is not known. From the data available, however, the following dates can be estimated. The young were probably weaned at 10 weeks of age. One litter taken from a nest in the wild had two young with their eyes open and two with their eyes closed. From this observation it was estimated that the eyes opened at about six weeks of age. At about seven weeks, the young first ventured from the nest but it was not until they were about nine weeks of age that they climbed to the ground. The young could probably have survived without the care of the mother at the age of 10 weeks, but they did not reach mature size until 15 to 16 weeks old.

Care of Young

The females had a particular pattern of activity while they had young in the nest. They fed close to the nest and usually circled it as they fed. They continued to build nest structures, completing some but leaving many unfinished. In several instances the females moved their young from one nest to another. In one case I examined a nest because it was new and found it uninhabited. Two days later when the nest was again checked, four young at least one week old were found in it. The young were born in another nest and moved to this one by the mother. In another instance after I had examined the young in a nest, the female moved the young to another nest 330 feet away.

When the young were small the females returned to the nests frequently, but as the young became older they returned less frequently. When the young were about six weeks old the mothers began to bring food to the nests, first mushrooms and later bones, pine seeds, and twigs.

The young were kept quite clean, and excrement was never found in their nests. After the young had obtained their complete fur, the female removed the top of the nest on especially warm days. When a rain squall approached, the roof was replaced.

The mortality rate in the young was probably quite low. As Sollberger (1943) points out, most squirrels have relatively few young so, from an ecological viewpoint, probably

have few predators; and the young receive good care. No mortality of the young was observed in the field during the present study.

Age Ratios

Throughout the present study only females were aged. The females were aged by the condition of their mammae (Allen, 1943). The mammae of the adults were enlarged and showed a black pigment. If the female had recently nursed young, an area around the mammae was void of hair. The mammae of the young females were inconspicuous. In the females aged in this study there was an age ratio of 309 young to 100 adults (Table 10).

Various other means were investigated to determine whether the males, as well as the females, could be aged. As mentioned earlier, the young had ear tufts as soon as they obtained their full pelage. These tufts were rather short but thick. In early September, therefore, the young had full ear tufts at a time when the adults were without the tufts. The adults first began to grow the tufts in late September, so that for a period of about three weeks data could have been obtained on age ratios by trapping or collections.

Relatively few males were examined in the fall of the year. Possibly the characters of the scrotum were satisfactory for aging. After breeding, the males showed a black

Table 10. Age Ratios of Female Abert Squirrels at Different Times of the Year

Time of year	Females		Juv.:100 Adults
	Juvenile	Adult	
September to December, 1953	15	4	375:100
January to August, 1954	19	7	271:100
Totals	34	11	309:100

pigment in the scrotum even after the testis had ascended. As the winter fur grows, this character became less discernible even upon close examination. The young of the year did not show black pigment in the scrotum before they acquired the winter pelage.

Sex Ratios

Sexing of the squirrels is always quite simple when the animal is in the hand. The sexes may be distinguished in the field with the aid of field glasses by the presence of the penis or vulva.

The data available on sex ratios are given in Table 11. This information is taken from the field notes of A.H. Trowbridge, O.N. Arrington, L.K. Sowls, and the author.

These records show a considerable dominance of males. The reasons for this are unknown. No evidence of a

Table 11. Sex Ratios of Abert Squirrels Collected by Various Investigators

Investigator	Date	Males	Females	Males:100 Females
Trowbridge	1941	122	107	114:100
Arrington	1943	117	82	143:100
Arrington	1944	93	51	182:100
Arrington	1945	20	16	125:100
Sowls	1952	13	18	71:100
Keith	1954	56	41	136:100
Totals		413	316	131:100

Table 12. Sex Ratios of Abert Squirrels at Different Times of the Year

Time of year	Males	Females	Males:100 Females
Sept. to Dec.	20	15	133:100
Jan. to April	17	11	154:100
May to August	19	15	127:100
Totals	56	41	136:100

differential mortality in the sexes was found. Table 12 shows that this dominancy of males is present throughout the year.

Mortality

Predation: Some evidence of predation on the squirrels was found. Remains of four squirrels killed by hawks were found. Hawks are probably the most successful predator of squirrels. The following hawks are found over the range of the squirrel (Phillips, 1947) and are capable of taking the animals: Sharp-shinned hawk (Accipiter velox), Goshawk (Astur atricapillus), Copper's hawk (Accipiter cooperi), Red-tailed hawk (Buteo borealis), Ferruginous rough-legged hawk (Buteo regalis), and the Swainson's hawk (Buteo swainsoni).

On one occasion I observed a Swainson's hawk attack a group of squirrels. It was unsuccessful and the squirrels showed little concern over the hawk after the initial attack.

The horned owl (Bubo virginianus) is common over the range of the squirrel and undoubtedly kills it for food. The hours of activity of these two species do not coincide, however, and the owl is not considered a serious predator.

The grey fox (Urocyron cinereoargenteus), coyote (Canis latrans), bobcat (Lyns rufus) and mountain lion (Felis concolor) are probably successful in capturing the squirrel, although no evidence of their predation was seen.

Disease and Parasites: Ectoparasites were present on all squirrels examined, but never in extreme numbers. The fleas (Opisodasys robustus) were identified by Jack Esslinger of the Rice Institute. This is the first record of these fleas from the Abert squirrel in Arizona.

All squirrels collected were examined for endoparasites, but only one infected individual was found. An unidentified nematode was found in its body cavity.

No evidence of diseased squirrels was found.

Other Mortality Factors: The squirrels are commonly killed while crossing roads. They appear confused at the approach of a car and are frequently run over.

Three squirrels were found which apparently died of exposure and starvation. Two of them showed that malocclusion of their incisors had prohibited successful feeding. The esophagus of the third animal had been punctured by a porcupine quill. The quill entered the chest and worked into the chest cavity.

I believe that the turnover rate is high in squirrel populations. I was not able, however, to isolate any serious mortality factors in the present study. Starvation and predation probably exert tremendous force on the populations. Additional studies are needed to determine these facts, and such information would greatly aid in squirrel management.

POPULATIONS

History of Populations

The records on population sizes of Abert squirrels are made up mainly of observations by the early naturalists who treked through the Southwest, and of the observations made by scattered writers in more recent times.

Merriam (1890) speaks of the many squirrels present in the woods in the same general area in which the present study was made. Mearns (1907) claims that the squirrels were abundant in Arizona. Pearson (1942) observed a steady increase in the squirrel populations from 1930. He had been in the Flagstaff area in northern Arizona since 1909.

Goldman (1928), however, claims that the Abert and the Kaibab squirrels were decreasing in numbers. Cary (1911) noticed that the squirrels were scarce in Colorado.

Trowbridge and Lawson in 1941 and Arrington in 1943, 1944 and 1945 were evidently working with high populations. The present study was made with what is considered an extremely low population. Several comparisons are made below which indicate a definite change in squirrel numbers around Fort Valley from 1941 to 1954.

Using the available data on success in squirrel trapping, it is shown in Table 13 that there was a change in

Table 13. The Success of Abert Squirrel Trapping by Various Investigators

Investigator	Year	Squirrels	Trap Days	T.D./Squirrel
Trowbridge	1941	231	2500*	10
Arrington	1943	173	3056	18
Arrington	1944	144	1959	14
Arrington	1945	36	773	22
Keith	1954	34	2485	73

*Estimated from known days in field and number of traps used

trapping success from the early 1940s to 1954. Each of these investigators was working on the Fort Valley Experiment Forest, using the same type of traps, similar baits and techniques.

Trowbridge and Lawson (1941) reported seeing an average of 2.55 squirrels per hour by still-hunting. As previously mentioned, only three squirrels were seen during 60 hours of spot counts in 1953 and 1954.

In 1941, on Unit 2, Trowbridge and Lawson estimated a squirrel population of one squirrel per three acres from trapping. The population was estimated in 1953 and 1954 to be one squirrel per 20 acres. On Unit 1, Trowbridge and Lawson estimated a population of one squirrel per two acres. In 1953 and 1954 this area appeared to have a lower population than Unit 2. On cut-over land, or that with scanty timber,

Trowbridge and Lawson found one squirrel per eight acres. Squirrels were almost absent on such lands in 1953 and 1954, with a population of perhaps one squirrel per 100 acres.

Cahalane (1947) was perhaps the first to realize that there was a fluctuation in the squirrel populations. From the written evidence, however, there does not appear to be a singular trend in squirrel population sizes, but merely a change in numbers from time to time. There probably has been a steady decrease in squirrel numbers over the past 50 years, superimposed on shorter termed fluctuations.

The squirrel is a climax species, and man has drastically changed the original habitat. Logging of the pine in northern Arizona began shortly after the squirrel was first described. The squirrels are dependent upon the pines for food and shelter. Logging, therefore, effectively reduces the carrying capacity of their range.

Trowbridge and Lawson (1941) showed that in virgin timber the squirrel population was higher than it was on cut-over lands. Their record showed that on Units 1 and 2 of the Fort Valley Experiment Forest, which in 1941 was largely virgin stands, a population of one squirrel per two to three acres was present. Unit 3, which was logged in 1939, however, showed a population of only one squirrel per eight acres.

Fluctuations are probably inherent in squirrel populations. Some natural features of the squirrel's environment

effect a variation in their numbers. It is obvious that the factors which cause this change must themselves be variable.

The cone crop in ponderosa pine is known to be erratic, although no definite records of past cone crops are available. There appears to be a similarity in the pattern of variation in cone crops and fluctuation of squirrel numbers. Cone crops and squirrel numbers vary erratically from year to year over the range of the pine. Good cone crops are found in different areas each year. Squirrel populations in one area are good one year and poor the next. Too few data are available to show a correlation between the presence of good cone crops and good squirrel populations.

Methods of Censusing and Estimating Populations

I tried to find various methods by which populations could be easily and quickly estimated each year. The following are three of the most useful.

Transects: In the fall, squirrels begin to feed on the inner bark of the terminal twigs of the pine. Through the rest of the winter and into the summer, these twigs which are cut by the squirrels are lying on the ground beneath the trees (Fig. 6). It is assumed that the number of twigs varies proportionately with the number of squirrels on an area. A method of using belt transects to intercept feeding areas was investigated and shows some promise.

A belt of land, one-half mile long and 50 feet wide, was

selected in areas where the squirrel populations were unknown. The transects were not located randomly, but they were selected with as little personal bias as possible.

An index of use, varying with the number of twigs, was recorded for each "squirrel tree."

Twigs on Ground	Index of Use
Over 100	5
51-100	4
21- 50	3
11- 20	2
1- 10	1

After completing the transect, the indices of use for all the squirrel trees were added to obtain an index of use for the transect. Three transects were taken on each area, and an average was obtained for the index of use of the area.

Three belt transects were taken on each of the two study areas where the squirrel populations were definitely known. The index of use for these areas was taken as a basis to determine populations on other areas. Populations were low on the study areas, but on the virgin area the index of use was as high as any taken.

Table 14 shows the results of the belt-transects taken during the first two weeks of June, 1954.

There is a possible source of error if this method is used on one area to detect changes in squirrel populations from year to year. Probably a poor cone crop will cause earlier utilization of the inner bark of the twigs. The twigs are also used as food in the spring before the staminate

Table 14. Correlation between the Index of Use and Populations of Abert Squirrels

Area	Index of use	Populations
Virgin*	194	1 squir./20 ac.
S-9*	64	1 squir./20 ac.#
Unit 1*	132	1 squir./20 ac.
Unit 3*	50	1 squir./40 ac.
Coulter Ranch*	77	Very low
Three miles north of Coulter Ranch	35	Very low
Kendrich Park	40	Very low
Munds Park	75	Very low
Toms Creek Road	5	Very low
Five miles north of Fort Valley	40	Very low
Section 19*	20	Very low

*Fort Valley Experiment Forest

#No squirrels were present on S-9 from February to June

and ovulate cones become large enough to be eaten. The date of spring growth varies from year to year. It is therefore possible to obtain a variation in twig numbers on the belt-transects caused by a variation in the duration of the use of this food rather than by a change in the squirrel population.

I believe that this technique is sensitive enough to be used in comparing squirrel numbers on different areas during any one year.

Snow Census: This method is a true census and not merely a technique of getting a population index.

During the winter of 1953-54, close observation was made of squirrel activity. It was found that after snowfalls of six inches or more, squirrel feeding areas could be easily located and defined.

The squirrels were feeding on the cambium of the twigs, and the needle groups that were dropped showed up vividly on the fresh snow (Fig. 6). Since it is known that one squirrel consumes about 46 twigs per day, a census of an area of any size could be made by merely counting the number of squirrel feeding areas and considering the possibility of there being more than one squirrel at each area.

When squirrel populations are low, this method is simple and takes little time. It is restricted to periods immediately after a snowfall of six inches or more, and is restricted

to accessible areas. When populations are high, it may be that individual feeding areas would not be so clearly defined.

By using this method, three 80-acre areas were censused after each storm during the winter of 1953-54. The technique was found to be satisfactory.

Twig Collections: In the winter of 1953-54 weekly collections of twigs were made from under the trees on a 10-acre plot on Unit 2 of the Fort Valley Experiment Forest. The original purpose was to delimit the period of twig use as presented in Figure 6.

The total number of twigs collected from the 10-acre plot during this period was 6,417. This collection was influenced by a mid-winter squirrel population of one squirrel per 20 acres. Since the number of twigs should vary in proportion to the number of squirrels on the area, a collection of these twigs was made in June, 1955 to see if there was a significant difference in the number of twigs present on the ground. A total of 5,180 twigs were collected. If the above hypothesis is true, the squirrel population was approximately the same during both years. Continued collections of these twigs from the same 10-acre plot should be a good means of following major changes in squirrel numbers.

The Fort Valley office of the Rocky Mountain Forest and Range Experiment Station will continue these collections each year to determine the effect of the squirrels on growth in the

pine. This work will also give some indication of squirrel numbers on this area each year.

ABERT SQUIRREL-PONDEROSA PINE RELATIONSHIPS

Foresters in the western United States have shown a great interest in the rodents because of their feeding on the seeds of commercially valuable trees. On many areas they have met with difficulty in re-stocking after lumbering. McArdle (1953) claims: "In the west, the difficulty of attaining satisfactory regeneration of forest following fire or logging may be because of rodent activities." The Forty-third Annual Report of the Northern Rocky Mountain Forest and Range Experiment Station (1953) states: "One of the most important objectives in intensive forest management (perhaps the most important of all) is the establishment of a new stand promptly following logging."

Because the Abert squirrel utilizes ponderosa pine for so many of its life requirements, it exerts an influence upon the pine. Cahalane (1947) states: "Of the many forest dwelling rodents probably none is of greater significance than the larger tree squirrels."

The need now is for data on the relationship of the squirrel to the pine. This need is not unique with the Abert squirrel, but is generally true of all our forest-dwelling rodents. Without such data, few conclusions can be drawn on wise land use or on the necessity of rodent control.

Ponderosa Pine Seed

The Abert squirrel prefers the seed of the ponderosa pine to any other food in its diet. It will use pine seeds as long as they are available before turning to other foods. The seed crop of ponderosa pine varies from year to year, as does the size of the squirrel population. When a few animals are dependent upon a good seed crop, there is little need for concern. Conversely, when a large squirrel population is dependent upon a small seed crop, there is need for concern. In 1941 the squirrel population in the Fort Valley area was high and the seed crop was poor. Pearson (1941) wrote in a memorandum to the director: "In my examination last week I observed that practically every tree on which cones were visible showed signs of recent visitation by squirrels. It is safe to say that very few cones will remain on the trees until maturity." The large squirrel population took a heavy toll of the seed crop that year. In 1954, however, there was an excellent seed crop around Fort Valley and the squirrel population was low.

In September, 1955 a collection of cones was made from under 48 trees to estimate the squirrel use of the 1954 cone crop. All the cones of the fall of 1954 had dropped from the trees and were lying on the ground. The cones utilized by the squirrels were also under the trees but, because the bracts were removed, they could be distinguished from the normal cones. The selected sample area had been earlier

cleared of all cones so that this analysis could be made.

This collection showed that 11 percent of the 1954 cone crop was taken by the squirrels. Of 2,579 cones collected 2,327 were normal and 252 were "squirrel cones." This collection was made after an excellent cone crop and during a year of low squirrel numbers. Under these conditions the squirrels did not seriously affect the reproductive ability of the pine. This was borne out by the multitude of seedlings which developed in 1955 from the 1954 seed crop.

The Rocky Mountain Forest and Range Experiment Station in Flagstaff, Arizona plans to make similar collections each year in the future to determine the percentage of cones used by the squirrels under various conditions of cone production and squirrel densities.

In the spring of 1954 two trees with numerous ovulate cones were protected from the squirrels by the use of sheet metal shields (Fig. 14). These trees grew in the open and were not near other trees. With this protection, they shed their seeds without further depredation by the squirrels. Both of these trees had had cones removed by the squirrels before the protectors were placed on them.

It is, of course, not practicable to protect each tree in the forest. However, if there is an area which is not reproducing, these protectors could be used to good advantage.

Certain trees have better genetic qualities than others

Figure 14. Shield on Ponderosa Pine which Prevented Abert Squirrels from Climbing Trees to Obtain Ovulate Cones.

Photo by L.K. Sowls.

and are desirable for stocking an area. By placing protectors on such desirable trees they will shed their seeds while the seeds of a lower quality will be utilized by the squirrels. Selective quality reseeding can be accomplished at a fraction of the cost of artificial reseeding and at the same time wildlife (the squirrel population) can be benefited.

In an analysis of the squirrel's effect on regeneration it must be remembered that many factors play a role in regeneration and that the presence of seeds does not always insure seedling establishment. In ponderosa pine, adequate moisture must be present for the germination of the seed. This moisture is seldom available in the Southwest.

The Abert squirrel is a climax animal of a climax forest. In the primeval pine forest it probably lived in harmony with the forest because seldom is a growing climax forest in need of regeneration. Only after logging by man does disharmony occur; then man, desirous or over-anxious for rapid regeneration (another abnormal situation), looks to the rodent for something to blame. When we can predict seed crops, prepare seed beds, set stocking rates, and forecast weather conditions we can begin to analyze the effect of a rodent. Until then it should not be necessary to blame our lack of knowledge on the squirrels.

Squirrel Twig Clipping

While feeding on the inner cambium of the twigs of the

pine, the squirrels clip the terminal needle groups from the trees. This activity leads to a defoliation of the crown of the trees. The squirrels have favorite trees for this type of feeding, and such trees have the appearance of serious defoliation (Fig. 15). Loss of some trees has been attributed to squirrel feeding.

Pearson (1942), in a memorandum to the Regional Forester, states: "It is not exaggerating to say that squirrels are decreasing the increment on cut-over land by ten percent."

It seems reasonable that defoliation would decrease food production and that a shortage of food would result in a decrease of growth in the trees. There has been no proof of a decrease in growth due to the defoliation activity, but I believe it is probably true.

Cook (1954) in referring to red squirrel damage to the European larch (Larix decidua) claims: "... repeated attacks may so thin the crown as to reduce both diameter growth and general vigor." Deuber (1934) defends the grey squirrel's attacks on the American elm (Ulmus americana) with the supposition that such defoliation could benefit the tree if it establishes a better ratio between the leaf area losing water and the capacity of roots to supply water. Terres (1939) in reporting the clipping of the elm by the grey squirrel states: "Apparently the cutting of the twigs to secure buds can have little more than a pruning effect upon the elm."

Figure 15. Results of Squirrel Twig Clipping which Led to the Defoliation of Tree on Right.
U.S. Forest Service Photo.

As forest management becomes more intensified, the need for knowledge of the relationships between the squirrels and the pines becomes more important. Such knowledge can be obtained only by following the effect of the squirrels on a sample of trees over a period of years.

A 10-acre plot was selected near the Fort Valley headquarters for such a study. This plot contains 262 trees over 11.5 inches in diameter at breast height. Initial tree measurements for this study were taken in the summer of 1954, and the twigs cut from each of the trees were counted during the winter of 1953-54. Again in the spring of 1955 the twigs clipped during the previous winter were collected from under the trees on this plot. The results of the collections on this plot in 1954 and 1955 are summarized in Table 15.

Future measurements of the trees and the collection of twigs will be continued by personnel at the Flagstaff Station of the Rocky Mountain Forest and Range Experiment Station. Thus it will be possible to follow the effect, if any, of defoliation upon the growth of the trees. It is hoped that in a few years statistically significant figures may be obtained as to the effect of the squirrel on growth of the ponderosa pine.

Growth Bud Feeding

In the winter, squirrels remove the terminal growth buds of pine twigs for food. The removal of this meristematic

Table 15. Data Gathered from Twig Collections for Abert Squirrel-Ponderosa Pine Relationship Study in 1954 and 1955

Feature	Data 1954	Data 1955
Area of plot	10 acres	
Number of trees 11.6" DBH and over	262	
Total number of twigs gathered on area	6,417	5,180
Number of twigs bearing cones	612	4
Trees clipped by squirrels	187 (71%)	155 (59%)
Trees not clipped	75 (29%)	107 (41%)
Clipped trees having less than 25 twigs removed	139 (74%)	113 (73%)
Clipped trees having more than 25 twigs removed	48 (26%)	42 (27%)
Maximum number of twigs clipped from any one tree	1,246	1,203
Average number of clips per clipped tree	34	33
Average dry weight of foliage removed from clipped trees*	19 oz.	19 oz.

*Average air dry weight of twig is .572 ounces.

tissue prevents further growth of the twig. Usually, however, an adventious bud develops immediately behind the apex and growth continues. Although squirrels must have been cutting growth buds in each year of the life of the trees, no evidence of such use can be found on the trees.

This type of feeding is thought to have little effect on the growth of the pine.

Squirrel Bark Feeding

Many squirrels remove the outer bark of trees to obtain the succulent inner bark for food. Cook (1954) mentions the fact that the European red squirrel (Sciurus vulgaris) attacks the bark of the larch. Fritz (1932) has observed the California grey squirrel (Sciurus griseus) removing strips one inch wide and from 4 to 12 inches long from the branches of young redwoods (Sequoia spp.). They remove the bark and scrape off the succulent layer on the exposed wood. He also points out that the squirrels can kill the tops of these trees by girdling the main vertical stem.

Cary (1911), in referring to the Abert squirrel, mentions that they will remove the bark of the ponderosa pine, leaving evidence much like that left by the porcupine. Coughlin (1938) offers this type of feeding as another point in his "cause against the tuft-eared squirrel."

This type of feeding was most noticeable in the winter when the diet of the squirrel was mainly the inner bark of

the pine. It was never noticed to such an extent that it appeared serious, as porcupine damage sometimes becomes.

Barking appeared to be correlated with the infection of the trees by the dwarf mistletoe. Most of the evidence of bark feeding was found surrounding the areas of the pine infected with mistletow.

The only serious aspect of the removal of this bark occurs when the squirrels girdle the upper vertical stems, killing the tops of the trees, as sometimes occurs on younger trees (Fig. 8). With further growth, such trees may assume a crooked stature undesirable for commercial lumber.

Even if the squirrels harm several trees per acre in this manner, they need not be condemned. In the areas where this type of damage was found, the number of trees present was more than sufficient for proper stocking. Some of the trees should be removed to allow for better growth conditions for the remaining trees.

Until excess trees can be removed economically, thereby selecting the remaining trees for future harvest, such activities on the part of the squirrel cannot be referred to as damage.

Staminate Cones

For a short period in the spring, the squirrels take the staminate cones for food. These cones are present for only a short period before they dry and the pollen flies. Although

the squirrels take large numbers of the staminate cones, they take a small percentage of the cones present. The removal of these cones is not believed to decrease the probability of fertilization of the ovulate cones, however, for the pines, as do most living things, produce many more male than female reproductive cells.

Acorns of Gambel Oak

In part of the range occupied by the Abert squirrel the Gambel oak is present, interspersed with the pine (Fig. 1). Squirrels utilize acorns as food, thus tending to restrict the reproduction of the tree. Since this tree is not desirable from an economic standpoint, foresters have been concerned with its apparent increase following logging operations in pine. Any restriction of oaks by squirrels, then, is beneficial to the forests.

MANAGEMENT OF THE ABERT SQUIRREL

A major aim of game research is the formulation of management plans. Management is usually directed towards increasing a desirable species by the improvement of its habitat and regulating the hunting season and bag limits to harvest the annual surplus.

Nowhere has the management of the Abert squirrel yet been intensive. The human population is small in Arizona and there is a great variety of huntable species. However, as the human population increases and more interest develops in this outdoor sport, more intensive methods of squirrel management probably will become necessary. In Arizona it seems plausible to consider the following questions: (1) What habitat improvement may be practical to obtain higher squirrel populations, and (2) How can information be gathered which is necessary to set hunting seasons on the squirrels?

Habitat Improvements

Allen (1943) has described various management practices which have been used successfully to increase the number of fox squirrels in Michigan. The fox squirrel habitat consists mainly of privately-owned farm woodlots which, when managed, have supported good squirrel populations and excellent sport.

By limiting grazing on the woodlots to insure

reproduction and replacement of the trees he cuts for wood and fence posts, the farmer has improved squirrel habitat in many eastern and midwestern states. By leaving several rows of corn or grain adjacent to the woodlots, the farmers have increased the available winter food for squirrels. By leaving dead trees or trees with hollows in the woodlots, the squirrels have been furnished den trees. Thus it has been the interest of the private land owner that has brought about successful management of the fox squirrel in large parts of the United States.

The Abert squirrel, however, exists on our National Forests, and management of the animal is the responsibility of the state and federal agencies who administer these lands. Management of the Abert squirrel is more difficult for the private land owner is not in the position to help. For instance, it is not feasible to add supplementary food to Abert squirrel habitat, a benefit which is easily afforded the fox squirrel by the farmer.

The Abert squirrel's requirements for food, cover, nesting, and escape are all closely related to the presence of ponderosa pine. This dependency upon the pine is sometimes disadvantageous to the squirrel. Lumbering has affected the squirrels by removing mature pines and creating more open stands of timber. The Abert squirrel is apparently best adapted to a climax forest. Unlike many game species, it does not benefit by the creation of openings and clearings.

Lumbering is necessary to forest management and it will continue to be in the future.

Habitat improvement is not justified when the cost of this type of management is balanced against the importance of the animal as a game species. If the Abert squirrel increases in importance as a game species, methods of improving food and cover should be considered. Squirrel habitat improvement is definitely limited, and I do not know of any feasible techniques for accomplishing it.

Hunting

There is a need for additional information on the factors affecting birth rate and mortality of the Abert squirrel. Little is known of the conditions that cause population fluctuations. One of the greatest needs is for accurate data on these population changes so that they may be accounted for in regulating the hunting of the squirrel.

In order to follow population changes, an indication of population sizes must be obtained each year. I have discussed the technique of collecting twigs from a 10-acre plot in the Fort Valley Experiment Forest as a means of following changes in the squirrel population (p. 74).

Because squirrel numbers vary from area to area, these plots are needed throughout the range of the squirrel. Plots could easily be established over the squirrel's range and used to follow population trends. The twig collections could be used also to estimate ponderosa pine seed crops

on these plots. With an index to this major food source, the importance of the pine seed to the squirrels might be better understood.

A system is needed for obtaining an index to the annual hunting success, and also of the demand for squirrel hunting in Arizona. The hunter's report card would give this and other information which would aid in the management of the squirrel.

The hunting of squirrels in Arizona is not a strong in-influence upon the populations. Hunting seasons are short and sportsmen interest is low. Out of some 50 hunters interviewed at a checking station near Flagstaff in October, 1953, only one young boy indicated intentions of hunting squirrel.

In 1942 there was a special hunt on the Abert squirrel on the Fort Valley Experiment Forest. The squirrel population was high, and the foresters felt that the animal was interferring with many of their experiments on the pines in that area. Five thousand acres remained open from August 16 through November 15, and the bag limit was five squirrels per day. O.N. Arrington of the Arizona Game and Fish Department took records of this hunt, and the results are given in Table 16.

Twenty-six of 132 hunters shot all 59 squirrels. One hundred and six hunters did not bag a squirrel. The variation in the bags of these 26 hunters is shown in Table 17.

Table 16. Records of the Abert Squirrel Hunt on the Fort Valley Experiment Forest in 1942

Period	Hunters	Squirrels Shot
First day of hunt	35	23
Month of August	67	38
Month of September	51	21
Month of October	14	None
Month of November	None	None
Total	132	59

Table 17. Daily Bag of the 25 Successful Hunters, Fort Valley Hunt

Bag	Hunters	Total Squirrels
5	1	5
4	4	16
3	4	12
2	9	18
1	8	8
Total	26	59

As can be seen from these tables, the hunting success even with a high squirrel population was very poor. One year earlier, in the fall of 1941, Trowbridge and Lawson found a squirrel population of nearly one squirrel per three acres on most of this area. The population in 1942 was almost the same.

When squirrels are scarce, the hunter is even more restricted in his kill. Hunting under such conditions is quite discouraging. The animals are extremely wary and hunting success is low. The squirrels which are shot come from near the roads or from other accessible areas. Much of the animal's range is in steep, broken country at some distance from roads. A very small percentage of a low squirrel population is harvested. If the squirrel season were opened at the beginning of deer season and remained open until early spring, I believe the hunting pressure would be more in accordance with population numbers.

The areas inhabited by the squirrel are generally snowbound from late December until early May, and the squirrels would be hunted only on the edge of their range during this period. This longer season would help to increase the sportsman's interest in the squirrel and would not be detrimental to the squirrel populations.

The isolated squirrel populations such as those in the Santa Catalina Mountains, the Pinal Mountains, and Mt. Graham should be regulated separately. These squirrels are probably

subject to greater hunting pressures since they are nearer to the human population centers of Arizona.

If we can obtain yearly estimates of the squirrel population trend, the available food and the expected hunting pressure to which these animals will be subjected, we will be able to better regulate seasons and bag limits on the Abert squirrel.

SUMMARY

1. Little information has been published on the life history and ecology of the Abert squirrel. This study was undertaken to give additional facts on the habits and characteristics of the animal and its populations.

Foresters have long been concerned over the effect of the squirrel on the growth and regeneration of ponderosa pine. Though interest in the Abert squirrel as a game animal in Arizona has not been great, sportsmen are beginning to show increased interest in it. The Abert squirrel is of great esthetic value also, and nature lovers and tourists are interested in its conservation.

2. Intensive studies were made on the Fort Valley Experiment Forest nine miles northwest of Flagstaff, Arizona. General observations were made on the Coconino National Forest. A low squirrel population was present in these areas during the study, but information was gathered on many phases of the squirrel's life history and ecology.

3. Feeding observations have indicated that the principal foods are from the ponderosa pine. The inner bark of the tree is taken during the winter and the ovulate cones are taken during the summer. Other parts of the pine eaten were the growth buds and staminate cones. Feeding was closely investigated to determine the effect on the pine.

Fleshy fungi, carrion, bones, and acorns of Gambel oak were also found to be foods of the Abert squirrel.

4. Five squirrels were trapped a sufficient number of times to enable a calculation of home range. The average of these individual ranges shows a home range of about 18 acres during the summer and fall. When snow was present, the squirrels became more sedentary, with an average range of about five acres.

5. Nests of the squirrels are located mainly in the branches of ponderosa pine. These nests have an outside diameter of about one and one-half feet, and an inside diameter of about six inches. Descriptions were made of 97 nests. These records indicate that the squirrels do not prefer any particular site in the tree for their nests.

6. The height of breeding activity occurred about May 20 in 1954. The length of the gestation period was estimated to be about 42 days. In 1954, young were born during the last two weeks in June and the first two weeks in July. An average of 3.4 young per litter was obtained from embryo counts of collected females and from young born in captivity. The number of young varied from two to five.

An age ratio of 309 juveniles to 100 adults among females was obtained. Adult females were distinguished from young females by the black pigment present in their mammae. A satisfactory method of aging males was not found.

Of 729 squirrels, the average sex ratio was 131 males

to 100 females. The reason for the predominance of males is not known.

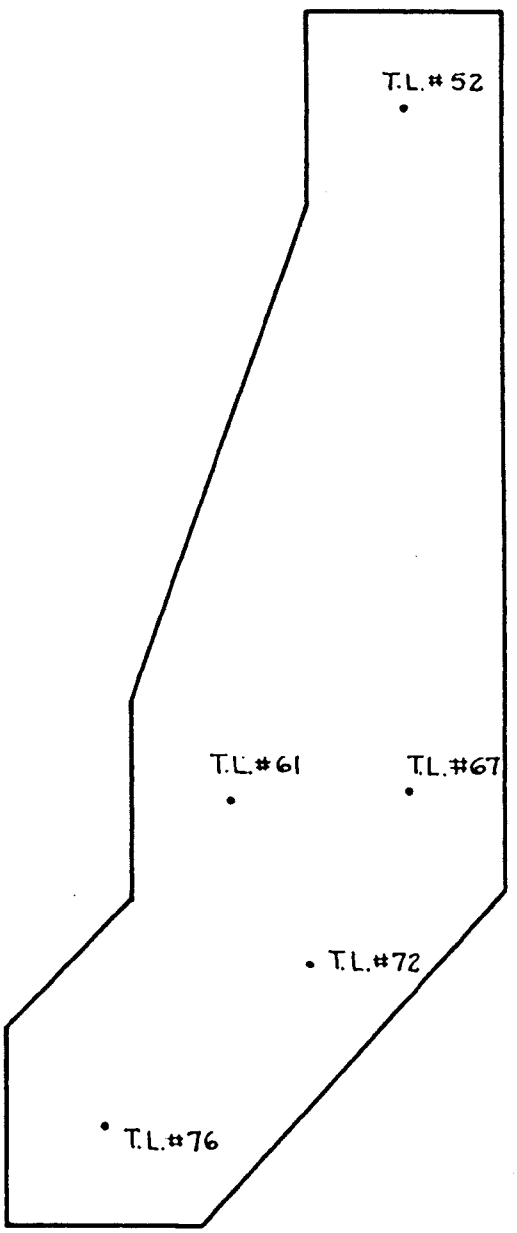
7. The squirrel population near Fort Valley was much higher in 1941 than in 1954. The populations are known to fluctuate, but the exact pattern of these fluctuations is not known. Several methods of estimating squirrel numbers were investigated. The "snow census," belt transects, and twig collections show some promise.

8. The relationship of the squirrel to reproduction and growth of the ponderosa pine was studied. It was found that data could be gathered only by studying the squirrel's effect on a group of trees over a number of years. A study was initiated on a 10-acre plot on the Fort Valley Experiment Forest. The Rocky Mountain Forest and Range Experiment Station will continue this study in the future.

9. Management of the squirrel, at present, is to be restricted to adequately harvesting the annual squirrel crop. A longer season is suggested to enable a greater harvest and to aid in increasing hunters' interest in the squirrel.

A P P E N D I X

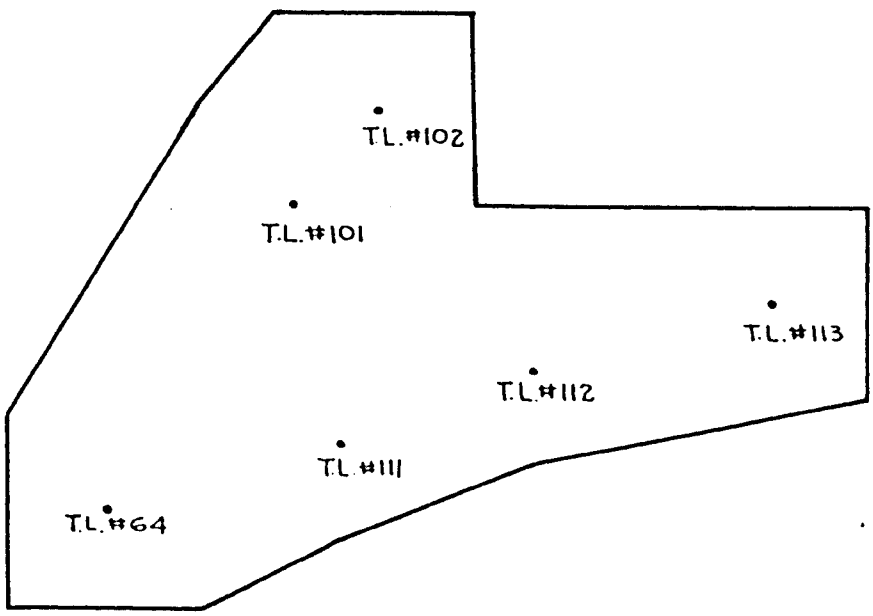
HOME RANGE OF SQUIRREL No. 1.



Home Range: 20.7 acres
Scale: 1 inch - 300 feet.

Plate 1

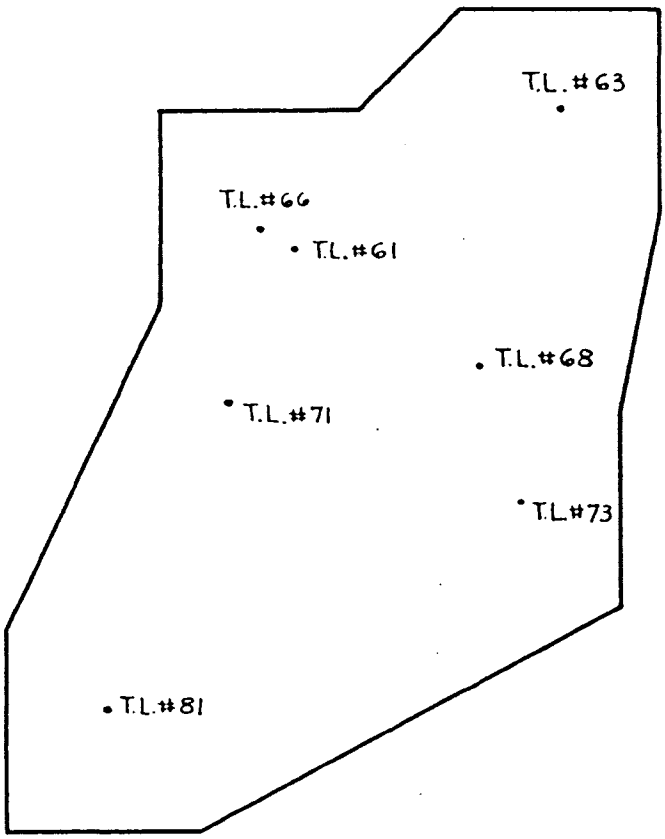
HOME RANGE OF SQUIRREL No. 2



Home Range: 15.6 acres.
Scale: 1 inch - 300 feet.

Plate 2

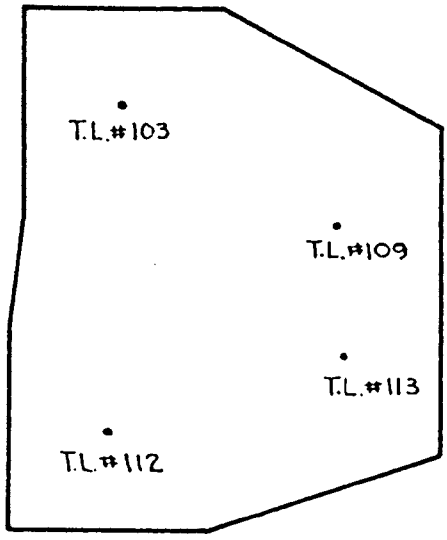
HOME RANGE OF SQUIRREL No. 3.



Home Range: 23.6 acres
Scale: 1 inch - 300 feet.

Plate 3

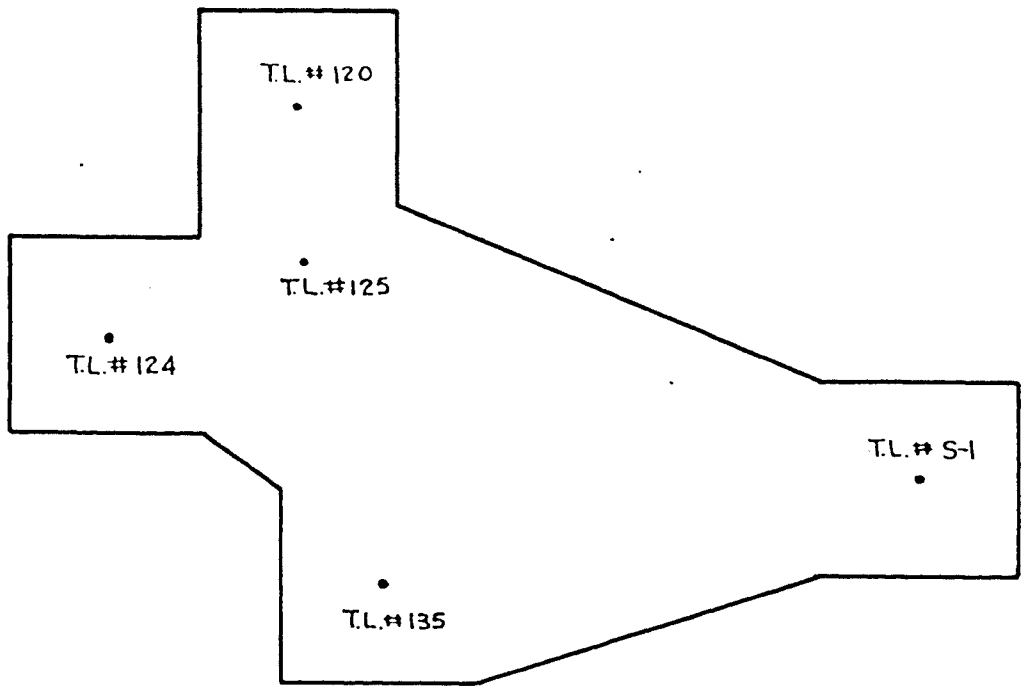
HOME RANGE OF SQUIRREL No. 6.



Home Range: 10.1 acres.
Scale: 1 inch - 300 feet.

Plate 4

HOME RANGE OF SQUIRREL No. 11.



Home Range: 18.1 acres.
Scale: 1 inch - 300 feet.

Plate 5

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