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Title: THE RELATIONSHIP OF NON-RECOVERED RODENT CACHES TO THE NATURAL REGENERATION OF PONDEROSA PINE

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Studies were conducted within a 12-mile radius of Camp Sherman, Oregon, in the Deschutes National Forest during the spring and summer of 1965 and the spring of 1966, with one follow-up visit in the summer of 1967. The feeding and foraging activities of _Eutamias amoenus_ and _Citellus lateralis_ were observed, especially in relation to the seeds and germinants of _Pinus ponderosa_. Such observations were conducted to relate the rodent activities to the overall picture of natural regeneration of _P. ponderosa_ in this area. About 75 pine seed caches which germinated in 1965 and 1966 were observed and their survival followed. Squirrel and chipmunk cheek pouch and cache contents were analyzed to relate this information to the size and source of germinating clumps. Such observations, plus observations and sampling of stands containing older pines growing in clumps demonstrated several things: 1) Where clumping occurs in this area, rodents are responsible for at least

half the pine regeneration; 2) Germinating pine clumps appear to be an important part of the early spring diet of various animals; 3) The advantages imparted to pine seeds germinating as members of rodent caches seem to outweigh the disadvantages; 4) Rodent activities--especially those of C. lateralis--are an important contribution to the natural regeneration of ponderosa pine in this area, especially following a major disturbance to the understory and/or overstory, such as by logging, road-clearing, and, in the past, fire.

The Relationship of Non-recovered Rodent Caches to the Natural Regeneration of Ponderosa Pine

by

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Inspiration and photographic help were provided by Dr. Kenneth Gordon, who took some 35 mm. color slides of animals, areas and pine clumps for me. Several of these are reproduced in black-and-white in this thesis.

Information and various materials were obtained from the Forest Research Laboratory at O. S. U., thanks to the cooperation of Ed Hooven.

The U. S. Forest Service District Ranger Station in Sisters provided local information and the multiple-use map which is depicted in Plate IV. This map is a real necessity for extensive navigating in the Deschutes National Forest, as it is the only map available which shows the myriad fire roads and logging spurs. The Sisters people also allowed access to their records of logging operations in the National Forest.

A visit to the Oregon Silvicultural Laboratory in Bend provided additional information and library references specifically related to the regeneration of ponderosa pine in central Oregon.

Credit for transportation over almost always dusty and often practically non-existent roads goes to a slightly battered green Rambler, without whose faithful and at times incredible assistance this survey would not have been possible.

Finally, I would like to acknowledge the encouragement and assistance of my parents and my husband, and the advisement by Dr. Kenneth Gordon, Dr. William Chilcote and various other members of the Departments of Zoology and Botany and Plant Pathology.

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INTRODUCTION

Much investigation and speculation has been devoted to the life of small animals in the coniferous forest, but most publications seem to concentrate upon the problems such animals present to silvicultural practices. Many publications may be found dealing with damage to lumber species by mice, squirrels, porcupines, pocket gophers, mountain beavers, rabbits and birds, as well as large mammals such as deer, elk and bears. Work dealing specifically with smaller animals, namely mice, squirrels, and birds, has been conducted by Adams (1950), Curtis (1948), Eastman (1960), Hooven (1953, 1958, 1966), Lawrence, Kverno and Hartwell (1961), Smith (1943), Smith and Aldous (1947), Spencer (1956, 1959), Squillace (1953), Stillinger (1944), Tevis (1952, 1953), and others.

This study concentrates on the effects of rodent seed cacheing upon the natural regeneration of *Pinus ponderosa* (ponderosa or western yellow pine) in the upper Metolius River area of central Oregon. This cacheing is particularly explored in relation to the two most common ground-dwelling sciurids in the area, the golden-mantled ground squirrel, *Citellus lateralis* (formerly *Callospermophilus chrysodierus*), and the yellow pine chipmunk, *Eutamias amoenus* (sometimes referred to in the literature by the more general term "western chipmunk" or the sub-species name "Klamath chipmunk").

Authors of the above-listed publications express a variety of attitudes about the role of these two sciurids and other rodents in aiding or retarding the natural or artificial reseeding of forest areas. Some of the differences of opinion have been discussed by Gordon (1943).

The majority of work done with seed-eating mammals in relation to reforestation focuses upon the deer mouse (Peromyscus maniculatus), the red squirrel (Tamiasciurus hudsonicus), and the chickaree (T. douglassii); (Adams, 1950; Curtis, 1948; Hooven, 1958, 1966; Smith and Aldous, 1947; Spencer, 1956; Squillace, 1953; Tevis, 1953a). These species are apparently responsible for the heaviest depredations upon conifer seeds.

No literature was found which emphasized extensive harmful effects of the golden-mantled ground squirrel and yellow pine chipmunk, although they have been mentioned as additional nuisances to reforestation. Various members of the genus Eutamias have been mentioned as "fairly heavy" seed-eaters (Adams, 1950; Curtis, 1948; Hooven, 1966; Smith and Aldous, 1947; Taylor and Gorsuch, 1932; Tevis, 1952, 1953; and others).

Whereas Tamiasciurus sp. store mainly entire cones in large caches above the ground, C. lateralis and E. amoenus gather individual seeds which have fallen to the ground, storing them in rock crannies, pits dug into the ground, and in their dens (Broadbooks, 1958; Cahalane, 1947; Gordon, 1943; Hooven, 1966; Tevis, 1952). Some of the non-den caches may be recovered in autumn or early winter, although this has not been reported. Those caches which are unneeded or over-looked remain in the ground until spring (Cahalane, 1947; Gordon, 1943; Hooven, 1966; Tevis, 1955; Wirtz, 1961). Unless recovered early in the spring, the over-wintered caches germinate as dense clumps of seedlings, which are found in especially large quantities after a good seed year (Hooven, 1966; Swedburg, 1961).

Several botany and zoology staff members at Oregon State University, and employees of the U. S. Forest Service in Corvallis, Sisters and Bend, have expressed a complete range of attitudes and ideas regarding the relationship of C. lateralis and E. amoenus to ponderosa pine regeneration. Some individuals expressed the idea that in certain localities where the edaphic and climatic factors are unfavorable to natural regeneration by wind seeding, successful regeneration is a direct result of the cacheing activities of these two animals. Other individuals assumed such activities to be unimportant to the total picture of ponderosa and possibly lodgepole pine regeneration.

Several authors have commented about the possibly beneficial nature of such a relationship, including Cahalane (1947), Gordon

(1943), Hooven (1966), Smith and Aldous,(1947), and Wirtz (1961). In a similar vein, Sherman (1966) has dealt extensively with clumps of bitterbrush (Purshia tridentata) resulting from non-recovered rodent caches.

The ambivalent status of C. lateralis and E. amoenus in relation to attempts at reforestation is very evident in the literature. Bailey (1931) commends chipmunks as being "of some value in the economy of the forest as seed planters," but also states: "Of systematic reforestation, however, chipmunks are probably the greatest enemies." Bailey continues by attesting to the probably beneficial seeding activities of C. lateralis, through the scattering of the squirrel's caches by other animals such as badgers, foxes and bears. He concludes, however, that "under modern methods of reforestation both squirrels and chipmunks will have to be destroyed over the areas to be planted...the most economical method of disposing of them should be employed."

Taylor and Gorsuch (1932) investigated rodent and bird influences on P. ponderosa in Arizona, concluding that "under natural conditions seed-eating rodents and birds in the long run exercise little or no detrimental effect on the reproduction of western yellow pine or other trees" due to the naturally balanced relationship of tree species to their "enemies."

Systematic logging and reforestation operations do not, however, represent "natural conditions" as implied above. Squillace (1953), as a result of studies of P. ponderosa in Montana, considers the activities of tree-dwelling squirrels to be inconvenient to organized reforestation plans, which must continue in poor and fair seed years when squirrel predation is most serious. Thus he recommends that until the interactions of mice and squirrels in such programs are better understood, methods of control of these rodents should be applied.

Cahalane (1947) comments that chipmunks may sometimes prevent reseeding "during the critical year or two following logging" but that "at other times the chipmunks give valuable assistance by carrying tree seeds into burned areas and forgetting some caches which sprout and grow." In addition, "a great many forest-damaging insects go into their ever-hungry mouths." He speaks similarly of the golden-mantled ground squirrel: "while they eat many tree seeds, they probably help the forest more than harm it, by planting (caching [sic]) numerous others and failing to eat them." Grinnell and Storer (1924) venture an almost identical statement about Eutamias speciosus in the Yosemite area.

Sumner and Dixon (1953) recognize C. lateralis and E. speciosus as "industrious" foresters who help "to perpetuate the forest." Hoffman (1943) credits the rodents with distributing seed to grassy slopes and other areas where the surface duff might otherwise be too heavy to allow a surface-germinating seedling to establish an adequate root system before desiccating.

Perhaps the most extreme attitude is expressed by Jaeger (1929), quoting E. R. Munns:

> Many areas which normally would be without timber have been seeded by the action of the chipmunk who buries small pockets of seeds during periods of heavy seed abundance, and my own feeling is that on many of our forest areas the presence of reproduction is due entirely to the action of this very busy little rodent.

Obviously, more extensive studies of population composition and fluctuation, home ranges, and overall food habits, such as those done by Hooven with the deer mouse (1958, 1966) in the Douglas fir forest of the Oregon part of the Coast Range, are needed to arrive at a compatible understanding.

Whether or not non-recovered rodent caches actually do represent an important contribution to the natural regeneration of ponderosa pine is the question which gave impetus to the present study, which represents a survey of the situation in the Metolius and Sisters Districts of the Deschutes National Forest. This area seems well-suited to such a study (not to mention subsequent, more intensive investigations) because of accessibility and status as national forest land.

Since being incorporated into the national forest program, the area has been subject to complete records of the logging activities carried out as part of the over-all, coordinated program of forest management. These records have been accumulating at the District

Ranger Station in Sisters. Thus it is possible to go into a given section of the forest knowing the date of the last major disturbance in the area. Also, the area has been free of major forest fires (uncontrolled burning) since the establishment of the Ranger station, according to information received in conversation with the U. S. F. S. staff at Sisters.

With these data and speculations as a foundation, observations were begun during the spring of 1965 to determine the size, abundance and substrate characteristics of clumps germinating in the spring, the survival of these new seedlings over a period of one to two years, the source of clumps (observed and inferred), the size, age, abundance and survival of clumps which had grown into seedlings, saplings, nearly-mature or mature trees, the relative number of clumped to singly growing trees in specific areas, and, if possible, the overall significance of clumping to forest growth.

Although more research along these lines is necessary for a decisive analysis, it is hoped that the observations and conclusions reported here will contribute to a better understanding of the total range of coactions in the P. ponderosa community.

DESCRIPTION OF STUDY AREA

Location

The area in which studies were conducted, from April to October of 1965 and spring 1966, includes a number of localities within an approximate 12-mile radius of Camp Sherman, on the east flank of the Cascade Range in Deschutes County, central Oregon. This area within the *P. ponderosa* belt ranges from 121° 34' to 121° 41' west longitude and from 44° 19' to 44° 25' north latitude.

Most of the investigation took place within coordinates T. 13S, R. 9E and T. 14S, R. 9E, U. S. Geological Survey Map, Sisters Quadrangle, 1959. Counts and samples were taken in 16 of the 72 sections within the two townships, although observations were made in at least 40 sections, wherever the roads were passable. In addition, samples were taken in three sections of neighboring townships, and many of these peripheral sections were used for general observations.

Physical Features

The elevations in the area traversed during the study vary from approximately 2800 to 5000 feet above sea level. Most observations were made between elevations of 3000 and 4000 feet, the "heart" of the ponderosa pine belt.

The climate is characterized by a low level of precipitation, spread more or less evenly throughout the year, and a more than 100° F. range of temperature extremes. As reported in Sherman (1966) the average precipitation in inches for the nearest town, Sisters, during the period 1921-1934 was 2.64 inches for January and 0.68 inches for July. The annual precipitation average for the same period was 16.65 inches. Similarly, the average precipitation figures for the 1959-1967 period were 2.55 inches for January, and 0.31 inches for July, for an annual average of 13.98 inches.

The average temperatures from 1959-1967 were 31.8° F. for January and 62.2° F. for July, although these moderate averages do not reflect the extremes to which the area is subjected. Listed below are pertinent precipitation and temperature data for 1962-1967, the period bracketing the time of observations for this study.

	Precipitation in Inches			Temperature Extremes (F.) and Dates	
	Jan.	July	Annual	High	Low
1962	1.87	0.01	13.85	95 (7-23)	-28 (1-22)
1963	2.21	0.36	12.94	99 (9-27)	-16 (1-12)
1964	3.48	0.09	20.20	99 (7-27)	-16 (12-17)
1965	3.05	1.37	11.80	92 (7-16)	- 2 (12-17)
1966	3.35	0.78	11.57	95 (8-2)	+ 6 (12-10)
1967	4.06	0.00	12.59	100 (8-19+)	- 6 (12-15)

The basic geology is dominated by the results of great volcanic activity in the Cascade Mountains, and the soils are relatively young and uniform mixtures of pumice and gravelly glacial outwash (West, 1964). Johnson (1961), Swedburg (1961) and West (1964) have reported extensively on the geology and soils of the area.

Vegetation

The dominant overstory species is ponderosa pine, which grades into western juniper (*Juniperus occidentalis*) to the east and grand fir (*Abies grandis*) to the west. (Considerable confusion can arise as to the identification of individual fir trees, since although most authors refer to the tree as *A. grandis*, there is also overlap and hybridization with white fir, *A. concolor*; (Swedburg, 1961; West, 1964).)

Within the ponderosa forest of the study area, the understory vegetation forms a gradient which seems directly related to elevation and moisture conditions. This gradient is therefore of an east-west nature, down the east slope of the Cascades into the desert beyond Sisters. In places local topographical features provide sufficient altitudinal relief to simulate these east-west effects.

Four tree species, four shrub species and one grass were used to characterize the dominant vegetational patterns, although other representatives of these three categories were also present. The trees used as indicators during the course of observations are ponderosa pine, grand (white?) fir, incense cedar (*Libocedrus decurrens*), and western juniper. Dominant understory shrubs used were buck-brush (Ceanothus velutinous), bitterbrush (Purshia tridentata), manzanita (Arctylostaphylos patula and/or A. parryana var. pinetor-um--see West, 1964), and green rabbitbrush (Chrysothamnus viscidiflora). The distinctive grass is Idaho fescue (Festuca idahoensis).

The community patterns formed by these species are presented in diagram form in Figure 1. Very complete vegetational analyses within this area have been presented by Johnson (1961), Swedburg (1961), and West (1964).

Fauna

During the spring, summer and fall of 1965 a number of animals were identified by the author, alone and in the company of Dr. Kenneth Gordon of Oregon State University and, on one occasion, members of the Oregon Audubon Society. Although systematic efforts to identify all the fauna of the area were not attempted, records were kept of vertebrates encountered in the course of investigation. These are listed below, with an asterisk (*) designating the forms which were most commonly observed.

Despite several attempts to capture specimens with a mist net, the bats* which were present nocturnally in fairly large numbers were not identified. Carnivores seen include a weasel (probably

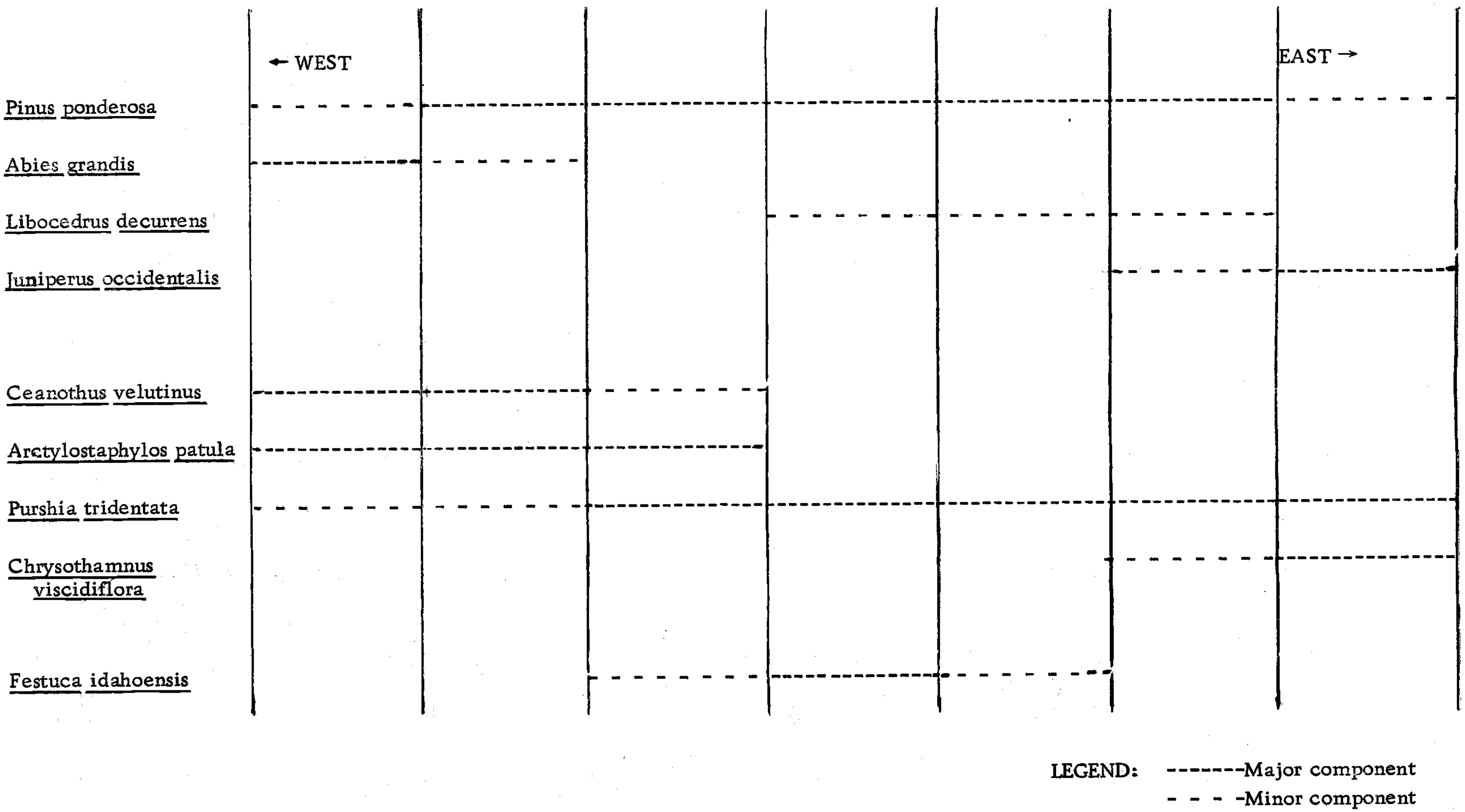


Figure I. Plant community gradient in the Pinus ponderosa belt including Camp Sherman, Oregon.

Mustela erminea), badger (Taxidea taxus), coyote (Canis latrans), gray fox (Urocyon cinereoargenteus), and bobcat (Lynx rufa). Although no bears were seen, climbing scars are present on a quaking aspen (Populus tremuloides) at Prairie Water Development #1. This is an indication of at least the past presence of a bear in the area, probably Ursus americanus.

A number of sciurids were observed, including the yellow-bellied marmot (Marmota flaviventris), Belding ground squirrel (Citellus beldingi), golden-mantled ground squirrel* (Citellus lateralis), Townsend's chipmunk (Eutamias townsendii), yellow pine or western chipmunk* (E. amoenus), western gray squirrel (Sciurus griseus), and chickaree* (Tamiasciurus douglassii).

A variety of other rodents are in the area. There is ample evidence of the presence of pocket gophers (possibly Thomomys talpoides or T. monticola [T. mazama]). The waters and shores of Indian Ford Creek showed recent activity by beavers (Castor canadensis), as there were many gnawed aspens and other fresh signs. The porcupine* (Erethizon dorsatum) seems to be abundant, as evidenced by many ponderosa pines which have been partially debarked plus a number of road-killed porcupines. The crepuscular or nocturnal deer mouse (Peromyscus maniculatus) is probably abundant, although few were actually observed, and runways such as those constructed by voles (Microtus sp.) were noted at Indian

Ford. Other mice may also be present.

Although not observed, the mountain cottontail (Sylvilagus nuttallii) is probably present. The characteristic large browser in this area is the mule deer* (Odocoileus hemionus).

Many birds were present in various localities throughout the summer. Observed were the Great Blue Heron, some unidentified ducks, Turkey Vulture, Red-tailed Hawk*, Goshawk*, Bald Eagle, Mourning Dove*, Common Nighthawk*, Poor-Will (abundant under the pines after seed-fall began in September), Kingfisher, Red-shafted Flicker*, Yellow-bellied Sapsucker*, Williamson's Sapsucker, Hairy Woodpecker*, Downy Woodpecker*, White-headed Woodpecker, Empidonax flycatcher, Western Wood Pewee, Olive-sided Flycatcher, Gray (Canada) Jay, Steller's Jay*, Common Raven*, Clark's Nutcracker (east of the study area, on lava), Mountain Chickadee*, White-breasted Nuthatch*, Red-breasted Nuthatch*, Pygmy Nuthatch*, Dipper, Robin, Varied Thrush (briefly during the spring), Hermit Thrush (voice identification), Western Bluebird*, Mountain Bluebird*, Townsend's Solitaire, Audubon Warbler, Black-throated Gray Warbler, Hermit Warbler (?), Wilson's Warbler, House Sparrow, Red-winged Blackbird*, Brewer's Blackbird*, and Western Tanager. A variety of fringillids were seen, including the Black-headed Grosbeak, Lazuli Bunting, Cassin's Finch, Pine Siskin*, Red Crossbill*, Green-tailed Towhee, Vesper

Sparrow, Oregon Junco, Chipping Sparrow and Fox Sparrow.

Only one reptile was seen, that being a pygmy horned lizard (Phrynosoma douglassii) found on a lava flow east of the study area at about 5000' elevation. Some species of garter snake (Thamnophis sp.) would be expected although none was seen. The only amphibians encountered were the western toad (Bufo boreas), western tree frog (Hyla regilla), and Cascade frog (Rana cascadae).

The Metolius River is noted for its trout, there being several species present, including the regularly stocked rainbow trout. Since this study was of terrestrial environmental situations, piscine inhabitants of the area were not surveyed.

METHODS

Newly-germinated Seedlings

The first problem encountered involved the actual finding of clumps of germinating P. ponderosa. This was accomplished by extensive early spring "ground-watching" excursions, especially to recently disturbed areas in various sections. Once located, the clumps were given an identifying number, described, and in many cases photographed.

To mark the clumps, several methods were attempted before one proved satisfactory. Lath stakes inscribed with a permanent marking pen ("Magic Marker") were unsatisfactory, due to bulk and inconvenience of handling. The possibility that these prominent stakes would appeal to the curiosity of various animals, thereby decreasing chances of clump survival, was also considered.

Clothes-hanger wire stakes with number-bearing tape "flags" about 15 inches above ground level were tried next. These were soon rejected, as they were dug out at the base and knocked down by rodents eager to chew off the tape.

Finally, aluminum wire stakes approximately four feet long and number-embossed aluminum tags were borrowed from the Forest Research Laboratory in Corvallis. These proved satisfactory, although in one area the stakes disappeared, presumably due to human activities. The newly-germinated clumps thus marked were observed periodically to follow their survival.

Two newly-germinated clumps in an area with an abundance of such clumps were enclosed by $\frac{1}{2}$-inch wire mesh cages. These cages protected the clumps on five sides, including the top, and were anchored firmly to lath stakes pounded into the ground on two sides. Losses to these clumps could then be attributed to insects, disease, or direct competition between clump members.

Although they were much more difficult to notice, a number of individually-germinating seedlings were also found and marked. One fairly large bare ground area was measured out and staked, as it contained a large number of singly-growing germinants as well as some clumps. The dimensions of this rectangular area were one chain by one-third chain (66 feet × 22 feet). The survival of germinants within this area was followed.

Since some of the newly-germinated clumps were quite large, the question arose as to whether or not each cache was the result of one or several rodent "deposits." To investigate this, several C. lateralis were collected for cheek pouch analysis. After attempts at trapping proved unsatisfactory for this purpose, specimens selected for having full cheek pouches were collected by shooting. In addition, some were found dead on the roads. Cheek pouch and mouth contents of these individuals were examined and recorded.

One newly-dug mantled ground squirrel cache was excavated and the contents counted.

Year-old to Mature Trees

Counting Methods

Several methods were used to survey areas where the trees had germinated in preceding years. Major areas were selected on the basis of the presence of clumped individuals, so the sampling cannot be considered random. However, both singly-growing and clumped trees were counted in the areas selected to allow comparisons between them.

Early in the study, attempts were made to establish a uniform means of transect sampling. Due to the experimental nature of these transects, the dimensions vary, ranging in length from 50 to 100 feet, although the width was set at eight feet. With this width, one could walk the center, making observations four feet to each side. While interesting, these few transects did not prove useful.

Considering the large area and survey nature of this study, the most effective methods proved to be individual stand counts and roadside transects. By the former method, trees growing in discrete stands were counted and described. This method allowed observations over a fairly large territory within a relatively short time, and accounts for a high percentage of the data.

The second method was utilized where growth was continuous and discrete stands could not be distinguished. By this method, the automobile odometer was used to "clock" 0.1 mile distances. Beginning at an "X" point, trees were counted for 0.1 mile, from the edge of the road to a depth of about eight to ten feet into the forest. The next 0.1 mile was skipped. Then trees were counted for 0.1 mile, etc.

Notation for the stand and roadside transect counts was devised to show both the number of trees and the manner of growth. Thus two columns were used, one for "clumps" and one for "singles." Within a given stand or transect the singles were simply counted and totals recorded. A clump of trees was, however, indicated by a circle around the number of trees in the clump; for example a clump of six trees was recorded as (6). This proved an easy way to keep track of both the number and composition of clumps. Clumps frequently contained dead members, requiring a modified notation; for example, a clump of six with three dead members was indicated (6-3), a clump of 15 with two dead members was indicated (15-2), and so forth.

Terminology used to describe trees by size class is as follows: "seedlings" are trees generally less than three feet in height; "saplings" are those between three feet and about 30 feet in height;

"nearly mature" includes trees exceeding about 30 feet in height but still possessing the blackish, juvenile bark; "mature" trees are those which have shed the dark bark to reveal the characteristic flaky, reddish bark of the ponderosa pine.

Aging Methods

No matter what the age, clumps of ponderosa pine frequently contain members of greatly disparate sizes. Thus the question arose as to whether or not all members of a clump were the same age, a necessary requisite if they originated from a rodent cache. To test this, samples of clumps of various sizes and ages were collected for subsequent laboratory analysis.

With the smaller seedlings it was possible to take an entire section of the stem, or trunk, the size that could be collected being determined by the diameter of the vials used. Radial sections or chunks of the trunk were collected from the larger seedlings and smaller saplings. For trees with a diameter exceeding four or five inches, a core drill (increment bore) was used, thus eliminating the necessity of destroying the trees, as was done with smaller individuals. Each sample was taken at a uniform height from the ground within a clump, at or near the base of the trunk. These samples were labelled, described, and preserved in 40-50% alcohol.

In the laboratory, each sample was trimmed and sectioned by hand for examination under a binocular microscope. Visibility was improved in most cases by briefly dipping the slice first in safranin, then in fast green. In some cases the annular rings were so compressed radially that it was necessary to use a monocular microscope to study them. In addition to age data, radial measurements of the wood (xylem) were recorded.

Animal Observations

Much time was devoted to watching the daily activities of *C. lateralis* and *E. amoenus*, especially in regard to their food-gathering activities. As many observations in as many different areas as possible were attempted, usually from the "blind" provided by the car. Binoculars were also a necessary tool for these observations.

OBSERVATIONS

Autumn Sciurid Activities

Foraging

Falling of pine seeds was first noted within the study area on September 9, 1965, and the Sisters Ranger Station reported that seeds had begun to fall elsewhere within the district about four days earlier.

A number of observations of ponderosa pine seed collecting by C. lateralis and E. amoenus were conducted in hopes of discovering the site of newly-made caches to follow through the following spring and summer. Most of the foraging for fallen ponderosa pine seeds was observed in T. 13S, R. 9E, sections 23 and 24, mainly along Road 139E. An attempt was made to arrive at these areas before the ground squirrels and chipmunks began their morning activities, so that they would not be disturbed.

The chipmunks were found out on the red cinder road before 6:45 a.m. (Pacific Standard Time). Most of the golden-mantled ground squirrels arrived somewhat later, about the time the rising sunlight struck the shadow of Green Ridge from the road. As the ground squirrels increased in number, the chipmunks gradually departed.

From about 7:30 to 9:30 a.m. the light was angled such that pine seeds were easily seen for some distance along the road due to the silvery reflection of light from the seed wings. In gathering seeds, the ground squirrels picked up a seed with both front paws, clipped off the seed wing and stuffed the seed into their cheek pouches. This entire process of collecting a seed took only one or two seconds. Occasionally, it appeared that seeds were consumed immediately.

As they foraged, quartering over the road, the animals often approached each other closely. An encounter within about 12 inches usually resulted in a brief mutual glare and a change of direction by one or both individuals. There were also frequent short chases, with what appeared to be the younger (smaller) squirrel retreating.

After concentrating for the first hour on seeds lying conspicuously upon the road, the ground squirrels gradually began to move into the adjacent open forest. Perhaps their habit of visiting the road first is an indication of the greater ease with which the seeds may be collected there. It is probable that without the attentions of various rodents and birds these seeds would go to waste, due to traffic on the road.

Including foraging observed both on and off the road, the morning active period for C. lateralis was about 7:00 to 10:00 a.m. Another active period from about 3:00 to 5:30 p.m. seemed to be a regular part of the daily behavior of these animals, barring a slight rain shower which might send all ground squirrels in the vicinity scurrying for shelter. A similar daily routine is reported by Wirtz (1961) for C. lateralis at Crater Lake, Oregon.

In these frequent and enduring observations, no ground squirrels or chipmunks were actually observed in the process of making a cache along Road 139E. It did become obvious, however, that many of the pits in the soft earth bordering the road were due to "false starts" at making a cache. One ground squirrel with full cheek pouches was observed digging and abandoning five pits before finally moving out of sight, still with full cheek pouches. A number of other individuals were also seen digging frequently in this manner, without actually making a cache.

These "false starts" plus attempts to recover hypogeous fungi (see discussion of food habits) left a rather pocked terrain in many areas, especially where the soil was soft from recent disturbance to begin with.

Cheek Pouch and Cache Contents

Six golden-mantled ground squirrels and one yellow pine chipmunk were collected for cheek pouch analysis. As mentioned in Methods, most of these were shot, although the chipmunk and two of the squirrels were found dead on the road.

The chipmunk was carrying 33 ponderosa pine seeds, and the ground squirrels had from 62 to 130 ponderosa seeds in their cheek pouches. The squirrel with 130 seeds was so "chock-full" that several of the seeds were actually being carried in its mouth. One of the ground squirrels was also carrying several strips of dark brown fungi, probably a hypogeous Tuberales of some type.

The actual deposition of a cache was observed at Bridge 99 ("Lower Bridge" on the map, T. 12S, R. 9E, section 2). The behavior of the young golden-mantled ground squirrel making the cache was as follows: look around--sniff ground--look around again--dig furiously--stop to look around--dig some more--stop to look in all directions--poke head into pit, emptying pouches by pushing rapidly and repeatedly against cheeks and throat with forepaws--look around again--fill pit by digging beside it, kicking dirt backward into pit--pat down dirt with forepaws--look around quickly--reach around and pull in adjacent dirt with forepaws--stretch out over now-covered cache, rubbing belly and hind legs across surface--stand up--look around--scamper away.

After this performance was completed, the site of the cache was examined. The only evidence of surface disturbance was about two inches from the cache, where the dirt had been dug out to fill the cache pit. The dirt had been tamped down so firmly and smoothed over so neatly that the exact location of the cache was difficult to determine. However, once excavated, the cache was found to contain

92 ponderosa pine seeds--a sizeable load for a squirrel so small.

Newly-germinated Material

1965 Clumps

Observations of rodent caches which germinated in the spring of 1965 are summarized on Table 1. The information was collected in two major areas, as indicated by the map coordinates. For convenience, these will be referred to as "Road 1424" (T. 14S, R. 9E, sections 26, 35) and "Indian Ford" (T. 14S, R. 9E, section 13).

The basic ground surfaces in the two areas differ mainly in respect to moisture and surface litter. The Road 1424 sites are somewhat drier, with less needle and bark litter covering the ground. Being near Indian Ford Creek, the Indian Ford site is moister, and the needle litter is very heavy in places. Evidence of the moister situation at Indian Ford is the presence of fairly lush grass and herbaceous growth adjacent to and including part of the observation area.

At Road 1424, 26 clumps of newly-germinating pines, containing a total of 558 germinants were initially marked for observation. The average clump size was 21.46 individuals, although the number per clump ranged from two to 72. After one week, only 34.77% of the young trees remained. This loss was attributed primarily to feeding by various animals (see Discussion). In ten cases, the entire clump was destroyed. Three clumps which could not be re-located are noted as NR (no record).

By the end of two months, five of the original 26 clumps had survived, accounting for only 2.34% of the initial number germinants. No observations were recorded for this area two years later. Although there may have been some survival, the site was largely destroyed by forest-clearing or road maintenance activities.

At Indian Ford, 13 clumps of new germinants, with a total of 240 individuals, were followed. The average clump size was 18.46, with a size range of three to 52 pines per clump. After one week (NR not included) 41.67% of the germinants had survived. After two months 29.17% of the initial number still existed, losses again being attributed to animal feeding.

At the time of the two-year check at Indian Ford (1967) the area had been badly disrupted, apparently due to horseback riding. Many of the wire stakes had completely disappeared, and the five clumps which were found accounted for a total of only three seedlings.

1966 Clumps

In the spring of 1966 germinating clumps were again marked and observed near the 1965 sites. This was to provide additional information on the events of the first week following germination.

Table 1. Survival of clumps germinating in 1965.

Clump no.	Location	Seedlings germinated	Survivors one week	Survivors two mos.	(Survivors) (two years)
1	T. 14S, R. 9E	11	2	1	NR
2	Sections 26, 35	22	0		
3	off road 1424	11	0		
4		30	0		
5		12	0		
6		12	12	0	
7		2	2	0	
8		5	0		
9		19	5	0	
10		28	0		
12		2	0		
14		6	NR		
15		6	NR		
16		26	0		
17		72	2	1	NR
18		47	50	3	NR
19		37	NR		
21		30	0		
22		50	4	2	NR
23		9	18	0	
24		37	39	0	
25		45	17	NR	
26		9	0		
27		9	8	NR	
28		15	14	NR	
37		6	4	4	NR
	SUMMARY OF AREA	558	177	11	0
	26 clumps, 558 seedlings germ., ave. 21.46 seedlings per clump; one week survival (NR's not included): 34.77% of seedlings; two months survival (NR's not included): 2.34 % of seedlings.				
29B	T. 14S, R. 9E	12	11	1	NR
30B	Section 13	15	15	5	NR
31	Indian Ford	16	10	10	0
32		21	21	20	NR
33		52	13	10	NR
34		16	8	7	2
35		13	0		
36		51	0		
38		5	6	6	0
39		10	6	5	1
40		3	2	2	0
41		16	8	0	
42		10	NR	4	NR
	SUMMARY OF AREA:	240	100	70	3
	13 clumps, 240 seedlings germ., ave. 18.46 seedlings per clump; one week survival (NR's not included): 41.67% of seedlings; two months survival; 29.17% of seedlings.				
	TOTALS:	798	277	81	
	PERCENTAGES		37.48% (of 739)	11.64% (of 696)	

Table 2. Survival of clumps germinating in 1966.

Clump no.	Location	Seedlings germinated	Survivors one week	(Survivors) (one year)
43	T. 14S, R. 9E	34	8	NR
44	Section 13	30	0	
45	Indian Ford	19	1	NR
46		28	1	NR
47		10	0	
48		31	0	
49		13	0	
50		6	1	NR
51		2	2	NR
52		39	30	NR
53		16	0	—
	SUMMARY OF AREA:	228	43	0
	11 clumps, 228 seedlings germ., ave. 20.73 seedlings per clump; one week survival: 18.85% of seedlings			
54	T. 14S, R. 9E	4	1	1
55	Sections 26, 35	9	0	
56	off road 1424	5	0	
57		13	0	
58		8	6	NR
59		8	4	0
60a		4	3	0
60b		8	4	0
61		8	4	0
62		8	7	0
63		13	11	0
64		5	3	0
65		8	8	0
66		5	2	0
67		5	2	0
68		5	5	NR
69		9	6	NR
70		6	4	0
71		7	7	0
72		5	5	0
73		6	5	0
74		22	9	2
	SUMMARY OF AREA:	171	96	3
	22 clumps, 171 seedlings germ., ave. 7.77 seedlings per clump; one week survival: 56.14% of seedlings			
	TOTALS:	399	139	
	PERCENTAGES:		34.84%	

The 1966 data is presented on Table 2.

At Road 1424, 22 clumps marked contained an initial total of 171 germinants, for an average of 7.77 per clump. These showed 56.14% survival after one week. When checked again in 1967, only three of the original 171 seedlings were found.

The Indian Ford site provided 11 clumps with 228 individuals. Each clump contained an average of 20.73 individuals, and after one week only 18.85% of the 228 survived. In 1967 no additional data could be recorded due to the disappearance of stakes and trampling of the area as noted above.

1965-1966--First Week Summary

Combined data from Road 1424 and Indian Ford shows that after one week beyond germination about 37.48% of the 1965 germinants survived. The average for 1966 is 34.84%, for a two-year average of 36.16%. The average size of the germinating clumps for these two years is 17.11 individuals per clump.

Caged Clumps, 1965

The two clumps of new germinants that had been caged in the Road 1424 area were observed repeatedly during 1965 and 1966, with one final check in 1967.

Clump 29A was initially composed of 21 germinants. After two weeks, four latecomers increased this number to 25. By the end of two months, 22 seedlings were alive. Three had withered up, presumably as a result of competition for moisture or some other non-animal-related factor. The remaining 22 germinants persisted through April 1, 1966, and by July 22, 1967, 20 remained.

Figures K and L (Plate II) show 29A as it appeared in July, 1967. Its protective cage lies crushed behind it, a casualty of forest-clearing operations. It is interesting to note that on one of these two-year-old seedlings the withered cotyledons have persisted, with the seed hull still clinging to them (Figure L).

Like 29A, clump 30A germinated beneath a nearly bare surface and was caged to follow its development free from the influence of birds and rodents. Of the 33 germinants, three shriveled up by two months time, and after four months only 11 had survived. Figure J (Plate II) shows 30A at two months. Although all clump members appear light-colored in the photograph, only the three prostrate or nearly-prostrate plants are dead. The very light appearance of the foliage is due to the dying cotyledons (yellowish, in life). The slightly darker (green, in life) cluster of true needles can be seen inside the cotyledons, especially on the plant farthest to the left.

In July, 1967, no remnant of 30A or its cage could be found.

Individual Germinants, 1965

The bare area transect near Road 1424 initially contained 40 singly-germinating pines. After one week, only eight of the original 40 remained, and five new ones had appeared. After two weeks, one marked germinant was lost and nine new ones were found. After three weeks three more marked individuals were lost.

Thus 18 (33.3%) germinants had survived out of a total of 54 which were marked and observed over a three-week period.

Damage to Germinants

Most of the mortality among the newly-germinated pines is presumed due to the feeding activities of various animals, particularly rodents (see Discussion). In most cases, damage was in the form of clipping off of the top of the germinant.

The least injurious degree of clipping involved the removal of the seed hull and the terminal portions of the cotyledon which still supported the hull. Damage of this type can be seen in Figure M (Plate III), and did not result in permanent damage, as only the temporary part of the plant was affected.

The second degree of damage involved almost complete clipping of the bunched up cotyledons and newly-developing leaves, down to but not including the meristematic tissues composing the stem apex.

This did not usually prove fatal to the germinants and most were able to survive without cotyledons until the first whorl of true leaves developed. Perhaps this survival without photosynthetic leaves is facilitated by photosynthesis in the stem, which is as bright green as the cotyledons during the first month or so of development.

The degree of clipping which always proved fatal involved the removal of both the cotyledons and the apical meristem. Frequently entire clumps were destroyed in this manner, with all the germinants decapitated.

A few fatalities occurred where germinants were nipped in the stem, or perhaps stepped on by man or some other heavy animal, so that the stem was broken but not entirely severed.

In some instances, the bases of germinating clumps had been partially excavated, bringing to the surface seeds which had just opened in preparation for the emergence of the radicle, or embryonic root. This situation occurred in combination with all degrees of clipping as described above.

Year-old to Mature Trees: General Observations

Seedlings

Seedlings were generally found in smaller clumps than germinants, as might be expected after a few years of competition and utilization as a food source by various animals. However, clumps two and three years of age often contain a large number of seedlings, at times as many as in newly-germinated clumps.

Disparity of size within a clump is frequently observed, even in fairly young seedlings, as illustrated in Figure N (Plate III). By comparison, Figure O (Plate III) shows a rather evenly-sized group of seedlings.

Browsing damage was frequently observed, resulting in stunted, multi-leader trees which may actually deserve to be classified in the "sapling" category were it not for the efforts of mule deer and possibly rabbits.

Chipmunk and ground squirrel damage to seedlings was not noted, which seems to indicate that these animals are concerned only with the seed and germinant stages of the ponderosa pine life cycle.

Saplings

A clump of saplings in which six trees have persisted is shown in Figure P (Plate III). Again a wide difference in size among clump members is demonstrated. By the time they are saplings, ponderosa pines may produce cones, so that they once again receive the attention of seed-eating rodents. Saplings are also seen as the victims of de-barking by porcupines.

Trees of sapling size in the Deschutes National Forest become subject to selective cutting by the Forest Service, which thereby performs the thinning role previously played by fire. Along Fire Road 42 (T. 13S, R. 9E, sections 20 and 21) a number of stands which were counted for this study had been thinned in this manner. Since regeneration in this area is extremely dense (difficult at times to walk through), singly-growing saplings as well as clump members had been cut down.

The density of regeneration in these sections and the uniformity of sapling size seems to indicate the area regenerated after complete or nearly complete clearing.

Nearly-mature and Mature Trees

For the most part, clumps of these age groups range from two to five trees per clump, and are not as abundant as younger clumps. However, at Prairie Water Development #1 (T. 13S, R. 9E, section 24) a high number (more than 40) of nearly-mature and mature trees may be seen growing in clumps (Table 3).

When nearly-mature or mature trees are found in clumps, there are frequently dead members, as in the mature clump shown in Figure Q (Plate III). In addition, it is typical to find that the trees are spaced farther from each other than in the younger groups. This is due to many years of growing away from each other, with accompanying basal expansion. It is not unusual to find a pair of mature trees arising from the ground so closely that the lower 12 to 20 inches of the trunks appear to be fused.

Year-old to Mature Trees: Results of Counting

Relative Frequencies, Clumped and Singly-growing Trees

All data pertinent to the stand counts and transects taken where clumped ponderosa pines were present is shown in Table 3. Each count is given a reference number (1 through 39) to correlate information on Tables 3, 4, and 5.

Township and range coordinates for the counts refer to the multi-use Forest Service map depicted on Plate IV. "Size Class" categories have been explained under Methods.

"Clump data" for each count, as presented in columns A through D, includes: A--number of clumps; B--total number of trees in all clumps; C--clump size range; D--average number of trees per clump.

As can be seen, the number of clumps per count (A) ranged from three to 75, involving from ten to 162 trees (B). However, these raw figures are not useful for direct comparisons, since the counts were not equivalent in area. The number of trees per clump (C) ranged from two to 21 (not including germinants) with clump size averages (D) among these counts ranging from 2.11 to 6.71. The total number of clumps counted was 896, involving 2822 pines, for an average size of 3.15 trees per clump.

The major factor in size of a clump seems to be age. The overall clump size averages (trees per clump) are as follows, with the number of counts included in parentheses: germinants, 16.41 (2); seedlings, 5.05 (6); saplings, 3.20 (10); nearly mature trees, 2.60 (1); mature trees, 2.56 (3). Counts with mixed categories are not included in these averages.

Table 3 also reports the number of singly-growing individuals and the combined total (clumped plus singly-growing) of individuals in each count. A total of 3424 singly-growing pines were counted, for a combined figure of 6246 individuals.

Although the linear dimensions of all areas are not known, it is possible to determine a relationship between the number of individuals growing in clumps and those growing singly. This can be done by expressing clumped individuals as a percentage of the total number of individuals in each count. Summarizing all counts, an average of 45.18% of all the individuals were growing as clump members. The lowest percentage was 13.51% in count #29; the highest in count #30, with 97.22%.

The final three columns of Table 3 include information as to the type of count (stand or measured), with areas and frequency

Table 3. Data for comparison of clumped and singly-growing trees.

Observation no.	Location	Size class	Clump data A	B	C	D	Single indiv.	Total indiv.	% of indiv. in clumps	Area in sq. yds.	Clumps per yd^2	Singles per yd^2
1	T. 12S, R. 10E, Sec. 32	saplings	32	114	2-9	3.56	73	187	60.96	SC		
2	T. 13S, R. 9E, Sec. 1	all ages	36	111	2-7	3.08	45	156	71.15	528.00	0.0681	0.0852
3		all ages	36	96	2-5	2.67	59	155	61.93	528.00	0.0681	0.1117
4	T. 13S, R. 9E, Sec. 10	sap, n. mat.	32	84	2-6	2.62	100	184	45.65	SC		
5		saplings	25	68	2-7	2.72	95	163	41.71	SC		
6		sap, n. mat.	10	25	2-5	2.50	32	57	43.85	SC		
7		sap, n. mat.	25	60	2-5	2.40	79	139	43.16	SC		
8		saplings	51	132	2-6	2.58	168	300	44.00	SC		
9		saplings	52	131	2-6	2.52	129	260	50.38	SC		
10	T. 13S, R. 9E, Sec. 20	saplings	19	99	2-19	5.21	81	180	55.00	242.00	0.0785	0.3347
11		saplings	55	188	2-18	3.42	501	689	27.28	183.33	0.3000	2.7327
12		saplings	27	96	2-8	3.56	165	261	36.78	116.67	0.2314	1.4142
13	T. 13S, R. 9E, Sec. 23	sap, n. mat.	11	36	2-5	3.27	36	72	50.00	SC		
14		sap, n. mat.	32	85	2-7	2.65	38	123	69.10	528.00	0.0606	0.0719
15		sap, n. mat.	59	195	2-11	3.30	96	291	67.01	SC		
16	T. 13S, R. 9E, Sec. 24	sap, n. mat.	26	57	2-5	2.19	147	204	27.94	SC		
17		mat., n. mat.	6	19	2-6	3.17	9	28	67.85	SC		
18		mature	10	22	2-3	2.20	25	47	46.80	SC		

(Continued)

LEGEND: sap = saplings n. mat. = nearly mature SC = Stand Count A = number of clumps
B = number of trees in clumps C = clump size range D = average number of trees per clump

Table 3. (Continued)

Observation no.	Location	Size class	Clump data A	B	C	D	Single indiv.	Total indiv.	% of indiv. in clumps	Area in sq. yds.	Clumps per yd^2	Singles per yd^2
19	T. 13S, R. 9E, Sec. 24	n. mature	15	39	2-6	2.60	61	100	39.00	SC		
20		sap, n. mature	20	49	2-3	2.45	50	99	49.49	SC		
21		mature	6	13	2-3	2.17	4	17	76.47	SC		
22		saplings	32	79	2-4	2.47	75	154	51.29	SC		
23		mature	4	11	2-4	2.75	5	16	68.75	SC		
24	T. 14S, R. 9E, Sec. 4	sap, n. mat.	33	74	2-8	2.24	204	278	26.61	SC		
25	T. 14S, R. 9E, Sec. 5	sap, n. mat.	75	162	2-6	2.16	347	509	46.68	SC		
26		sap, n. mat.	11	26	2-3	2.36	67	93	27.95	SC		
27		seedlings	9	19	2-3	2.11	159	178	10.67	SC		
28	T. 14S, R. 9E, Sec. 13	germinants	8	149	4-52	18.62	6	155	96.12	} 88.89	0.1237	0.7874
29		seedlings	3	10	2-5	3.33	64	74	13.51			
30		germinants	5	71	2-40	14.20	1	72	97.22	} 44.44	0.2475	1.1026
31		seedlings	6	32	3-12	5.33	48	80	40.00			
32	T. 14S, R. 9E, Sec. 15	sap, n. mat.	6	13	2-3	2.17	53	66	19.69	SC		
33		sap, mature	27	82	2-6	3.04	58	140	58.57	SC		
34	T. 14S, R. 9E, Sec. 18	seedlings	19	120	2-21	6.32	91	211	56.87	SC		
35		saplings	8	25	2-10	3.13	125	150	16.66	SC		
36	T. 14S, R. 9E, Sec. 26	seedlings	6	39	2-13	6.50	10	49	79.59	35.56	0.1687	0.2812
37		sap, n. mat.	11	29	2-4	2.64	13	42	69.04	SC		
38		saplings	41	115	2-7	2.80	82	197	58.37	SC		
39		seedlings	7	47	4-12	6.71	23	70	67.14	35.56	0.1968	0.6467
	SUMMARY:		896	2822		3.15	3424	6246	45.18%			

computed where possible. This data is not significant except possibly as a matter of incidental interest.

Mortality in Older Clumps

Of the 39 counts listed in Table 3, there were 28 in which at least one clump contained one or more dead members. Table 4 is devoted to mortality among such clumps. Where only one clump is involved, the "average number of trees per clump" and "percent mortality" are indicated by parentheses.

In the case of the older trees (nearly mature and mature) it is likely that not all original members of the clump are represented, so the percent mortality figures for these counts are probably erroneous on a lifetime basis. They do, however, represent an indication of survival during the later years of growth.

The percent mortality as evidenced by persistent (though dead) members ranges from 23.07% to 57.14%. In the total of 208 clumps with at least one dead member, there were 839 trees, 369 of which were dead. Thus the average percent of mortality was 43.98%.

A comparison can also be drawn between clumps which do have dead members and those that don't. In Table 5, the average number of trees per clump for each count (all clumps) is indicated in the first column. The average number of trees per clump with dead members is in the second column.

The size difference between these two columns has been converted to a percentage figure. From this it can be seen that most clumps containing dead members are larger than the total average for each

Table 4. Survival data for clumps, year-old to mature trees.

Observation no.	A. No. clumps in count (see table 3)	B. No. clumps with dead members	C. Total trees in affected clumps	D. No. of dead trees	E. Average size clumps which include dead trees	F. Percent mortality (D/C)
1	32	19	78	38	4.10	48.71
2	36	8	31	10	3.87	32.25
3	36	12	36	19	3.00	52.77
4	32	8	23	14	2.87	60.86
5	25	2	7	3	3.50	42.85
6	10	2	7	2	3.50	28.57
7	25	6	17	9	2.83	52.94
8	51	9	35	10	3.88	28.57
9	52	16	50	22	3.12	44.00
10	19	5	52	12	10.40	23.07
11	55	5	38	13	7.60	34.21
12	27	9	40	12	4.44	30.00
13	11	0				
14	32	1	3	1	(3.00)	(33.33)
15	59	40	148	82	3.70	55.40
16	26	2	7	4	3.50	57.14
17	6	0				
18	10	1	2	1	(2.00)	(50.00)
19	15	1	6	3	(6.00)	(50.00)
20	20	8	24	10	3.00	41.66
21	6	0				
22	32	8	23	10	2.87	43.47
23	4	0				
24	33	5	10	5	2.00	50.00
25	75	15	36	16	2.40	44.44
26	11	1	2	1	(2.00)	(50.00)
27	9	0				
28	8	NR				
29	3	NR				
30	5	NR				
31	6	NR				
32	6	0				
33	27	5	22	8	4.40	36.36
34	19	4	54	23	13.50	42.59
35	8	0				
36	6	4	35	16	8.75	45.71
37	11	1	2	1	(2.00)	(50.00)
38	41	8	28	15	3.50	53.57
39	7	3	23	9	7.67	39.13
SUMMARY:	896	208	839	369	4.03	43.98%

Table 5. Comparison: total sample averages to clumps within samples having dead members.

Observation no.	Average size of clumps in sample	Average size of clumps which include dead trees	Size difference +	Size difference -	Difference as percentage
1	3.56	4.10	0.54		15.16
2	3.08	3.87	0.79		25.64
3	2.67	3.00	0.33		12.35
4	2.62	2.87	0.25		9.54
5	2.72	3.50	0.78		28.67
6	2.50	3.50	1.00		40.00
7	2.40	2.83	0.43		17.91
8	2.58	3.88	1.30		50.38
9	2.52	3.12	0.60		23.80
10	5.21	10.40	5.19		99.61
11	3.42	7.60	4.18		122.22
12	3.56	4.44	0.88		24.71
13	3.27	----	----	----	-----
14	(2.65)	(3.00)	(0.35)		(13.20)
15	3.30	3.70	0.40		12.12
16	2.19	3.50	1.31		59.81
17	3.17	-----	----	----	-----
18	(2.20)	(2.00)	(0.20)		(9.09)
19	(2.60)	(6.00)	(3.40)		(130.76)
20	2.45	3.00	0.55		22.44
21	2.17	-----	----	----	-----
22	2.47	2.87	0.40		16.19
23	2.75	-----	----	----	-----
24	2.24	2.00		0.24	12.00
25	2.16	2.40	0.24		11.11
26	(2.36)	(2.00)		(0.36)	(18.00)
27	2.11	-----	----	----	-----
28	18.62	-----	----	----	-----
29	3.33	-----	----	----	-----
30	14.20	-----	----	----	-----
31	5.33	-----	----	----	-----
32	2.17	-----	----	----	-----
33	3.04	4.40	1.36		44.73
34	6.32	13.50	7.18		113.60
35	3.13	-----	----	----	-----
36	6.50	8.75	2.25		34.61
37	(2.64)	(2.00)		(0.64)	(32.00)
38	2.80	3.50	0.70		25.00
39	6.71	7.67	0.96		14.30
	149.72		123.40	Σ Average number in clumps	
	- 72.70			Σ Averages for non-affected clumps	
	77.02				
			- 15.00	Σ Averages, one clump only affected	
			108.40		

108.40
- 77.02
31.38 = 40.74% larger average size of affected clumps over non-affected clumps

count, by from 9.54% to 130.76%. Summarizing the averages indicates that the clumps containing dead members are 40.74% larger--thus, the larger the clump, the greater the mortality.

Year-old to Mature Trees: Results of Aging

Ages and radial measurements of the wood (xylem) of the clumped tree samples are reported in the Appendix. This detailed information has been summarized on Table 6, which includes identification of the samples, number of pines in each clump, average radius of clump members and approximate date of origin (see explanation below).

The largest sample was a clump of 34 two-year-old seedlings which had an average radius of about 1 mm. (2 mm. diameter). The next largest sample was a clump of 17 seedlings 13 years of age. The average radius for these was 1.5 mm. (3 mm. diameter), a seemingly small gain for the additional years of growth. The suppression within this sample is more pronounced in contrast to another clump of 13 seedlings 15 years of age. These had an average radius of 2.5 mm.

In several cases, trees which were sampled for aging turned out to be much older than their size implied. For example, a group of four, originating about 1925, had an average radius of only 5.2 mm., while another group of four originating eight years later (1933) averaged 5.3 mm. Seven clump members dating back to 1935 had an average radius of 4.7 mm. and a younger (1937) group of six trees averaged 8.7 mm.

Some of the most interesting figures involve the oldest trees. Here are found the largest radii and also the greatest disparity of size among clump members. Three trees dating to about 1893 averaged 129.6 mm. in radius, although the individual measurements were 72 mm., 134 mm., and 183 mm., for a maximum difference of 111 mm. Similarly, two 1898 trees showed an average radius of 114 mm., with individual measurements of 80 mm. and 148 mm.

Such differences in size among clump members originally motivated taking of samples for aging, since age difference is frequently associated with size difference. In most cases, the results demonstrated that the clumped trees could have originated from rodent caches.

As can be seen by examination of the data on aging as presented in the Appendix, age determination of individual trees can become a problem of interpretation. One assumes that to age a tree one must merely count the annual growth increments. One problem immediately encountered is defining this annual increment. The usual method is to count the annular rings of the trunk as seen in cross-section. However, it is not unusual for a tree to put on more than one "ring" per season, if the season is interrupted as by a prolonged unusually dry or moist period. The difference in size of cells developing during such periods can cause a "new" ring to become apparent.

Table 6. Summary of clump aging data. (See Appendix for complete tabulation.)

Sample date and no.		Location	No. in clump	Average radius (mm)	Approximate date of origin
7-6-65	1	1	?	0.5	1965
	2	2	3	4.3	1950
	3	3	5 {3, 2}	7.3, 4	1936
	4	4	6	8.7	1937
	5	5	5	9.1	1942
7-7-65	1	6	8	4.5	1945
	2	7	2	12	1940
	3	8	4	3.4	1940
	4	9	7	4.7	1935
	5	10	3	4.3	1942
	6	11	4 {3, 1}	14.5, 4	1945?
	7	12	4	5.3	1933
7-12-65	1	13	19	1	1963
	2	14	5	1.6	1950
	3	15	17	1.5	1952
	4	16	8	0.7	1954
	5	17	3 {2	1.5	1957
			1}	4	1945?
	6	18	7	1.6	1953
	7	19	8	2.3	1951
	8	20	2	1.8	1950
7-20-65	202	21	3	129.6	1893
	204	22	3 {2	92.5	1893
			1}	28	1920?
	206	23	2	134	1895
	208	24	2 {1	159	1897
			1}	30	1918
	210	25	2	46	1913
	212	26	2	114	1898
	214	27	3	58.3	1910
7-21-65	216	28	(single)	263 +	before 1732
	218	29	(single)	148	1710
	1	30	7	0.5	1963
	2	31	5	1.3	1953
	3	32	(single)	2.5	1950
	4	33	7	5.6	1944
7-27-65	1	34	7 {5, 2}	2.3, 0.7	1952
	2	35	13	2.5	1950
	3	36	6	6.6	1955
8-3-65	1	37	13	1	1963
	2	38	2	7.6	1932
8-9-65	1	39	4	5.2	1925
8-12-65	4	40	34	1	1963

Other variables such as insect infestation, disease and suppression can also cause changes in wood growth. Trees growing in suppressed conditions have annular rings so closely spaced as to cause difficulty in counting. Thus in such trees--as found growing in some clumps--"false rings" become even more difficult to determine.

Accurate age determination, therefore, is a by-product of knowledge of the ontogeny and anatomy of ponderosa pine xylem, as well as familiarity with fine points of aging technique. Such a study in depth was not warranted for the present purposes, so that annular ring counts expressed in the Appendix reflect not only a variation in individual growth patterns, but also problems in counting technique. Because of such variables, a difference of ±5 rings was interpreted as "close enough" to demonstrate a similar date of origin, and the summarized data on Table 6 is the result of extrapolation from such interpretations.

Fire and Logging Disturbances

Fire

According to the staff at the Sisters Ranger Station, no major forest fires have occurred in this area of the Deschutes National Forest since the establishment of Forest Service fire protection operations. Thus the only areas which have been affected by fire in recent years are those subject to routine slash-burning following logging, so that fire can no longer be considered a major factor in this section of the ponderosa pine belt.

Logging

Logging operations have been taking place under the U.S. Forest Service management program since at least the 1940's, according to the U.S.F.S. records at Sisters. The significance of this to the current study is mainly the great ecological disturbance to logged areas, with subsequent succession and regeneration.

Much high-density regeneration, including an abundance of clumped trees, was found in areas where the soil had been "churned" by various vehicles associated with logging. It seems that rodent caches germinate in greater density in these highly-disturbed areas, possibly indicating a habitat or cache-site preference, particularly by the golden-mantled ground squirrel.

Copies of the logging history maps for 1950-1964 were made, and show overlap in many sections. It is evident from these records that very little of the National Forest land near Camp Sherman and Sisters has not been subject to logging sometime within the past 20-30 years.

PLATE I

Figure A. General area of Indian Ford observations. Note density of sapling growth on left, presence of quaking aspen in background. Typical mature ponderosa pine stands on right.

Figure B. Close view of path along which first Indian Ford transect was taken. Note heavy needle and cone litter. (Photograph taken after path had been extensively used, subsequent to time of sampling.)

Figure C. Example of ponderosa pine-bitterbrush-Idaho fescue understory, at Indian Ford north of area depicted in Figures A and B.

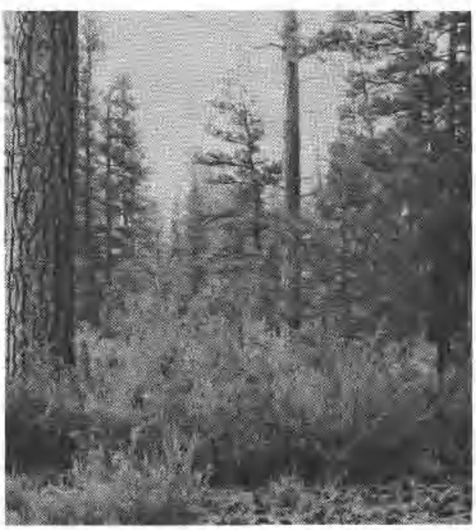
Figure D. General view of area near Road 1424, showing ponderosa pine-bitterbrush-manzanita-buckbrush understory.

Figure E. Close view of area in Figure D, showing buckbrush in left foreground, manzanita in right foreground, and bitterbrush in background.

Figure F. Bare area near Road 1424 where survival of singly-growing germinants was followed. Note interspersal of young manzanita bushes.


A


B


C


D


E


F

PLATE II

Figure G. Golden-mantled ground squirrel with full cheek pouches, a typical sight after ponderosa pine seeds begin to fall.

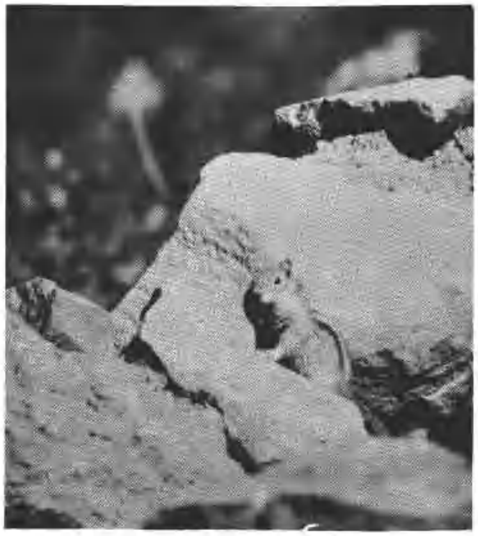
Figure H. Newly-germinating clump no. 41, at Indian Ford. Note heavy needle litter.

Figure I. Newly-germinating clump no. 30A, near Road 1424. Manner in which seed hulls are carried up by the cotyledons is typical of ponderosa pine.

Figure J. Clump no. 30A, three months later. In photograph, slightly darker cluster of true needles is surrounded by now dead cotyledons. Four leaning plants in foreground are dead and withered.

Figure K. Clump no. 29A, 26 months after germination. Protective cage in background was knocked over and crushed during forest clearing operations along Road 1424.

Figure L. Closeup view of clump no. 29A as shown in Figure K. Note how after two years, a seed hull still clings to the dead but persistent cotyledons in lower right corner.



G

H

I

J

K

L

PLATE III

Figure M. Clump of week-old germinants excavated for root and stem measurements. Note how cotyledons have not yet spread out, and how some have been clipped off by rodents and/or birds.

Figure N. Clump of seedlings showing disparity of size among clump members at this stage.

Figure O. Clump of similar sized seedlings.

Figure P. Clumped saplings growing along Green Ridge. Again note that some clump members have grown more vigorously than others.

Figure Q. Clump of mature trees near Road 1424, in which three of the five trees appear to have been dead for some time.

Figure R. Pair of ponderosa pine cones at top of eight foot sapling, probably worked over by golden-mantled ground squirrel or yellow pine chipmunk to get at seeds. Note shredded appearance of cone scales.

M

N

O

P

Q

R

Plate IV. Multiple Use Map.
Metolius Ranger District, Deschutes National Forest, 1964. Each square measures one mile to a side.

Transportation System Legend:

- paved road
- surfaced road
- improved road
- primitive road
- road number
- forest trail
- protective boundary
- section line marker
- cinder pit

(Cross-hatched areas are private land.)

R. 9E R. 10E

T. 12S

T. 13S

T. 14S

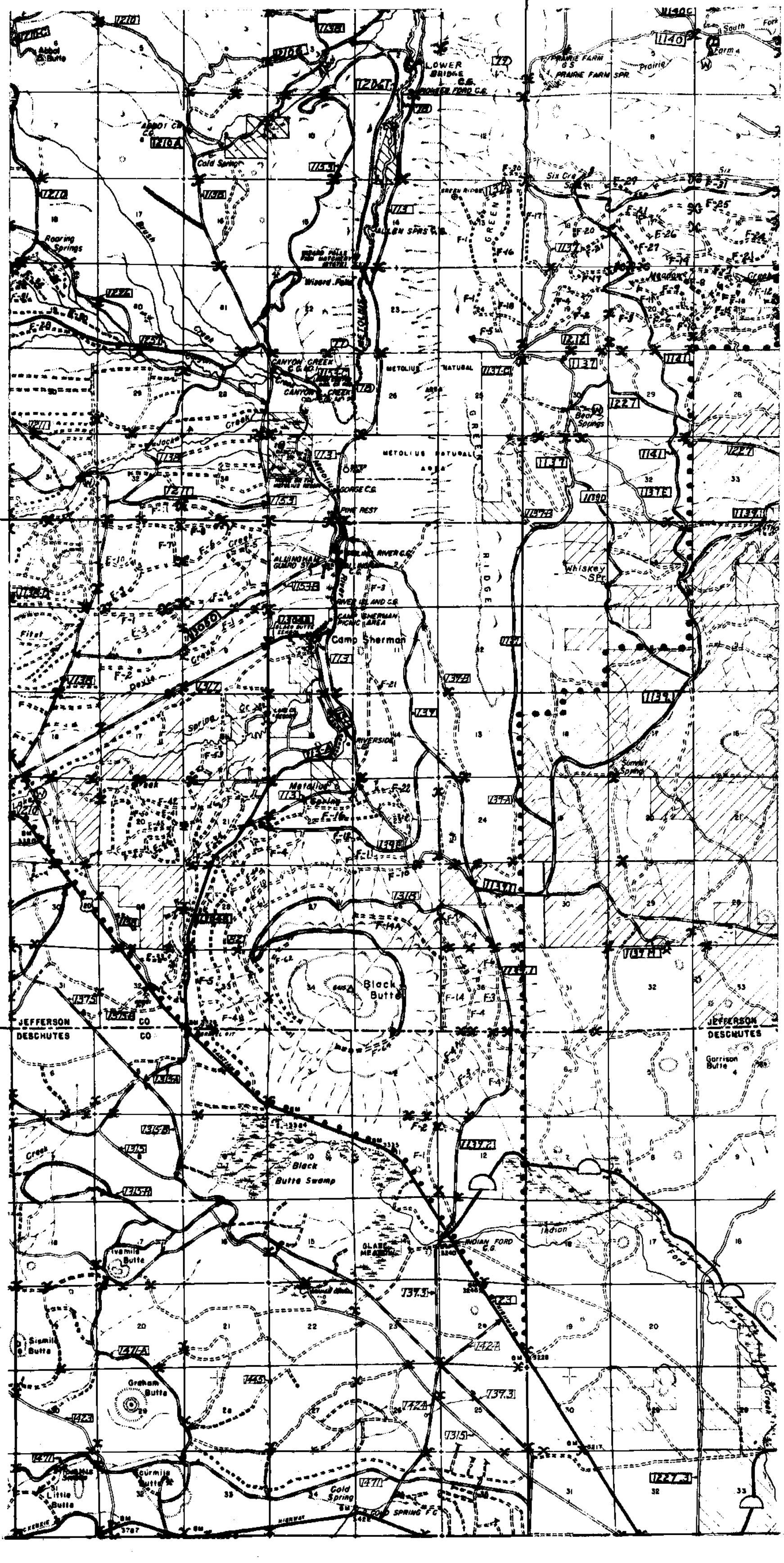


PLATE IV

DISCUSSION

Food Habits of *Eutamias amoenus* and *Citellus lateralis*

General

Bailey (1936) describes the food of *E. amoenus* as "seeds of various flowering plants, grasses, berries, bulbs, roots, green vegetation and insects," and that of *C. lateralis* as "almost anything of an edible nature they can find." A more complete listing of food items is presented by Gordon (1943), whose lists of food taken by each of the animals are included in Tables 7 and 8. Gordon comments that since the food habits of chipmunks have received more attention than the ground squirrel, their list is more complete. As can be seen from these lists, the food taken is primarily the vegetative or reproductive parts of a wide variety of plants. (For a more complete list for *E. amoenus*, see Broadbooks, 1958.)

Although commonly considered vegetarians, these rodents also, eat a variety of animal food (Bailey, 1930, 1936; Aldous, 1941; Gordon, 1943; Broadbooks, 1958). For example, Tevis (1952) observed *E. amoenus* feeding extensively upon caterpillars infesting desert mahogany (*Cercocarpus*). By stomach content analyses, he showed that insects constitute a large percentage of this rodent's diet. Chipmunks are especially noted for eating insects of various

Table 7. Food items reported for Eutamias sp. (adapted from Gordon, 1943)

TREES (seeds, nuts and fruits)

pines, spruces, Douglas fir, firs, juniper, oaks, chinquapin, walnuts, hazelnuts, California buckeye, wild cherry, crabapple, plums, dogwood, birch, maple, boxelder

SHRUBS (seeds or berries)

hackberry, greasewood, salal, manzanita, huckleberry, blueberry, cranberry, mountain mahogany, rose, bitterbrush, raspberry, blackberry, salmonberry, thimbleberry, serviceberry or Juneberry, shadblow, chokecherry, currant, gooseberry, buffalo berry, buckbrush, elderberry, snowberry, honeysuckle, bush honeysuckle, sagebrush, rabbitbrush, mesquite, and bullberry

HERBS AND GRASSES (seeds)

squirrel corn (Corydalis), skunkweed (Peritoma), violet, pussy-paws, geranium, dock, bindweed, black bindweed, Russian thistle, plantain, Phacelia, lungwort (Mertensia), borage, beard-tongue (Penstemon), speedwell (Veronica), strawberry, Potentilla, lupine, willow herb or fireweed (Epilobium), cactus, prickly pear, suma, ragweed, aster, thistle, sunflower, dayflower (Commelina), twisted stalk, Chinaberry (Melia), chico seeds, creeping snowberry, rush, sedges, galingale, wild grasses, timothy (Phleum)

OTHER PLANT ITEMS

roots, buds, blossoms, leaves and bulbs of various plants; brown fungus and mushrooms

HANDOUTS (around camps, cabins, resorts)

oats, rolled oats, puffed wheat, peanuts, dried fruits, prunes, apples, peaches, bananas, melons; seeds of apples, melons and squash; bread, fig bars, "and probably a good many other things"

Table 8. Food items reported for Citellus lateralis (adapted from Gordon, 1943).

TREES (seeds, nuts and fruits)

pines, Douglas fir, oaks, chinquapin

SHRUBS (seeds or berries)

rose, service-berry, thimbleberry, currant, gooseberry, bitterbrush, chokecherry, buckbrush

HERBS AND GRASSES (seeds)

wild beans, lupine, Astragalus, puccoon (Lithospermum), clover, smartweed (Polygonum), Capsella, false indigo (Amorpha), Gilia, green gentian (Frasera), Penstemon, Mentzelia multiflora, mullein (Verbascum), strawberries, weed seeds, rice-root lily (Fritillaria), grass seeds, grain

OTHER PLANT ITEMS

roots and green vegetation, mullein flowers, lupine leaves, dandelion leaves and heads, clover leaves; bulbs; mushrooms and bracket fungus

HANDOUTS

bacon, macaroni, flour, bread, pancakes, cake, pie, soda crackers, fig bars, potatoes, oats, rolled oats, barley, puffed wheat, peanut butter, peanuts, filberts, walnuts, dried fruit, prunes, apples, bananas, cantaloupe (flesh and seeds), watermelon (flesh and seeds), cabbage, "almost anything at hand" kinds, but C. lateralis seems to be "less insectivorous than are the chipmunks" (Bailey, 1936), and they have been reported to feed only occasionally upon insects (Gordon, 1943).

Chipmunks, especially, are also occasional predators upon the nests of smaller birds, eating not only the eggs but also the hatchlings (Jaeger, 1929; Twining, 1940; Cahalane, 1947). One case of predation upon hatchlings by C. lateralis is cited by Cahalane (1947).

Both E. amoenus and C. lateralis eat carrion, especially the latter. Near the Metolius area, the ground squirrels were frequently seen dining upon the roadside remains of various traffic victims, and in one case two of them seemed to be dragging the carcass of another from the center to the edge of the road. Gordon (1943) also observed them feeding upon carcasses of their species, as well as that of a young meadow mouse. Bailey (1936) describes C. lateralis as being "fond of fresh meat of almost any kind, eagerly taking the bodies of mice and birds that have been skinned for specimens and used for trap bait. They also get into traps baited with bacon or any fat meat and pick up meat scraps around camps."

Two incidents of predation in captivity have been reported, plus one possible attempt at cannibalism. Cahalane (1947) reports that a chipmunk caged with two mantled ground squirrels was killed and partially eaten by them. Broadbooks (1958) reports a yellow pine chipmunk which "ate one of the eyes and part of the neck of a deer mouse when the two were confined in the same live trap overnight." Jaeger (1929) witnessed a fight between two golden-mantled ground squirrels in which the death of one appeared imminent had not Jaeger and his companion interfered.

Spring and Summer

Bailey (1936) briefly classifies the food preferences of C. lateralis by seasons, that of springtime being primarily green vegetation, roots and old seeds. Later ripening fruits such as serviceberries, currants, gooseberries, raspberries and manzanita berries are eaten.

During the spring of 1965, golden-mantled ground squirrels were seen eating vegetative material which appeared to be dandelion greens. Gordon (1943) has also reported feeding by these rodents upon dandelion leaves and heads, and Carleton (1966) demonstrated "a profound dependence" by the sympatric C. lateralis and E. minimus upon the common dandelion during the Colorado summer. He found that this plant constituted more than 80% of the June-August diet for both the animals, the chipmunk preferring the flowers, seeds and seed-laden heads, and the mantled ground squirrel preferring the stems and leaves. Thus, they were not in direct competition for the plant. A preference by E. amoenus for seed heads is also reported by Broadbooks (1958), who observed them eating "the soft, immature seeds of various ripening flowers." He reports the springtime diet of the animals as primarily the common dandelion and other herbs and grasses.

Summer and Autumn

More exclusive utilization of seeds and nuts is reported by Bailey (1936) for the late summer and fall diet of C. lateralis. In the Deschutes National Forest area, summer brings the ripening of seeds of bitterbrush, manzanita and buckbrush. The golden-mantled ground squirrels and chipmunks harvest these either for immediate eating or for storing. The surface cacheing of these plants is evidenced by the abundance of clumped young bitterbrush germinants which appear each spring. Sherman (1966) feels that extensive ground squirrel and chipmunk cacheing of bitterbrush seeds is responsible for a large degree of the bitterbrush regeneration in this area, as he found no singly-germinating plants. Also, two groups of germinating manzanita seedlings were discovered in the spring of 1965.

At the lower elevations east of this area, juniper berries also ripen in the summer, providing food for chipmunks, ground squirrels, deer mice and birds (Hooven, 1966). In addition to seeds and berries, Broadbooks (1958) also found corms of various plants to be part of the E. amoenus harvest in summer and fall.

Late in the summer, fungi became an important food for the two sciurids. Around Camp Sherman, golden-mantled ground squirrels were seen foraging for and feeding upon some type of hypogeous fungi (Tuberales, or "truffles"). Pits dug by the animals in search of fungi were found in great abundance on roadside banks and moist, litter-strewn portions of the forest floor. An abundance of such pits has also been reported by Tevis (1952), being from one to six inches in depth. He states that these hypogeous fungi (Gasteromycetes and Tuberales) are located by the rodents by odor, a method similar to that used by dogs to locate truffles for their European masters.

In addition to the hypogeous type of fungi, many large Basidiomycete fruiting bodies were found with rodent teethmarks on the cap portions. Gordon (1943) also reports the feeding of E. amoenus and C. lateralis upon various mushrooms. Tevis (1952) found that with late summer rains, surface Agaricales appeared and were consumed in large quantities, especially members of the genera Clitocybe and Boletus.

Although Tevis (1952) comments that fungi, being perishable, are generally eaten immediately, the author collected one Camp Sherman area C. lateralis whose cheek pouches contained six or seven strips (approximately one inch by one-fourth inch) of dark brown fungus appearing to be the hypogeous type. This may have been food for storage, or perhaps represented the sciurid equivalent of a "sack lunch."

The significance of fungi to the diet of these rodents, especially during a year of conifer seed shortage, seems very great. Stomach analyses by Tevis (1952) showed that where fungi were available, chipmunks had consistently fuller stomachs and put on hibernation fat sooner than animals depending upon other food sources during a poor seed year.

Broadbooks (1958) reported that *E. amoenus* fed upon fungi from July to November, although the autumn fungi were most abundant. Tevis (1953b) found fungi to be the most important food of chipmunks and golden-mantled ground squirrels in a portion of northeastern California, with *E. townsendii* and *E. quadrimaculatus* relying almost entirely upon them in certain habitats. He comments, however, that "*E. amoenus* showed less seasonal preference for fungi and ate relatively more seeds and insects than the other species." This statement tends to support observations near Camp Sherman, pointing to *C. lateralis* as the primary fungus consumer there.

Further, more intensive observations of fungus eating in the study area might demonstrate a surprisingly high utilization of fungi by *C. lateralis*. In the few weeks preceding the fall of ponderosa pine seed, golden-mantled ground squirrels were frequently seen eating the dark brown, hypogeous fungi, and dropped scraps of it on their feeding rocks when startled and abruptly chased away from these posts by inquisitive humans. Also, the areas in which they foraged for these fungi were "plowed up" to such an extent as to indicate very great squirrel (and possibly chipmunk) activity.

One of the most important foods for E. amoenus and C. lateralis is the seed of ponderosa pine. Not only do the oily, nutritious seeds provide an immediate food source in the fall, but they are also stored to provide the animals with food during the winter and following spring.

Ponderosa pine seeds are probably available to the chipmunks before the ground squirrels, since the chipmunks are more arboreal in their tendencies (Grinnell and Storer, 1924; Jaeger, 1929; Cahalane, 1947; Broadbooks, 1958; Wirtz, 1961). Broadbooks (1958) reports observations of E. amoenus plucking seeds from cones high in trees as soon as the cone scales were sufficiently opened for the animals to reach the seeds. He observed one female chipmunk climb to 70 and 100 foot heights during her foraging.

In contrast to this, Ingles (1947), Cahalane (1947) and Broadbooks (1958) state that C. lateralis rarely ascends more than 20 feet above the ground. As stated by Ingles (1947), "if surprised up in a tree they usually rush to the ground and run for the burrow beneath some protecting rock." Though this is usually the case, various golden-mantled ground squirrels have been observed climbing half-way up large ponderosa pines (Gordon, 1943).

Some observations were made at Camp Sherman which tend to demonstrate that _C. lateralis_ may occasionally attack the pine cones directly, rather than simply waiting for the seeds to fall. A young _C. lateralis_ collected for cheek pouch analysis was perched at the top of an eight-foot sapling bearing a pair of cones. Although these cones were not damaged, others found at the top of such a sapling in a different section were. Figure R (Plate III) shows the peculiar type of damage found in the latter case. It is notable for the manner in which the cone scales have been shredded.

Although this may actually be the work of _E. amoenus_, the manner in which the seeds are removed does not agree with the description afforded by Broadbooks above. Neither does it resemble work of the chickaree, which cuts cones from higher branches of mature trees, flinging them to the ground for subsequent collection. When the chickarees remove the seeds, they nip the ovuliferous scales off cleanly next to the core, so that the remaining cone cores are unmistakable. This is in sharp contrast to the messy-looking, shredded appearance of the cones in Figure R. A number of these shredded cones were found at a stump feeding station, along with the seed hulls and "wings" of a number of pine seeds. By elimination, therefore, and in lieu of direct observation, the work is attributed to _C. lateralis_.

Although *C. lateralis* may occasionally obtain ponderosa pine seeds directly from the cone in the manner described above, the majority of its foraging is for those seeds which have fallen from the trees and are lying on the forest floor or upon roads.

Cacheing of Food in the Autumn

Burrow Caches

Broadbooks (1958) found that the underground seed hoards of *E. amoenus* contained a variety of plant materials placed in the bottom of the nests within reach of the chipmunks. The seeds of "at least twenty kinds of native plants" as well as corms were found in three examined caches. Stored seeds in these caches averaged 35,400 per cache, with an average weight of 143 grams per cache. The maximum number of food items in a single burrow cache was 67,970, consisting predominantly of the seeds of *Collinsia* sp., *Carex* sp., and pieces of corm. By weight, these items constituted 24.5%, 19.9% and 42%, respectively, of the total food store of 190 grams in this largest cache.

Burrow cacheing by *C. lateralis* does not seem to have been conclusively demonstrated. Bailey (1930) mentions "underground storehouses" prepared by these squirrels, but does not repeat such a reference in his 1936 publication. Wirtz (1961) examined the burrows of five golden-mantled ground squirrels at Crater Lake, Oregon, and found no food caches, although one nest was discovered. Ingles, (1947) does not report burrow storage by these animals, but Cahalane (1947) states that blind side tunnels may be filled with seeds and acorns, "perhaps for use during the lean springtime when food may be needed badly."

It was frequently mentioned that E. amoenus does not hibernate as completely as does C. lateralis, but there seems to be evidence that both are what Cahalane (1947) terms "restless hibernators" and that the duration of their seasonal underground existence depends upon the severity of the winter conditions. Both animals have been reported by some of the above authors as having been seen occasionally above the ground on winter snow.

Authors who have worked with one or both of the species under discussion here have noted that the golden-mantled ground squirrels become exceptionally fat preceding hibernation, but the yellow pine chipmunk does not (Grinnell and Storer, 1924; Bailey, 1936; Gordon, 1943; Ingles, 1947; Broadbooks, 1958; Hooven, 1966).

From the available information, then, it appears that the winter food storage for E. amoenus consists predominantly of burrow caches, while C. lateralis depends mainly upon accumulated body fat.

It is interesting to note that the factors stimulating the onset of hibernation have not yet been entirely clarified. Various behavioral and physiological aspects of the hibernation of C. lateralis have been studied intensively by Mulalley (1953), Tevis (1955), Pengelley and Fisher (1961, 1963), Jameson (1964, 1965), Jameson and Mead (1964), and others. The results of further investigations will be of interest in relation to the food storage habits of both C. lateralis and E. amoenus.

Surface Caches

Around Camp Sherman, several rodents may be responsible for the type of surface cacheing associated with clumps of ponderosa pine. The most likely candidates are the deer mouse, golden-mantled ground squirrel, and yellow pine chipmunk. The question of "who?" becomes a matter of elimination of possibilities, relating the size of germinating clumps to the size of the animals and to the literature.

Cacheing by the deer mouse can be eliminated in relation to larger clumps on the practical basis of cheek and mouth capacity. In addition, Hoffman (1923) states that these mice cache individual seeds.

Various chipmunks have been credited with surface cacheing. Hoffman (1923) states that chipmunks (species not identified) cache single mouthfuls of seeds separately. The deposition of seeds "in a shallow pocket in the ground" (Cahalane, 1947) and "in shallow crevices or in holes at the surface of the ground" (Broadbooks, 1958) has been attributed more specifically to members of the genus *Eutamias*, the western chipmunks.

The chipmunk most frequently associated with surface cacheing is the lodgepole chipmunk, *E. speciosus* (Grinnell and Storer, 1924; Ingles, 1947; Dixon and Sumner, 1953). They also note the making of surface caches by *E. merriami*, the caches being located mostly at the bases of manzanita bushes.

Since *E. amoenus* is abundant around the Deschutes National Forest, its activities might be of great significance to ponderosa pine regeneration. Speaking of this chipmunk, Bailey (1930) states that "unlike the caches of the squirrels, their stores are placed in cavities close to their winter nests." In 1936, Bailey again mentions this chipmunk's habit of burrow storage, without reference to surface cacheing. Studying the life history and habits of *E. amoenus* in Washington, Broadbooks (1958) found large caches of seeds in the burrows, but did not observe surface cacheing.

From this information, or lack of it, one would conclude that surface caches are not as frequently utilized by *E. amoenus* as by *C. lateralis*, although Gordon (1943) uses a line drawing to show a chipmunk (*E. amoenus*) in the process of making a surface cache.

Although the golden-mantled ground squirrels thus seem to be responsible for most surface cacheing of pine seed, they have been reported as "less likely" to gather tree seeds than mice or chipmunks (Bailey, 1936; Tevis, 1953). However, observations by the latter author were made during a poor seed year, so that seeds on the ground were relatively scarce.

In contrast to these general statements, it seems that analyses of stomach contents (Tevis, 1952), cheek pouch contents (Gordon, 1943; Broadbooks, 1958), and nest contents (Broadbooks, 1958) demonstrate a preference by *E. amoenus* for seeds *other* than those of coniferous trees. Obviously, more information is needed to replace conjecture and set the record straight. On the basis of all these reports, the majority of pine clumps in the Camp Sherman area are assumed to be the result of surface cacheing by *C. lateralis*.

Whether or not chipmunks and golden-mantled ground squirrels retrieve many of their own caches is unknown, as is the means by which they locate the caches. Grinnell and Storer (1924) speculate that "the sense of smell is probably of important service" to them in relocating caches, and report retrieving of caches by *E. speciosus*. The use of the olfactory sense was examined by Gordon (1943), who observed a chipmunk digging up a moth after first sniffing the needle litter covering it. Gordon's experiments with peanuts indicate that *C. lateralis* use the sense of smell to locate these morsels. As mentioned previously, Tevis (1952) postulates that the sciurids locate hypogeous fungi by scent.

Several authors have speculated that the true value of surface caches is not realized by the animals making them until the spring following the harvest (Gordon, 1943; Ingles, 1947; Tevis, 1952). This is reasonable, considering the abundance of autumn food, and is an important point in consideration of the damage done to newly-germinated ponderosa pine seedlings. This connection will be discussed subsequently.

Although the largest cheek pouch load was 130 pine seeds, and the excavated cache contained 92 seeds, the largest germinating clump observed contained 72 individuals. This discrepancy suggests several things: 1) Not all the seeds in a cache germinate, 2) germination of seeds in a cache is not simultaneous, 3) golden-mantled ground squirrels make more than one surface cache from a single "load" of seeds.

Newly-germinated Caches

Animal Damage to Germinants

As reported under Observations, the majority of newly-germinating ponderosa pines were fed upon to various degrees during their first week above the ground. The problem of determining the animals responsible for this damage lies in lack of direct observation, so that deduction again is the best tool.

Studying seedling survival of six coniferous species, Ellison (1934) found that juncos caused damage to the germinants of white pine and Douglas fir by nipping the cotyledons. He and his workers "surmised that the juncos had picked off the attached seeds which still contained some nutrient matter." This damage is similar to the "first degree" of clipping as reported here in Observations.

Pearson (1923) also reports that _Junco dorsalis_ (Gray-headed Junco?) "plucks the seed coats and cotyledons from young (ponderosa pine) seedlings and even cuts down the entire plant." Although _J. dorsalis_ does not occur in the Camp Sherman area, the Oregon Junco (_J. oreganus_) is abundant in the spring and fall. From Pearson's conclusions, then, it appears that juncos alone could be responsible for all degrees of clipping as found at Camp Sherman.

Eastman (1960) observed Oregon Juncos eating pine seeds during May in central Oregon. Since this is during the time of germination, Eastman speculates that "this bird may be a factor in damage of seed or seedlings at this critical time." He also noted "an extremely high total population of Oregon Juncos in October, coinciding with the fall of pine seed."

Although it is highly likely that some of the clump losses noted in 1965 and 1966 near Camp Sherman were due to the activity of the Oregon Junco, it is also possible other birds were involved. Eastman (1960) lists a number of birds which he observed eating pine _seed_ in

May and June, including the Robin, Oregon Junco, Mountain Chickadee, Red-shafted Flicker, Steller's Jay, Mourning Dove, and White-breasted Nuthatch. All of these birds plus other species are present in greater abundance during September through December, when pine seeds are plentiful on the ground (Eastman, 1960). Therefore it is likely that their major concern is the seed, not the succulent young germinant.

Various rodents, as well as birds, must be taken into account when considering damage to newly-germinated pines. Lawrence et al. (1961) report rodent clipping and feeding on the germinants of Douglas fir and ponderosa pine. In their key to wildlife damage, they indict the deer mouse, chipmunks and ground squirrels as responsible for clipping of germinants, although they state that in this case, where tooth marks cannot be distinguished, "field signs of rodents are needed to distinguish from bird or insect injury." Lawrence, et al. also found that "deer mice feed on the cotyledons of newly emerged Douglas fir seedlings in preference to true needles."

A variety of insects can also cause damage to germinants. Lawrence, et al. (1961) report that damage by cutworms resembles that by deer mice. However, no cutworms were observed in the study area, although they may have been present. It is also possible that grasshoppers or locusts caused some damage, although these insects were not commonly observed. Ants were present in great abundance in the study area, raising crater-like elevations of tiny pebbles at the mouths of their nests. Whether or not these are of a conifer-preferring, leaf-cutting variety is unknown, but none was observed climbing in the germinating clumps.

Damage to germinants may also have been caused by mule deer, rabbits, horses, stray cattle or sheep, and perhaps beavers at Indian Ford. However, based upon observations and the literature, the majority of clump damage is probably the result of feeding by birds--especially the Oregon Junco--and rodents, including *C. lateralis* and *E. amoenus*.

In the cases where germinating clumps were dug out at the base, the nature of the excavation appeared suited to the size and style of *E. amoenus* or *C. lateralis*. There was no sign of bird "scratching" at such diggings.

Importance to Rodent Diet in Spring

The literature contains no references to direct observations of surface cache recovery in the spring by either *E. amoenus* or *C. lateralis*. Some caches may have been recovered at Camp Sherman, but no activity or other evidence (diggings, fresh seed hulls, etc.) was seen to indicate this. The question arises, therefore, as to whether or not these species actually utilize the seeds they so diligently collect and cache, especially in the case of

C. lateralis.

At the time the golden-mantled ground squirrels come out of hibernation near Camp Sherman, herbaceous growth is just beginning, so that fresh food is not immediately abundant. Clumps of germinating ponderosa pine were observed between snow patches at this time of sparse new growth. Thus it seems possible to correlate the germinant damage to the rodent diet.

Perhaps the true significance of surface caches, prepared primarily by C. lateralis, does not lie in springtime recovery of the seeds, but in utilization of the newly-germinating pines. The existence of such a relationship would eliminate the question as to if and how the squirrels are able to locate the buried pockets of seeds. The massed germinants are not only tender food, but are easily seen by an animal traveling close to the ground, and are also a clue to the location of seeds which have not yet emerged from the cache.

Certainly direct observations are needed to establish this as a valid interpretation, but the main problem lies in the difficulty in locating germinating clumps, especially before they are damaged. Several suggestions for investigating this avenue of thought are presented subsequently.

Effects of Cacheing on Germination

Figures H and I (Plate II) illustrate caches germinating in two different ground surface situations. Clump #41 at Indian Ford (Figure H) was originally cached in a heavy layer of needle litter, so that the germinants had to push up through this obstruction. Individuals in this clump and others in similar situations appeared exceptionally vigorous, however, indicating favorable conditions for germination. It seems likely that seeds cached in this type of surface litter have an advantage over those which remain on the surface after falling from the cones. The latter seeds are not only more subject to winter freezing, but the newly-emergent root must penetrate a thick layer of rapidly drying needle and bark litter in the spring in order to reach soil.

Clump #30A at Road 1424 (Figure I) germinated beneath a nearly bare surface, as compared to #41. Although the germinants were caged for protection from animal damage, a number of them died and shriveled up, possibly indicating unfavorable moisture conditions. If this is the usual case at such a site which is unshaded and without surface litter, it would seem that again the seeds which were planted beneath the surface of the ground would have an advantage over those left lying on the surface. Temperature and moisture availability again seem to be the crucial factors for germination at such a site.

Examination of a newly-germinating ponderosa pine gives evidence of the crucial "race" for soil moisture from the earliest stages. One group of newly-germinating seedlings was excavated for measurement (Figure M, Plate III). Since the cotyledons had not yet begun to spread out, the germinants were judged to be approximately one week old. At this stage, the length of the root is shown to be more than $2\frac{1}{2}$ times the length of the shoot, with no lateral or secondary roots.

The soft, dusty soil typical of the ponderosa pine forest near Camp Sherman dries rapidly after the snow melts. Thus germinating pines must reach the soil surface and rapidly send a tap root down to contact a depth with sufficient moisture to sustain them beyond their initial growth thrust. It is logical, then, that a germinant originating from a rodent-cached seed has a strong advantage for success, especially in areas which might otherwise be rather unfavorable for germination.

Effects of Cacheing on Survival

Because they are more obvious, it is possible that clumps of germinating seedlings attract more attention from food-seeking animals than singly-growing individuals. For the investigator who wishes to test this, germinating clumps are somewhat difficult to locate, and it is even harder to find singly-germinating pines. In addition, one is not likely to notice the small stubs left where single individuals have been clipped off by some animal.

Along these lines, it might be helpful to compare the survival among 1965 and 1966 germinating clumps and the individual germinants on the bare area near Road 1424. About one-third of the original clumped germinants survived after one week, while only one-fifth of the original individual germinants were present after one week. After three weeks, with new individuals coming up, the survival of singly-sprouting germinants was also one-third.

Another possible disadvantage to the individuals growing in clumps might be intra-clump competition. Closely crowded as clumped germinants are, competition for moisture would seem to be a serious limitation. In this case, however, one assumes that the hardiest will survive as a result of selection. Where several individuals survive to the sapling age, suppression of one or more individuals frequently occurs, though not enough data is present to indicate the seriousness of this.

In consideration of these factors, therefore, it seems that the favorable aspects of cacheing seem to outweigh the unfavorable.

Ponderosa Pine Regeneration

Under the "multiple-use" policies of the U. S. Forest Service in relation to national forest lands, the Deschutes National Forest is subject to controlled logging operations. In some sections, clear-cutting is used, while in others cutting is selective in nature. In either case, the accompanying road-building operations plus the activities of heavy equipment such as log trucks, water trucks, and log-loaders cause major disturbances of the understory as well as the overstory. The removal of shade-producing mature trees plus the general churning of the forest floor act together to make a natural seed bed for the regeneration of ponderosa pine, a species not adapted for reproducing in a shaded situation.

Around the Camp Sherman area reseeding of logged areas occurs naturally, rather than by human agency. In areas which have been selectively logged, remaining seed trees provide most of the new potential, although seeds also drift in from other areas. Where clear-cutting has been employed, seeds must arrive wind-borne from adjacent areas or in the cheek-pouches of foraging rodents.

Observations in the study area showed that the most extensive clumping occurs where the soil has been disturbed by a road cut or by logging. This may demonstrate a preference by the rodents for cacheing seeds in the soft, yielding earth, or for living in semi-open areas, as is typical of C. lateralis. Though ill-fated, a number of newly-germinated clumps can also be seen at the side or in the middle of the dirt roads in the area, especially recently bulldozed roads.

Dense regeneration following clearing is obvious in section 20,

T. 13S, R. 9E. This section was logged in 1947, then again in 1963. The stands inventoried in this section were all saplings, probably germinated after 1947, which had been extensively thinned out by man, probably in 1963. Most of the saplings collected and aged from this section germinated between 1947 and 1957 (Table 6, nos. 14 to 20, 31). The roadside transects along Road 1137 (Green Ridge, T. 13S, R. 9E, section 1) show a high degree of clumping in the swath bordering the road cut.

Unlike areas which are managed on a sustained yield basis, as by various lumber corporations, this area has no problem in naturally reseeding cleared areas. As noted by several staff members at the Sisters Ranger Station, the main problem is too much regeneration, seedlings and saplings growing "as thick as grass" in places. The ecological factors contributing to this "adequate or superfluous" regeneration are discussed by Swedburg (1961).

Ironically, the lack of fire as an ecological factor--due to U.S.F.S. controls--is intensifying the problem. Ponderosa pine is known as a "fire-adapted" species, since it seems to be more resistant to fire damage and able to heal more quickly than other coniferous species such as grand fir (white fir) and Douglas fir (Johnson, 1961). Also, strong regeneration of young ponderosa pines occurs best under an open or semi-open canopy, such as that provided by the well-spaced mature trees growing in a natural pattern achieved by periodic fire "thinning" of the understory. Without fire, however, the understory around Camp Sherman has become more dense and more shaded, making a less favorable situation for the regeneration of young ponderosa pines, and a more favorable situation for other shade-tolerant species.

Thus Swedburg (1961) sees changes "impending" in this ponderosa pine area, with the "aggression of the less commercially valuable grand fir, incense cedar and Douglas fir," so that soon ponderosa pine may be able to outcompete these species only where moisture is more of a limiting factor than fire. If this occurs, the typical ponderosa pine forest of today may become the Douglas fir and grand/white fir forest of tomorrow (Johnson, 1961; Swedburg, 1961).

Fires, though usually controlled, do occur within the ponderosa pine forest around the area, as slash is frequently burned off following logging. Such a circumstance, or even an unintentional "forest fire," presents conditions which might also demonstrate beneficial aspects of rodent cacheing of the pine seeds. In the first place, caches which were in the ground at the time of the fire might escape the destruction which would almost certainly be the fate of seeds lying upon the ground. Secondly, the forest floor cleared by the fire of needle, cone and bark litter and various understory components would offer suitable substrate for the cacheing of new seeds. Seeds thus deposited under the charred surface would rest in relatively unaffected soil awaiting germination into a now open or semi-open forest.

Let us return at this point to the mixed attitudes about the relationship of squirrels and chipmunks to ponderosa pine regeneration that initiated this study. Throughout the area traversed, a "mosaic" is evident, wherein some areas show extensive clumping while others show none, with all degrees of intermediacy. Thus it is possible to go into certain fairly large areas within the Deschutes National Forest and conclude that the regeneration as evidenced by the scattered pattern of seedlings, saplings, nearly-mature, and mature trees is due entirely to wind-seeding. In other areas, an observer can conclude that regeneration is due almost 100% to rodent cacheing. Such local differences are perhaps what gave rise to the existing differences of opinion as to the importance of rodents in planting trees. Conclusions based upon observations in either of such extreme examples will, naturally, be biased.

To dispel bias in both directions, therefore, a fair evaluation of the relationship needs yet to be made. Hopefully, this study has helped to "set the stage" for such future work, although as noted in Methods, bias in sampling was a "necessary evil" for the scope of this study. There are several generalities arising from this study which would make good subjects for further study. Such further work needs to involve many direct observations of sciurid activity and pine regeneration under natural and "manipulated" conditions.

What is the relative extent to which _C. lateralis_ and _E. amoenus_ rely upon fungi and pine seeds during the late summer and early fall? Observations of foraging in areas where there is a large concentration of animals, combined with cheek pouch, stomach (or scat) and food store content analyses would provide some answers to this question. The disadvantage of population decrease by sacrifice for stomach content analysis might be a factor to consider here in relation to long-range observations.

What rodents are most responsible for surface cacheing of ponderosa pine seeds? As concluded by deduction, the golden-mantled ground squirrel seems to be most responsible for making most of the large surface caches around the Camp Sherman area. However, live trapping to investigate possible deer mouse activity at night and to relate abundance of animals to regeneration in specific areas could be conducted. In addition, the construction of an enclosure large enough to include the homes of a number of ground squirrels and chipmunks would be helpful. Thus these animals would be restricted in their cache sites so observations would probably be more successful. The construction of such enclosures in a number of different sites could be observed from some sort of elevated blinds, or "towers", and might yield sufficient data under a variety of conditions to test some of the ideas presented here.

Location and marking of caches should definitely be a part of future plans so that a long-range following of the fate of such germinating pines could be attempted. The enclosure idea would facilitate such observations, as would possible use of radioactive tracers, although the latter possibility should be very critically evaluated and carefully controlled.

What species are responsible for the clipping off of newly-germinating pines? Direct observation within an enclosure would again be useful here, and in addition, various types of exclosures around germinating clumps will allow selective access by rodents or birds. A "rodent-proof" exclosure may be constructed of wire-mesh sides with outward-reaching flanges at the top to frustrate rodent attempts at entry. Devices could also be built of similar materials to allow access to rodents but not to birds. Cages intended to exclude both rodents and birds are easy to construct, as those used in this study. A person interested in various types of exclosures should contact the staff at the Forest Research Laboratory in Corvallis.

A combination of these techniques and others would provide work for as many years as desired for a number of individual projects. It seems that only such long-term investigation will, in the end, offer solutions to the questions giving rise to and encountered during this study. From the trees which are now standing one can only deduce the preceding events. Continual observations from the seed to the mature tree would be helpful in providing some real answers.

SUMMARY

Studies were conducted within a 12-mile radius of Camp Sherman, Oregon in the Deschutes National Forest to assess the relationship of *Eutamias amoenus* and *Citellus lateralis* to the natural regeneration of *Pinus ponderosa* in this area.

Observations of rodent activity, germinating clumps of ponderosa pine, and older stands including clumps of ponderosa pines, occupied the spring and summer of 1965, with additional observations in 1966 and 1967.

Intended as a general survey of the relationship of these rodents to such natural regeneration, the study has opened as many questions as it may have answered, and additional observations of a more limited nature will be necessary to reach a final, satisfactory picture of the situation. Several conclusions may be derived from the current work, however.

Large surface caches of ponderosa pine seeds are prepared primarily by the golden-mantled ground squirrel, *Citellus lateralis*, although a smaller number may also be made by the yellow pine chipmunk, *Eutamias amoenus*. The deer mouse, *Peromyscus maniculatus*, may also be responsible for the planting of single ponderosa pine seeds in the study area.

Caches which are not recovered during the subsequent winter or

spring germinate as dense clumps of seedlings. Germination of such clumps was first noted on April 23, 1965, as the last snow patches were disappearing.

The largest germinating cache contained 72 seedlings and the overall average size of germinating caches in 1965 and 1966 was 17 pines per clump. The numbers of germinants in the clumps are compatible to the cheek pouch contents found for *E. amoenus* and *C. lateralis*, though generally smaller. The largest cheek pouch content was found in a *C. lateralis* bearing 130 ponderosa pine seeds.

After one week of germination, slightly more than one-third of all germinants observed in 1965 and 1966 survived. Most of the losses were due to feeding by various animals.

The germinating clumps of ponderosa pine apparently play an important role in the springtime diet of several animals, especially the Oregon Junco, the golden-mantled ground squirrel, and the yellow pine chipmunk. It is not known whether or not the caches are of any value to these animals before germination occurs.

Young pines which originate as clump members are not apparently subject to higher mortality immediately following germination than singly-germinating individuals. In addition, clumped individuals have the advantage of beginning germination planted firmly in the ground. They thus escape the rigors of winter weather and the full threat of desiccation during germination. The advantage seems to be greater where there is dense surface litter.

All clumps of two or more ponderosa pines were considered to be the result of rodent activities, although other possibilities were investigated. Concentration by wind in depressions in the ground and release from a cone which had dropped to the ground before opening were ruled out, since neither of these would give the tight pattern exhibited by the clumps which were observed. The tandem release of adjacently-developed seeds was also considered, as pitch-bound couplets of white fir seed were seen. No such pairs of ponderosa pine seeds were found.

Beyond the germinant stage, damage and mortality to clump members was attributed primarily to intra-clump competition--especially for moisture--and damage from browsing animals and porcupines, rather than squirrels and chipmunks. The average mortality among older groups as evidenced by dead clump members exceeded 40%, with the greatest mortality being in the larger clumps.

Many seedlings, saplings, nearly-mature and mature trees which apparently originated as members of rodent caches were observed. Such observations were reinforced by age determinations, which indicated similar dates of origin for the clumped trees. Generally, the age of the trees and the size of the clumps tended to be inversely related, the larger the clump, the younger the trees, etc.

Approximately half the regeneration for all areas where counts of "older" trees (seedlings through mature) were taken was due to rodent cacheing. Considering the possibility of single seed cacheing by the deer mouse, and the heavy mortalities encountered by newly-germinating individuals, it is probable that the original proportion of regeneration due to rodent activities is even larger.

The greatest impact of rodents upon the natural regeneration of ponderosa pine in this area seems to be by restocking of areas disturbed by road-clearing and logging. When periodic fires were a part of the natural balance of the forest, the role of rodents in regeneration was probably even greater.

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APPENDIX

APPENDIX

CLUMP AGING DATA

Location (see map)	Date and sample number		Radial measure. (in mm)	Annular rings counted	Comments
1	7-6-65	1	0.5	--	1965 germinants
2		2	3	14*	*scars present
			5	15*	
			7	16*	
3		3	10	29	
			8	29	
			5	29	clump probably had two temporal contributions
			2	18	
			6	18	
4		4	7	29*	*scars present
			10	28*	
			8	27*	
			18.5	29*	
			5	26	
			4.5	22?	?difficult to count due to very small size
5		5	17.5	25	
			7	25*	*scarred
			13	25	
			4.5	20?	? difficult to count
			8	21?	
6	7-7-65	1	6.5	19	
			2.5	15	
			2.5	15	
			18.5	27	
			7	20	
			5	23x	x dead members of clump
			5	17x	
			4.5	24x	
7		2	16	25	
			13	25	
8		3	5	30	ring counts of clump approximate
			4	20	
			2.5	18	
			5	30	

Location (see map)	Date and sample number		Radial measure. (in mm)	Annular rings counted	Comments
9	7-7-65	4	10.	31	
			6	31*	*scarred
			3	28?*	? difficult to count
			1.5	20?	
			5.5	33	
			8	38	
			2	17x	x dead
10		5	5	30?	
			2.5	20	
			7	20	
11		6	19	49	earlier origin?
			10	37	
			14.5	36?	
			4	20*	* scarred
12		7	7	33	
			4.5	32	
			4.5	22x	x dead
			8	22x	
13	7-12-65	1	1	2	all 19 individuals the same
14		2	1.5	15	ring counts of clump approximate
			1	13	
			2.5	16	
			3	16	
			1	13?	
15		3	1.5	12	
			1	8?	
			3	16	
			2	12	
			1.5	12	
			3	20?	
			2	12	
			3	12	
			2	12	
			1.5	12	
			2.5	12	
			2	12	
			1	12	
			5	12	
			1	? x	x dead
			1	? x	

Location (see map)	Date and sample number		Radial measure. (in mm)	Annular rings counted	Comments
16	7-12-65	4	1	11	
			1	11	
			1	11	
			1	11	
			1	11	
			1	11	
			0.5	? x	x dead
			0.5	? x	
17		5	4	18	
			2	10?	
			1	10?	
18		6	3.5	12	
			1.5	13	
			1.5	12	
			1	12	
			2	12	
			1.5	12	
			2	12	
19		7	2	13	
			2	13	
			1	3? x	x dead
			6	14	
			1.5	14	
			2	14	
			2	13	
			6	15	
20		8	3	15*	* scarred
			2	15	
21	7-20-65	202	183	73	
			134	72	
			72	70	
22		204	64	72	
			121	72	
			28	45?	
23		206	65	66	
			203	74	
24		208	159	68	
			30	47	

Location (see map)	Date and sample number		Radial measure. (in mm)	Annular rings counted	Comments
25	7-20-65	210	60	55	
			32	49	
26		212	148	67	
			80	67	
27		214	50	56	
			54	55	
			71+	48+	+ centermost rings not included in core
28	7-21-65	216	263+	233+	+ centermost rings not included in core
29		218	148	255	
30		1	0.5	2	all seven individuals in sample the same
31		2	1.5	12	
			2	12	
			1.5	12	
			1.5	12	
			1	8x	x dead
32		3	2.5	15	individual had four leaders
33		4	4	20?	
			4	21	
			4	22	
			3	21	
			9.5	22	
			7	21	
			12	22	
34	7-27-65	1	4	14	
			4	14	
			3	14	
			2	13	
			2	13	
			1	8x	x dead
			0.5	6x	
35		2	3	15	
			3	16	
			2	15	
			?	? x	x ten dead individuals

Location (see map)	Date and sample number		Radial measure. (in mm)	Annular rings counted	Comments
36	7-27-65	3	11.5	10	
			10.5	13	
			6	10	
			7	10	
			4.5	10	
			5	8?	
37	8-3-65	1	1	2	all 13 individuals the same
38		2	5	33	
			12	33	
39	8-9-65	1	15	43	
			6	42	
			5	39?	
			3.5	40?	
40	8-12-65	4	1	2	33 individuals the same
			1	1?x	x dead