DISTRIBUTION AND LIFE HISTORY OF THE BLACK POCKET GOPHER, THOMOMYS NIGER MERRIAM

by

KENNETH MERRIAM WALKER

A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1949

APPROVED:

Kenneth L. Gordon
Professor of Zoology
In Charge of Major

Kenneth L. Gordon
Head of Department of Zoology

Chairman of School Graduate Committee

W Wenige
Dean of Graduate School

ACKNOWLEDGEMENTS

I am indebted to several people for assistance tendered in this study. To Dr. Kenneth L. Gordon, my major professor, I wish to express boundless gratitude for the help he has given freely at any time called upon, the concretion of the problem, discussion of any new phase, and valuable suggestions. Many hours we have spent hashing over the problems at hand and always I have emerged with a clearer conception.

To my father, Mr. Alex Walker, a naturalist in every sense, I owe more than a few brief words can convey. I have been fortunate to grow up surrounded by, and accepting, what others find it necessary to learn. Going to him with the news of the problem I had selected and its many qualities and ramifications, he heard me out, then replied: "I'm glad you finally settled on niger, I have been preaching the need of such a study for years." The idea, as many others, had been so instilled in my mind I thought it was my own! In addition to specimens of Thomomys niger he has collected in the past year he has liberally loaned other material from his private collection. The skins of Thomomys hesperus were especially valuable.

To Dr. C. Andresen Hubbard I am grateful for the identification of the fleas collected from the black pocket gopher.

Acknowledgement is also due the Oregon State College Museum of Natural History for use of facilities there.

My wife, Charlotte M. Walker, has been very patient and helpful, many of her weekend plans have vanished when I flew off after gophers, taking advantage of a break in the weather; other acts of commission, innumerable, have been willingly accepted.

TABLE OF CONTENTS

INTRODUCTION

GENERAL. Having collected mammals on the Oregon Coast since my years were tender I was fascinated by the stories of a black pocket gopher that I had never encountered. Though strikingly different from all other gophers, very little was known of Thomomys niger, in fact in the Oregon mammalogist's bible, Bailey's Mammals and Life Zones of Oregon, only the briefest of mention is made of the species.

The summer of 1948 found me heading out in a delapidated Model A Ford, dragging a borrowed one-wheeled trailer loaded high with camping equipment, collecting materials, and food, and determined to find out about this gopher. Two general problems were in mind, first, just what is the range of this gopher, and second, what is its life history. The books and people I knew could give me but little assistance; I was starting out blind.

After searching vainly about for several days I fortunately stumbled upon Mr. Overton Dowell of Mercer Lake. His aid in pointing out colonies on his place and helpful hints on where to expect the gopher placed the study on its feet.

During the summer, from June 28 until October 24, the area from the Alsea River on the north to Coos Bay on the south and west of the summit of the Coast Range to the Pacific Ocean was traversed by highway, secondary roads, and some roads barely worthy of the name. Driving slowly along, the area adjacent to the road was scanned for workings and periodically the more likely looking spots were traversed on foot. Conversations were entered upon with farmers but in

general these proved unsatisfactory, few knew their mammals well enough to be of assistance. On discovery of gopher workings traps were set out and camp made nearby.

The Macabee gopher trap was used with success. A small transplanting trowel was a valuable aid in opening up the burrow and loosening the dirt for insertion of the trap. Sticks or wire stakes were used to secure the trap and a tuft of absorbent cotton placed on a nearby twig to facilitate return to the trap.

From late October until April numerous short and overnight trips were made into the study area and adjacent territory for gophers; these trips were much less strenuous thanks to a more modern car.

POSITION IN CLASSIFICATION. The black pocket gopher, Thomomys niger, belongs to the numerous kinds of pocket gophers found in North America, all of which are grouped into the family Geomyidae. These are fossorial rodents, seldom to be seen above the ground surface. Their tunnels are constructed by use of both the fore-feet and the incisors as an excavating mechanism, the loosened dirt is then pushed out short side tunnels to form the typical cresent-shaped mounds, the most apparent indication of their presence, or the dirt is tamped into tunnels no longer desired for use. It is largely within the confines of these narrow walls that the pocket gopher finds safety, searches out, eats or stores food, builds sleeping chambers and toilets, and rears its young.

All are very similar externally, possessing a broad flattened head, fur-lined cheek pouches, large incisors, smallish eyes and ears, a thickset body, short strong legs, the forefeet equipped with long, sharp claws, and a thick, rather short tail. The three genera occupying the United States are most readily distinguished by the grooves and ridges on the anterior face of the upper incisors.

The eastern pocket gopher, Geomys, has deeply grooved upper incisors. Its range encompasses the area from Minnesota to the Gulf of Mexico and from the eastern foot of the Rocky Mountains to the Mississippi River. A second area is found from central Alabama and Georgia south into central Florida.

The chestnut-faced pocket gopher, Cratogeomys, has but one groove on the upper incisor. The range is from southeastern Colorado and western Oklahoma south through New Mexico and Texas into Mexico.

The genus Thomomys is widespread in the West and is differentiated into a multitude of forms by the extremes of habitats encountered. In Oregon alone no fewer than 15 forms are found, Washington boasts 17 forms, and California has well over 30 forms.

The pocket gophers are of squirrel-like ancestry but the origin was in remote times; the genus Thomomys has been in existence since the Miocene period (11,p.248).

ORIGINAL DESCRIPTION. The original description of Thomomys niger was published by Dr. C. Hart Merriam, of the Biological survey, United State Department of Agriculture, in 1901 from

undescribed material residing in the U. S. National Museum Biological Survey Collection, (17,p.116-117). Being most pertinent to this work the entire description will be quoted.

Thomomys niger sp. nov.

Type from Seaton, near mouth of Umpqua River, Oregon. No. 69,407, ♂ ad., U. S. National Museum Biological Survey Collection. October 6, 1894. J. L. McLellan. Original No. 1147.

Characters:--Size medium; feet large; tail medium; ears short; head and body all round glossy slate black with greenish iridescence; nose duller; feet and tail white, sometimes irregularly blotched with dusky.

Cranial characters:--Skull of medium size, massive, showing well developed temporal ridges; interparietal oval or broadly subtriangular; zygomata moderately spreading and rounded; nasals emarginate, strongly and abruptly narrowed on posterior two-thirds.

Remarks:--In coloration the 6 specimens at hand from the type locality strikingly resemble T. crinitae from southern Mexico. They differ from crinitae in having less black on the feet and tail and in marked cranial characters. The nearest relative of T. niger appears to be T. douglasi from the Columbia River. It differs from T. douglasi, apart from color, in smaller size and in the following cranial characters: frontals narrower interorbitally, zygomata rounded instead of angular, their outer sides parallel instead of diverging anteriorly; nasals abruptly constricted between anterior and middle thirds and narrow posteriorly (instead of having straight sides); bullae heavier anteriorly; molar series of same length as in douglasi but broader; incisors strikingly large and broad; under jaw deep, the angular process much more heavily developed.

Measurements:--Type specimen (♂ ad.): total length 225; tail vertebrae 81; hind foot 30. Average of 5 adults from type locality; total length 215; tail vertebrae 72; hind foot 30.

Thomomys niger is again mentioned in the revision of pocket gophers of the genus Thomomys by Bailey in 1915, (3,p.121).

He states:

> "This is probably a dichromatic species of which as yet only specimens of the black phase have been secured."

Bailey also lists 22 specimens examined.

> "Mapleton 8, Mercer 7, Scottaburg (2 miles east) 1 albino without skull and not certainly identified; Sesston 6."

Further mention of this species has been made in such more recent literature as Anthony's Field guide to North American Mammals (1,p.285) and Bailey's Mammals and Life Zones of Oregon (4,p.256). Bailey adds this comment:

> "...they occupy the small open spaces near the Coast but have not been found in the dense timber covering most of that country. No peculiarities of habits have been noted."

These meager threads of information, being all that was available on a form as strikingly different as the black pocket gopher, with so many possibilities of adding to the scientific knowledge of the form, naturally tempted this investigation into the distribution and life history of Thomomys niger.

SIZE

Thomomys niger is a medium sized pocket gopher. The females are definitely smaller in size than are the males, therefore when comparative measurements are desired the sexes are best segregated. The size classes of 96 specimens are presented in Table 1.

Table 1. SIZE CLASSES OF 96 Thomomys niger, TAKEN JULY TO SEPTEMBER, BASED ON TOTAL LENGTH.

	Male	Female	Undetermined
165-169			1
170-179		1	4
180-189		1	1
190-199	2	7	
200-209	5	12	
210-219	10	23	
220-229	13	10	
230-232	3		
Totals:	35	54	7

To obtain the average size of adults it was necessary to determine the minimum adult length. One female, total length 205, was taken from the same system with three juveniles; with this as an indicator a minimal length for females of 200 was selected. The males, running larger, were selected with a minimal length of 110 millimeters. Twenty-six males and 45 females fall into these categories.

Table 2. MEASUREMENTS OF ADULT POPULATIONS OF Thomomys niger. EXTREMES INCLUDED IN PARENTHESIS.

	Total length	Length of tail	Length of hind foot
Type (ad. ♂)	225	81	30
Topotypes (5 ad.)	215	72	30
26 adult ♂	222 (210-232)	67 (52-76)	29.5 (27-31)
45 adult ♀	214 (203-226)	65 (58-77)	28.5 (27-30)

The above average measurements correspond with the published original description with the exception of the length of the tail vertebrae. The type specimen, a male, had a tail length of 81 as opposed to the maximum of 76 and average of 67 found in this study. The average of 5 adults from the type locality displays the same

trend, a tail length of 72 as compared to an average of 67 for the males and 65 for the females of this study.

COLORATION

COLOR OF PELAGE. Bailey, (3,p.121), remarks that "This is probably a dichromatic species of which as yet only specimens of the black phase have been secured." However, later (4,p.256) he makes no mention of dichromatism. As more specimens have been collected it has become increasingly apparent that the black phase is alone represented in the population. Bailey lists 21 specimens examined (deleting the questionable albino); Overton Dowell estimated that he has collected around 60 specimens; Alex Walker has collected 13, and the author has collected 83 individuals. Thus the known individuals examined by scientific workers is in excess of 175, surely a fair sample of the rather small and restricted population, yet no exceptions have been noted.

That dichromatism was at first expected is not unreasonable, this phenomenon occurs in several species of Thomomys. Black phases have been recorded in the Townsends pocket gopher, Thomomys townsendii townsendii, Snake River of Oregon and Idaho; the Nevada pocket gopher, Thomomys townsendii nevadensis, northern Nevada and southeastern Oregon; the southern pocket gopher, Thomomys umbrinus umbrinus, Vera Cruz, Mexico; the Orizaba pocket gopher, Thomomys umbrinus orizabae, Puebla, Mexico; and the Mexican pocket gopher, Thomomys umbrinus peregrinus, the Federal District of Mexico.

Fourteen of 16 topotypes of crinitus were black (3,p.91).

Closer to the range of niger is the West Coast pocket gopher, Thomomys mesperus, of Clatsop, Tillamook, and Lincoln counties of Oregon, in which, in some colonies, as many as 10 percent of the individuals are partially or wholly black. Some specimens of the black phase are scarcely distinguishable, externally, from niger; others, however, have more of a brownish tone and are more readily separable.

In describing the color of niger Merriam says: "...head and body all round glossy slate black with greenish iridescense." (17,p.116). This was from specimens collected in October and is typical of the winter pelage. In summer much of the iridescence and sheen is lost, the pelage taking on a dull slatey black appearance. The underparts are duller and more plumbeous. The young are a dull sooty black. The feet and distal portion of the tail are white, the amount varying between individuals.

MOLTS. Two complete changes of pelage occur in the genus Thomomys each year, a summer coat acquired in spring and early summer and a winter coat in the fall (3,p.121). The molt in niger proceeds from the nose backwards in an erratic fashion, forming conspicuous crescent-shaped waves, moving most rapidly along the back and lagging on the sides, the waves becoming further distorted by change of rate, often overtaking and running into each other. The change occurs when the old hair is forced out by the new, a thinning and filling up process, the new hair contrasting with the old in both color and length.

The spring molt is accompanied by numerous waves and is protracted well into the summer, two and three waves are often displayed into July and August. By October the waves are lacking and the uniform glossy black pelage of winter is complete. However, by the following summer the gloss is missing and a dull grey remains. Only the tips of the hairs are glossy; wearing off of these tips against the tunnel walls is undoubtedly the cause of the duller coat.

The young do not molt until the change into winter coat when the fine, silky hairs are shed for the mature, coarser, adult covering.

GENETICS OF COAT COLOR. Color abnormalities have always possessed a peculiar fascination for man. In the earlier days designations such as "albino" or "melanistic" were common but no further attempt was made to determine the factors responsible for these freaks. In the past three decades the animal geneticist has learned much concerning the factors involved in the production of coat color in laboratory animals, but only a limited amount of work has been concerned with wild populations. The best known wild population, genetically, is Peromyscus. Genetical analysis requires transporting the individuals into the laboratory maintaining health and vigor, and controlled breeding over a period of several generations. This offers a serious obstacle for the pocket gopher since no one, as far as I could determine, has been able to breed these fossorial rodents in captivity.

Storer and Gregory (19,p.300) attacked the problem by the inferences of parallelisms. Numerous similar factors controlling the coat coloration have been found in one or more laboratory mammals; the Norway rat, Rattus norvegicus; house mouse, Mus musculus; guinea pig, Cavia porcellus; the European grey rabbit, Oryctolagus cuniculus; and the black rat, Rattus rattus rattus. Genetically, it may be assumed that homologous genes are operating in the production of at least certain of the color aberrations, these having been inherited from common ancestors.

Five mutations have occurred in the agouti series of alleles; A^y, A^w, A, a^t, a, in order of dominance. A^y occurs in the mouse, resulting in the hair being a yellow. This factor is lethal in the homozygous state. The A^w allele occurs in all the laboratory species of rodents, causing a grey condition with a yellow or light colored belly. The A, found in the mouse, black rat and guinea pig, causes a yellow band to be present on all hairs of the body. The allele a^t occurs only in the mouse and rabbit, causing a black-and-tan condition. The lowest allele is a, non-agouti, in where presence the black hair lacks a yellow (or white) band resulting in a black or chocolate colored fur.

The normal coat of pocket gophers is typical agouti with both black and yellow sections on each hair. The numerous local races differ from one another in the tone of coloration, from quite blackish through admixtures of red to the very pale forms found in the desert areas.

Returning to the case at hand, Thomomys niger, Storer and Gregory (19,p.309) state:

"From these observations we may conclude that niger has become homozygous for the black, non-agouti (aa) condition, that townsendii shows local differences in the frequency distribution of this mutation, that orizabae possibly has a high percentage frequency of the mutation, while in the pocket gopher population elsewhere this mutation occurs, but is of relatively low frequency."

One other possibility merits mention at this time, namely, the allelic series which affects the extension of black or chocolate, E^D, E, e^P, and e. The allele E^D produces extreme extension, the yellow band in the hair being either completely lacking or being present as a very narrow band which shows on only a few hairs. This gene is epistatic to the agouti factor. It has been found only in the rabbit and black rat. (19,p.305). The allele E results in the normal extent of black or chocolate pigment through the coat. The third allele e^P produces partial extension, the black being only partially extended through the coat, red in the unextended portion producing a brindling effect. With the allele e, the coat is red, the black or chocolate being not at all extended.

Specimens of Thomomys mesorus from Tillamook County, Oregon, display a varied amount of "melanism" ranging from a darkening of the mid-portion of the back to an apparent black. However, closer observation discloses a chocolate rather than a pure black color,

even in the darkest specimen. Undoubtedly this condition of the coat is the result of E^D; no yellow band is apparent on any hairs. The question arises, could this extension gene, E^D, equal in intensity of black that produced by the non-agouti aa? The taxonomic relationship of the two neighboring forms hesperus and niger has not been satisfactorily worked out, but some relationship may exist. If so possibly the hesperus coat is an intermediate step in the formation of the niger coat in which no trace of chocolate has been found.

EVOLUTION OF THE BLACK COLOR PHASE. Regardless of whether the black coat color of niger is a result of one or the other of two gene actions, that of aa non-agouti or E^D extension, the problem still remains as to how the factor for black could become fixed in a population, excluding entirely the normal brown or agouti.

No black forms have been found in most species of Thomomys, some have a low frequency of the black phase, other species have a variable frequency, higher in some sections of the population than in others as is the case in hesperus. The extreme is approached in which a high frequency is maintained, an example of this being orizabae. Niger would complete the transition with a frequency of 100 percent.

While it is realized that the species is the result of the total genic constitution with its complicated interaction of constituent genes, we are here delving into the relationship and possible means of establishment of a single gene, in other words, the

evolution of the black color phase. Numerous factors affect the ratio of a gene within the population as a whole; their effects may be additive or subtractive, may establish balances of ratios or destroy such balances that exist, may wipe out a gene or cause fixation of that gene to the exclusion of its allele. Such factors are those of mutation pressure, chance, migration, size of population, natural selection, and linkage.

Mutations, and chromosomal changes, are the first stage in the process of evolution. In the early stages immediately following the mutation it may become lost or increased in frequency. If not lost it is acted upon by selection, migration, and geographic isolation.

The process of evolution is one of several or all of these factors interacting at the same time, yet we can better visualize the phenomenon if each factor is considered separately, then again synthesized into a complete picture, keeping in mind always the application to the species under discussion, niger. First we will consider mutation pressure.

The presence of the mutation to black has been noted in many species of Thomomys. This pattern indicates an unstable gene, inherited from a common ancestor, that mutates independently in each species. When we consider the likelihood of a new mutation becoming established in a population we find the cards stacked against that mutation; only a few normally become established. Mutation pressure is a contributing factor in the early establishment of the new gene. However, when the frequency of the new gene reaches a larger percentage of the

population additional mutation pressure begins to loose its significance. If, for instance, 0.5 of the population carries the mutation, either in the heterozygous or homozygous state, one new reoccurrence of the mutation is not apt to materially alter the balance already established. We must then look for other factors than mutation pressure.

The possibility of chance is often overlooked. All animals produce many more offspring than can survive to the following year if the population level is to remain nearly stationary. According to Hardy's formula, a genetic balance between alleles is established and theoretically this would be maintained generation after generation. However, according to Dubinnin and Romaschoff (3,p.161-163) chance, or the scattering of variability to use the words of Dobzhansky, may result in the complete loss of some mutations and doubling the frequency of others. At the same time this factor of chance may be of greatest assistance in establishing a mutation past the critical stage, or be its greatest enemy perpetrating its annihilation. Even after the gene has become well established chance does not cease to operate. If the gene frequency is balanced at 0.6, chance might throw this frequency in any one generation to 0.7 whereupon it would be again balanced but at this new level. Chance alone could decrease the frequency until the loss of the mutation, or increase the frequency until complete fixation is reached; thus, both fixation and loss of a gene within a population could occur without selection, mutation pressure, or any other factor.

Population size is also a critical consideration with the variability due to chance. "The smaller the population size, the more rapid is the scattering of variability and the eventual attainment of genetic uniformity," states Dobzhansky (8,p.165). Thomomys niger would justly be considered a species with a small population. The total area occupied is not extensive, and within this area the species is limited to a very small ecological habitat in which it may be frequent, rare, or occurring not at all. This is the condition today; when the alteration of the native country by white man is visualized it is apparent that more area suitable as habitat is available now than was under the original conditions. Chance, then, would seem to be one of the major possibilities amongst the factors controlling the evolution of the black population.

Migration would tend to neutralize the shift of aberrant gene ratios away from that of the surrounding forms. It is difficult to conceive of any extensive amount of migration into the incipient black group. First, the pocket gophers do not show meeting populations and subsequent genetic mixing, this being a trait of the entire genus. Secondly, the gopher is an animal of low motility, seldom leaving the confines of his tunnel system. Any gopher migrating into an area previously occupied would meet stiff competition from the original form which has already filled its niche so completely that many of its own kind must, of necessity, perish in the competition for living space and food. Therefore, it seems unlikely that migration could play more than a minor role, if that, in the formation of a black

species.

The part that natural selection plays in the formation of the multitude of animal species has been emphasized repeatedly. For many species this is true but the premise is not a blanket to cover all forms; our gopher may be another exception.

Gloger's ecological rule, applying to warm blooded vertebrates, states that the melanins increase in the warm and humid parts of the range while reddish or yellow-brown phaeomelanins prevail in the arid climates where the blackish eumelanins are reduced (16,p.90). The pocket gophers, in general, conform rather nicely to this rule which may be explained by the selection of the more conspicuous individuals out of a population. But it is a little more difficult to explain the presence of black forms in an area normally occupied by dark brown forms, not to mention the semi-arid areas of townsendi. In daylight, the black gopher, casting out dirt at the mouth of a tunnel, would be more conspicious than a brown gopher. On the other hand, the dark gopher could be better protected from predators, especially owls, during hours of darkness than the lighter phase.

Since niger seldom appears above the surface except when expelling dirt from its systems, it seems unlikely that any extensive amount of selection is exerted. In fact this lack of selection could well be one reason for the allowance of aberrant characters to reach full development.

The length of time required for a gene to become fixed, even

with a selective advantage of one percent over its allele, which probably is far in excess of the selective advantage, if any, that is present, is in the magnitude of 1,001,742 generations to progress from a frequency of .01 to 99.99 percent. Since the pocket gopher has an annual breeding cycle, better than a million years would be required for the fixation of a mutant gene by selection alone! The process then would antedate the middle of the Pleistocene period.

Linkage of the gene responsible for black with another of benefit to the individual, and the population, cannot be ruled out as a possibility. However, it is impossible to determine if this factor does exist in the case under discussion.

Of the various factors controlling the rate of fixation of a mutation, the chance scattering of variability has probably been most effective in establishing the aberrant black coat in niger to the exclusion of the typical wild type coat.

SPOTTING MUTATIONS. Typically the pocket gopher displays a variable amount of white on the distal portion of the tail and the feet, often up to and including the wrists. Some white areas are usually present in the vicinity of the cheek pouches and mouth. This condition is found throughout the genus Thomomys and is very apparent in niger, standing in bold contrast to the black coat. Furthermore, a goodly number of specimens show additional white spotting on some portion of the body, the condition being found on 37 of the 96 specimens examined, a frequency of 38 percent. The condition varies from one or two small spots on the midventral

surface of the abdomen to extensive ventral white areas, often connecting with legs and feet, extending forward broadly over the nose and narrowing to a mid-dorsal stripe from nose to between the ears.

The genetical explanation of spotting as described for laboratory animals is not simple. Storer and Gregory (19,p.310) apply the Dutch spotting of Castle to the spotting of gophers. The series in rabbits contains three alleles, Du, du^w, and du^d. Du is the unspotted condition, du^w the white Dutch, and du^d dark Dutch. The genic interpretation of the Dutch spotting has been controversial. Castle and Punnet both have investigated this condition; their findings agree in general but the two men hold different views as to the number of genes and their interrelationships. Punnet believes Dutch spotting is the result of multiple genes; four different allelemorphs. Castle assumes a single set of alleles are present; the great amount of variation between the dark extreme and the white extreme is the expression of heterozygotes. According to Castle's chart of grades of Dutch spotting (7, plate 1) 32 of the specimens of niger examined fall into grade 1 Dutch; ranging from slight to moderate amount of ventral spotting with more extensive white on the feet, throat, and cheek pouches, and occasionally a few scattered white hairs on the forehead. One specimen is grade 3 Dutch, with a moderate amount of white on the underparts, a few white hairs on the mid-dorsal line half way between the eyes and the ears, and on the right side, an extension of the ventral white in a broad stripe up to the mid-dorsal

line in the belt area. The 4 remaining specimens are difficult to place; posterior to the head region they correspond with grade 2 Dutch, but have white throat, nose, and mid-dorsal stripe extending nearly to the region of the ears as in grade 4 Dutch. Lateral extensions of the ventral areas reach the flank but do not approach the mid-dorsal line.

Another approach may be made by way of homologizing the gopher with the mutations found in the house mouse, Mus, by Grüneberg (12,p.49-66). This attack would seem somewhat more reasonable since the gopher and mouse are more closely related, phylogenetically, than are the gopher and rabbits. At the same time it should not be overlooked that these two explanations may be merely different interpretations of the same phenomenon. Grüneberg states that spotting is the result of a recessive gene s, the phenotype in mice being given the name piebald. Mice which have been found to be homozygous for s still may differ widely as regards the white areas of their coat, the result of the k complex of genes, estimated to be at least three in number, such genes are spotting genes in their own sense. To further explain the picture of the interaction of these genes he states (p.55):

> "In the absence of the "k" genes, that is in the presence of their normal allelomorphs, s is almost completely recessive to its normal allelomorph. On the other hand, the "k" genes are almost recessive in the absence of s; however, on an s/s background, they are semi-dominant. In other words the dominance of s is influenced by the presence or absence of the "k" genes, and the dominance of the "k" genes is influenced by the presence or absence of s."

The "k" complex is thought to contain about three genes with major effect and possibly several others with minor effects. Even the major genes, however, have only a limited effect singly but combined may have a greater effect than s.

Thus, following this explanation, a variety of spotting would correlate with the constituents of the gene combination from the basic pattern, the distal portions of feet and tail, through a great number of intermediate combinations until with s and the full compliment of "k" genes an all white phenotype is secured.

This explanation is further enforced by the findings of Barto and Huestis (5,p.245-248) in wild populations of Peromyscus. In breeding experiments they found that white star, a patch of hairs white to the base, on or near the mid-dorsal line about half way between the eyes and the pinnae, was the result of interaction involving multiple genes. A white ventral spot was found in starred mice more often than would be expected by chance association.

It would seem that the presence of multiple genes with modifying and cumulative effects is the most tenable explanation of spotting in mice.

RANGE

EXTENSION OF KNOWN RANGE. One of the starting points in the study of any species is the inquiry into its exact geographical

distribution. A complete comprehension of the range of an animal is necessary before substantial correlations can be determined as to the relationship of the animal to all its environment, the ecology of that animal.

Bailey (4,p.256) lists the following distributional records: "Known only from near the mouth of the Umpqua River, at Seaton and Scottsburg, and in the Siuslaw Valley at Mapleton, Deadwood, 10 miles northeast of Deadwood, and Mercer." Seaton, Deadwood, and Mercer are examples of vanishing reference points. In the early days postoffices were often located in farm houses scattered throughout the coastal areas, these usually being near the few routes of access to the more populated areas. The farmer and his family operated the postoffice largely as an accomodation to the neighbors in his vicinity. Since the advent of improved roads and better means of transportation much of the area enjoys rural mail service. The postoffices have ceased to function, except where towns have become established. For a few, the names still remain on maps, such as the United States National Forest Service maps. Mercer may be located on the map, the farm house still stands but is no different from many others round-about. Unfortunately other names are no longer on maps, the best source of information being the old timers who can remember back when--. The location of Seaton will be discussed in detail later. Deadwood was near the confluence of Deadwood Creek with Lake Creek, some 4 miles northeast of Swiftshome. The locale, 10 miles northeast of Deadwood, would then lie in proximity to Triangle Lake.

During the summer of 1948 much of the country lying west of the summit of the Coast Range from the Yaquina River drainage south to Coos Bay was traversed in search for populations of niger. The following table illustrates the localities where specimens were collected.

Table 3. COLLECTION RECORDS OF 96 Thomomys niger.

	Male	Female	Immature	Total
Mercer Lake, 6 mi. N. Florence, Oregon	4	6	9	19
China Creek, 13 mi. N. Florence, Oregon			2	2
Big Creek, 14 mi. N. Florence, Oregon	10	12	2	24
Tenmile Creek, 7 mi. SE. Yachats, Oregon	6	9	7	22
Yachats River, 7 mi. E. Yachats, Oregon	1	3		4
Indian Creek, 12 mi. N. Mapleton, Oregon		2	1	3
Walker Creek, 3 mi. NW. Mapleton, Oregon		6	1	7
Alpha, 9 mi. NE. Swiftshome, Oregon			1	1
Paris, 14 mi. N. Swiftshome, Oregon	2	2		4
Lobster Creek, 8 mi. SW. Alsea, Oregon	3	5	2	10

The above table indicates an extension of the known range northward to the Yachats River and the Alsea drainage area, about twenty miles airline beyond previous records. A considerable area further northward remains to be searched, the Big Elk, Yaquina, and Siletz drainages lying between niger and the southernmost known range of hesperus at Devils Lake in Lincoln County. Trapping three miles west of Alsea, Benton County, revealed the presence of brown

gophers, tentatively referred to the Oregon pocket gopher, Thomomys douglasi oregonus. Five specimens were taken on a steep, grazed hillside in November 1948. Also not positively identified is a black gopher collected from the top of Mary's Peak, elevation 4097 feet, 14 miles southwest of Corvallis and 9 miles north of northeast from Alsea, in August, 1942, by the author. The black condition of the pelage is intermediate between the darkest hesperus and the pure black of niger, just a trace of chocolate is noticeable and only under magnification of the hairs. Return to Mary's Peak in the summer of 1948 unfortunately did not result in the location of additional gophers, even with an exhaustive search of the prairie area near the summit.

Bailey (4,p.255) places specimens from Alsea with hesperus, and, of a specimen from Philomath, 5 miles west of Corvallis, and one from the top of "Chintimini Mountain" (Mary's Peak), he says these are not fully typical of hesperus but can be referred to it better than to any other form. As yet not enough material is at hand for a taxonomic investigation into this perplexing problem. Grossly, it appears that oregonus extends south along the margin of the Willamette Valley and breaks over into a similar type of habitat in the upper Alsea Valley.

A thorough search of Grass Mountain, elevation 3612 feet, located 5 miles northwest of Alsea by Alex Walker revealed no gophers are present in the grassy areas there.

There seems to be no visible limiting barrier to the north of the range of niger, the physiography of the area is continious to the north. Major streams are few and not large enough to preclude chance crossing during a prolonged period of occupation of the present area. While the entire population is broken up into small discontinious, completely isolated populations in the valleys by the intervening dense forests, the gopher has been able to occupy these areas and in the same sense could extend its range further to new, unoccupied areas. The vegetation is uniform, adaptations to specialized food or soil requirements could be easily met outside the present range. The answer, again turning to theory, may lie in the fact that this is a young, expanding population, not yet attaining its maximum range.

Eastward the range is bounded by the upper valleys of the coastal drainage systems. The more arid conditions and accompanying change in the vegetation prevents an extension of the range into the Willamette Valley. Again the periphery has not been adequately covered. The published record of 10 miles northeast of Deadwood places the locality in the vicinity of Triangle Lake, the most easterly record to date. Lobster Valley in which niger was taken heads at the foot of Prairie Mountain. It would be interesting to pack in to the prairie area on top in search of further records. Maximum elevation is 3,437 feet.

Southward I found no colonies south of the Siuslaw River, and, east of the junction at Swisshome, south of Lake Creek. The upper

reaches of the Siuslaw beyond this junction remain to be critically examined. Nearer the coast the area adjacent to U. S. Highway 101 was adequately covered, side trips were made in to Canary, 5 miles southwest of Florence, and up Smith River from Gairdner at the mouth of the Umpqua to Spencer Creek. No gophers. South of the Umpqua the search was carried to Coos Bay, then up the Millicoma River and East Glen Creek to Silver and Golden Falls. Nothing but moles. From Scottsburg, on the Umpqua, a trip was made southward up Mill Creek to Loon Lake and Ash Valley; more moles.

The part played by the Siuslaw River as a geographical barrier cannot be evaluated until further collecting is conducted along its upper reaches. Conceivably this major stream course may limit the southward extension of the range. As this statement brings us into sharp conflict with published records from the Umpqua drainage, this will now be discussed.

CORRECTION OF PUBLISHED RANGE. Returning to the original description again it is noted that the new species is described from type and topotype material "...from Seaton, near mouth of Umpqua River, Oregon." This statement is in error, Seaton was located on the Siuslaw River, not the Umpqua. The mistake was perpetuated in Bailey's revision of Thomomys (3,p.121). In Mammals of Oregon (4,p.256) Bailey almost corrected himself; of the type specimen he says, "Collected at Seaton, near mouth of Siuslaw River, Oregon,..", but under the heading of distribution and habitat he again errs, stating: "Known only from near the mouth

of the Umpqua River, at Seaton and Scottsburg, and in the Siuslaw Valley....and Mercer."

Inquiry into the correct location of Seaton led from one person to another, finally an unidentified elderly lady said "Yes, I was here at Mapleton when a post office was at Seaton, about two miles up river from here." Mapleton is on the Siuslaw, Seaton then was 2 miles northwest of Mapleton and near the head of tidewater. Today there is no indication of the vanished site, a fisherman's cabin occupies the stream bank surrounded by a dense growth of salmonberry, thimbleberry, and alder. Certainly there is no habitat left for gophers in the immediate vicinity by the quickly encroaching vegetation.

Based upon the belief that niger was present on the Umpqua Bailey (3,p.121) lists a specimen taken 2 miles east of Scottsburg, an albino without skull and not certainly identified as niger. But later, (4,p.256) as cited above, he merely designates Scottsburg as a locality record without reservation.

A visit to Scottsburg in August netted reports of first black, then brown gophers from farmers in the area but none were caught in traps set in locations where gophers reportedly resided. A return visit was paid to Van Landingham's bulb farm on the valley floor 2 miles east of Scottsburg in November. This time five gophers were taken, the white-toothed pocket gopher, Thomomys bottae leucodon! The owner of the farm was genuinely surprised, he had never seen a brown gopher. What he had taken as black gophers must

have been the meadow mouse, Microtus.

Ecologically the finding of bottae leucodon is not illogical, the area is more arid than the typical niger habitat. Green grass was absent in July, poison oak, Rhus, wild rose, Rosa, and the oak, Quercus, indicate the drier trend. The soil in general was clayish and baked hard on the hills away from the riverbottoms.

Thus, the determination of the correct location of Seaton and collection at Scottsburg of another species leaves us no established record of niger south of the Siuslaw.

HABITAT

GEOLOGICAL HISTORY OF AREA. The Oregon Coast Range is composed of low outline mountains extending from the Klamath Mountains on the south north to the Columbia River. The rocks of the area are of Tertiery age and generally weak, though not uniformly so. The details of topography are, therefore, in part determined by relative resistance. Volcanic rocks are also present, intruded into the sediments; these form the highest peaks as Mary's Peak in Benton County, Mt. Hebo in Tillamook County, and Saddle Mountain in Clatsop County. Fenneman (9,p.460-461) states:

> "The general aspect of this range is that of a dissected plateau or upraised peneplain. The hilltops, ridge crests, and in some cases tabular features which determined the nearly level horizon on the sedimentary rocks, rarely rise above 1,700 feet in northern Oregon. .... Well-preserved patches of peneplain are more abundant in the northern than in the southern part. East and west from the higher central zone the level of the crests declines.... The peaks which rise above this general level are all monadnocks and all, so far as known, are of igneous rocks."

The main stream courses are east and west, the Columbia and the Umpqua cross the entire section while the Nehalem, Yaquina and Siuslaw Rivers are so near the east foot of the range that divides of less than 400 feet separate them from the Willamette Valley basin. In cross section the valleys show a narrow valley contained in a broader one which indents a peneplain. Some of these older valleys have become destroyed by erosion of the younger streams. The younger streams are wide, containing considerable flats where the rocks are soft, but are mere gorges or canyons where the rocks are hard.

Along the coast a narrow plain, not more than one or two miles wide, borders the mountains, evidence of a recent uplift of the land during the Pleistocene. Since that time, a number of topographical adjustments have been made in the late Pleistocene and Postglacial. Hansen (13,p.14) believes that during glacial times the ocean level was lowered 200 to 240 feet; in this phase the streams incised deep valleys to be submerged again, drowning river mouths for many miles inland, by the return of water to the ocean during deglaciation. The Umpqua and Siuslaw valleys are drowned for a distance of approximately 25 miles. A certain amount of diastrophism also has created warping along the coast.

The mountain range is of recent origin, at least post-Eocene; it was of gentle folds, never extending high. By the Pliocene the peneplain was formed, the streams flowed in their present courses. Then as this peneplain was uplifted the Columbia

and Umpqua kept pace, cutting their present valleys. As mentioned, in the Pleistocene the land stood high, then in post-Pleistocene again subsided to its present level.

From the pollen analysis conducted by Dr. Hansen we learn something of the vegetation in this region during postglacial times, especially of the trees. From bogs on the coast he found pollen of lodgepole pine, Pinus contorta, Douglas fir, Pseudotsuga taxifolia, western hemlock, Tsuga heterophylla, and Sitka spruce, Picea sitchensis represented throughout this period; the same trees are present in the immediate areas today, (13,p.95-97). The lack of the regional changes in vegetation he had found elsewhere is probably the result of a relatively constant postglacial climate due to the marine influence. The warm, dry period noted in succession analysis throughout the Northwest is not here indicated. It is possible that the warm, dry period resulted in climatic fluctuations but did not elicit a response from the vegetation, the precipitation did not drop below nor the temperatures rise above the optimum for the species present, succession did not take place. With the assurance that the vegetation of the area has undergone little change in the past 20,000 years we might ask the question, just what areas were available for occupancy to the pocket gophers?

Thomomys niger displays certain definite habitat requirements. First that of food, largely grasses and herbs that would occur in natural clearings, and second, a well drained site, free from the danger of rising water table or flooding. With these requirements

in mind it is difficult to visualize extensive areas available at any time in the past. Climax vegetation of the area is the dense forests, wholly unsuitable for the gopher; these forests extend over most of the area involved. Natural meadows were perhaps formed where the excess water present precluded the climax trees. However, these were likely limited in extent, ranging from marshy conditions, unsuitable for the gophers, through drier stages until the point was reached where the climax type was best able to endure. This intermediate area is not given over entirely to grasses; such trees as red alder, Alnus oregona, and shrubs as thimbleberry, Rubus parviflorus, and salmon-berry, Rubus spectabilis, thrive thereon. The populations of niger perhaps hung on by a precarious thread; as climate and vegetation fluctuated slightly the gopher probably spread to new areas as they became available, and was expelled from areas by the gradual invasion of forest species. It is difficult to visualize conditions that would favor the gophers before the advent of man.

INFLUENCE OF MAN. The Indians often burned areas to improve hunting. The fire succession as we know it today would yield no favorable habitat. The barren ground following a fire would be adverse, food would be lacking. Soon the brake-fern, Pteridium aquilinum, would shade out the few grasses that gained a temporary foothold, the fern loses to the dense brush, and this in turn gives way to the tree species.

CLEARING. The coming of white man has been a great boom to the gopher. The areas most easily cleared were settled first, then the forests and brush were pushed farther and farther back, man always toiling against the attempts of the plants to recover the area by vegetative succession. Grazing and mowing kept the fields clear as more fields were continually being added. Today it is difficult to visualize the original condition of these fertile valleys but here and there a huge stump of Douglas fir or western red cedar still stands in the middle of the valley, a reminder that these giants once held the area. Occasionally some of the marginal lands have been neglected and the battle swings in favor of the vegetation again; in the span of a few years the potential homesites for gophers have vanished under the closed canopy of fern, brush, and small trees. It has been said that in most parts of the country man strives to promote growth, here he must strive to prevent it!

Logging operations are often followed by slash fires resulting in clearings within, or on the margin of the forest. As we have seen, if allowed to progress naturally, the vegetation will undergo successional stages until the sub-climax or climax vegetation is again restored. However, interference of man, and his domestic stock, may alter or retard this succession. After fires have denuded an area he may seed it to grasses of his own liking, and with mowing or grazing by stock hold succession in check. Well drained hillsides are often held in this manner, offering the gopher excellent habitat.

Thus, we see more clearly why ecological barriers are not found to the north of the range of this species. The opening of habitat by man's cultivation in the last century, or less, has increased more rapidly than the inherent ability of the gopher to expand into these potential homes. Predation, inability to readily cross from one area to another through the intervening forest, a rather low reproductive rate, all indicate that time is the essence of the ability of niger to extend its range. Population numbers should now be on the increase.

VERMIN CONTROL. Wherever gophers become abundant in an area they come in conflict with man. Wight (22,p.40) found the Dalles pocket gopher extremely detrimental in orchards. In California a considerable amount of control over gopher populations in farming areas is necessary. The populations of niger are small and of limited distribution and I found that few farmers even knew they existed on their property, the mounds being generally confused with the much more abundant mole. A few persons are aware of their presence and apply a certain amount of control, mainly trapping. On Big Creek a Mr. Miller said he had trapped about 30 around his house and garden in the summer of 1948. On the Yachats River in March, 1949, a lady asked if the spotted gophers were a "different kind"; she and her husband trapped in their yard and garden. Time and again, when I would seek permission to trap in systems spotted from the roads, the farmer would deny the presence of gophers, that is, until I returned to display the evidence of captures. In general

it may be assumed that nixer is not subjected to any appreciable amount of control and then only in isolated and limited situations.

CLIMATE. The moderate climate of the central Oregon coast is the result of the marine influence exerted by the Pacific Ocean. Pertinent weather data is summarized in Table 4 for stations in and adjacent to the area.

The temperature is moderately low and relatively stable. The January average is around 43 degrees, the July average about 60 degrees. The maximum average temperature may reach 102 degrees and the minimum fall to 10 or even one degree, but only for times of short duration. Last killing frosts occur in March and April and the first of winter in late October and November with a growing season of 195 days in the areas sheltered from the marine influence to 250 days right on the coast.

The precipitation comes largely as rainfall, only a very limited amount occurring as snow in mid-winter. The rainfall is distributed throughout the winter months, tapering off in spring, reduced to around .5 inch or slightly more in mid-summer, and again increasing in the fall. An average lies somewhere around 70 inches of annual rainfall. The winter and spring rainfall is more than ample for the vegetation but in summer the reduction approaches the critical point. Heavy blankets of fog occurring during the summer materially increases the precipitation efficiency.

VEGETATION. Immediately adjacent to the ocean is a strip of chaparral and lodgepole pine extending along the coast. Spruce

	TEMPERATURE					FROSTS			
	Length of Record	Jan. Av.	July Av.	Max.	Min.	Length of Record	Last in Spring	First in Fall	Growing Season
Coos County - Marshfield	37	44.4	59.2	100	16	29	Apr. 17	Oct. 31	197
Douglas County - Gairdner	13	44.5	60.7	102	16	11	Mar. 20	Nov. 30	255
Lane County - Deadwood	21	41.0	63.8	102	11	21	Apr. 21	Oct. 30	192
Lincoln County - Newport	40	43.7	56.8	100	1	29	Mar. 23	Nov. 26	248
- Toledo	26	43.0	60.9	102	8	31	Apr. 20	Nov. 1	195

PRECIPITATION

	Length of Record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Benton Co.														
Summit	22	10.42	7.89	7.48	4.24	2.96	1.74	.47	.60	2.31	4.47	9.82	10.00	62.40
Coos Co.														
Marshfield	37	10.86	8.74	7.81	4.73	3.11	1.74	.41	.36	2.21	4.25	9.62	1.00	54.84
Douglas Co.														
Gairdner	16	13.42	10.38	9.07	5.30	4.35	2.67	.55	.75	3.25	5.77	12.50	10.71	78.72
Lane Co.														
Deadwood	22	16.21	12.40	10.50	5.82	3.87	2.17	.70	.66	3.58	6.40	15.29	14.18	91.78
Florence	14	12.38	8.72	7.30	4.74	3.26	2.13	.78	.60	3.13	5.03	11.30	10.04	69.41
Lincoln Co.														
Newport	39	10.15	8.15	7.61	4.52	3.45	2.54	.74	.93	2.86	5.00	10.00	10.24	66.19
Toledo	27	11.89	10.07	8.73	5.43	3.76	2.40	.70	1.03	2.81	5.48	11.75	11.60	75.65

Table 4. SUMMARY OF CLIMATIC DATA (21, p. 1075-1079)

and hemlock also occur here. Since the black pocket gopher is not found in this area we will pass inland where Douglas fir is the climax species of the forest originally covering most of the area. In moist situations western red cedar is found and some western hemlock is scattered through the forest. Much of the virgin timber has been scathed by logging and fires, whereupon all stages of succession from barren areas to climax forest are now apparent.

Early in the regeneration of the forest such plants as fireweed, Epilobium, and brake-fern are obvious, followed by salmonberry, thimbleberry, and vine maple. Red alder will predominate for a time before the final climax Douglas fir again invades the area. On marshy ground and floodplains alder and willow thrive, sedges and such hydromorphic plants as the skunk cabbabe abound. These areas may have harbored some grasslands, but now cultivation has obliterated the original condition, grasslands now extending far more widely due to the efforts of man.

SOILS. The soil of the coastal mountains of Oregon are classified as Melbourne. Quoting from Soils and Men, (20,p.1045), the parent materials are, "...shales and sandstones giving rise to the Melbourne soils." Of the soils themselves "Dark brown friable surface soils beneath a superficial layer of forest litter, becoming rich brown below and grading into moderately compact plastic subsoils, yellowish and mottled with reddish brown in the Melbourne... Clay loam and loam textures predominate. Soils and subsoils mod-

erately to strongly acid in reaction."

EFFECT OF GOPHERS ON THE HABITAT. It is interesting to notice the micro-succession of vegetation on the bare soil expelled from the tunnels of the gopher's subterranean system. The areas are small and this succession is not significant when viewed from the general vegetative aspect, but this does not destroy its novelty. At first a few annuals manage to sprout on the mound, quickly covering it completely, then the vegetation of the surrounding meadow encroaches upon the pioneers, forcing them from existence. The loosened soil, with its buried vegetative matter beneath, soon supports a more luxuriant growth of grasses and herbs than the adjacent undisturbed areas.

Grinnel dwells at length upon the part played by burrowing rodents, especially Thomomys, as agents in soil formation. He enumerates the following relations of pocket gophers to their environment, (10,p.139-140).

(1) The burrow systems hasten the weathering of the substratum by carrying air, water, and solutes down into the subsoil and rock masses.

(2) The subsoil is brought to the surface where it is exposed to increased weathering.

(3) The loose earth piled on the surface of the ground may be eroded and transported by wind and water to the valleys below.

(4) Porous soils retain water for a longer time than packed ground and gives it up with corresponding slowness.

(5) Porous, moist soil produces a fuller vegetative cover, thereby acting as a further agent in water conservation.

(6) Loosening of the soil and the permeation of it by the tunnels admits both air and water to the roots of plants; the roots are better able to penetrate such soils.

(7) The vegetative material above the surface of the ground that is buried by the mounds becomes incorporated to form humus and increase the fertility of the soil.

Each of these statements is applicable to the black pocket gopher. In areas where cultivation is yearly practiced the effect of the gopher is minimized. The depth of the main tunnel system is about that reached by the plow, the vegetation is turned inward to form humus, the soil texture is loosened by cultivation. Here, with his usefulness curtailed, the pay extracted by the gopher by way of green vegetation and roots in competition with crops and livestock makes him an undesirable character. But most of the colonies of niger do not occur on such areas, rather the greatest proportion are confined to uncultivated grazing lands. The gopher becomes here beneficial to man; the maneuvering of the soils and resultant improved vegetation outweighs the food consumed.

The usefulness of the gopher in turning over the soil is readily apparent on the upper reaches of Tensile and Indian Creeks where the A horizon of the soil is shallow, the B horizon containing a considerable quantity of shale pebbles. Better than 25 percent of each mound in these areas is composed of these shale pebbles,

now exposed to an increased rate of weathering.

It is interesting to speculate on the amount of soil moved by the gophers. In an area well populated by gophers I would estimate that in a year's time the soil brought to the surface, if spread evenly over the ground would be to a depth of one-eigth of an inch, or a covering of slightly more than one foot each century!

In addition to the burying of vegetation by the mounds at the surface, other organic matter is added to the soils at greater depths. Cuttings are found in the dirt packed in discarded branches of the system, more is found in the storage chambers, the nest chamber is lined with fine grass. Even the excreta is returned to the soil in special depository sites. Thus, on wild lands, lands untouched by the farmer, the gophers serve in a valuable role as enrichers of the soil.

HABITAT DISTRIBUTION

MERCER LAKE. Six miles north of Florence and one mile east of Highway 101 Mercer Lake lies in a steep-sided valley. This, as many other coastal lakes, is the result of blocking of the original drainage by sand dunes to the west. The colonies were pointed out to me by Mr. Overton Dowell who has collected here for many years, his specimens are deposited in museums throughout the country. The first area visited was a small bench 25 feet above the lake level. An old clearing, it was practically taken over by brake-fern and wild blackberry, Rubus macropetalus. In the small patches of grass, workings were to be found. About 8 systems were observed

here. The second colony was strung along the valley of Bailey Creek which empties into the northeast corner of the lake. One mile above the lake the gophers were located in the tall grass of the valley floor for a distance of at least another half mile. The systems were grouped in the better drained sites. Fifteen gophers were collected without making a dent in population numbers. This area had at one time been homesteaded, cleared, then abandoned; the old buildings are now falling to ruin. The land is still grazed by stock and the establishment of a large new dairy farm in the valley will result in new alterations of the area. The soil is a fine dark sandy loam.

CHINA CREEK. China Creek is a short stream flowing into the ocean some 13 miles north of Florence. The black gophers were found on a knoll rising above the chaparral to the west and connected by a ridge to the rising hills behind, this covered by alder and fir. A small area had been graded out for a building site, around the edges of this, in the undisturbed grasses and herbs, the gophers lived. Not more than 6 gophers occupied the limited area, which is only one-half mile removed from the ocean.

BIG CREEK. This stream rushes to the ocean a mile north of China Creek, 14 miles north of Florence. Its valley is narrow and near the ocean no gophers are found. Upstream, between the third and fourth mileposts, several small clearings occur on both sides of the stream. Here again is sub-marginal farm area that has been

largely abandoned. A few boards lying around and an orchard or two indicates original homestead sites. Today the area is used as open range from cattle and horses which keep the meadows closely cropped. Bear and deer frequent the area. The various clearings are isolated from each other by strips of bottomland trees, alders, big-leaf maple, and fir. Since there is a very narrow bottom to the valley most of the clearings are on slopes and benches, well drained and acceptable habitat for niger. The soil is of medium texture and supports a luxuriant growth of vegetation. In the more suitable locations niger is frequent but the total number is small due to the smallness of each clearing.

TENMILE CREEK. Tenmile Creek crosses Highway 101 6 miles south of Yachats, Oregon. The valley of Tenmile is broader than that of Big Creek, and scattered along its banks are small farms. Gopher workings were first encountered 2 miles upstream from the creek mouth and occupied cleared areas up to where the secondary road leaves the creek to cross over to Indian Creek, some 7 miles inland. Here the clearings are not confined to the bottomlands; they extend well up the flanks of the valley. Grazing by livestock preserves the grass and herb composition. On the bottomlands the soils are deep and loamy but on the hillsides they become shallow and contain small pebbles of shale. In some of the hayfields on the more level lands gophers are common, their mounds annoying the farmers, especially at mowing time. The largest population of niger found in this study is located here along Tenmile.

YACHATS RIVER. Acting on information received from Mr. Stanley G. Jewett, the search for black gophers was carried up the Yachats River. Seven miles east of the town of Yachats a small colony was found on the North Fork. The valley here is extensively farmed with both hay meadows and grazing pastures present. The gophers were found in both. In one pasture the tunnels frequently suffered cave-ins by trampling cattle. In March one of the fields had been cultivated and a few fresh mounds appeared thereon. The colony is small, 9 were caught and trapping discontinued in fear of critically reducing population numbers. The soil varied from loamy creek-bottom to more clayish red hillside soils.

INDIAN CREEK. This creek drains mainly from north to south, entering Lake Creek 2 miles north of Swisshome. It is part of the Siuslaw drainage system. Approaching the upper stretches from Tenmile Creek gophers were located in the first clearings. Small farms on the upper reaches gave way to the larger, more prosperous farms as the creek grew larger and the valley widened. Workings were observed beside the road for 6 miles. The colonies were small, the total population is not large. Unmown hayfields may have obscured many workings as observations were unfortunately confined largely to grazed slopes where workings were more readily visible.

WALKER CREEK. Searching the vicinity of Mapleton and Seaton, for which published material records the presence of nigar, several days expended resulted in no colonies located. Quite by accident a clearing was stumbled upon in which the gophers were rather abundant.

Located near Walker Creek one-half mile above the Siuslaw Valley floor was a logged off area, 4 acres in extent, that had been cleared and planted to Port Orford cedar, Chamaecyparis lawsoniana, by the Forest Service in 1942. Here, surrounded by virgin timber and recently logged lands was a well isolated population. The plantation was kept clear of fern and brush by grazing cattle, driven up each day from a farm down in the valley. Much trampling resulted, any system placed outside the shelter of the trees was caved in, consequently most workings were confined to the protected areas. The trees, 4 to 8 feet tall, were grid spaced at 10 foot intervals. Also noticeable were the corkscrew lateral tunnels beneath the mounds rather than the straight tunnels typical of all other areas. Although the runway systems were almost confined to area of the roots no damage to the trees attributable to gophers was found. The soil was hard packed, somewhat clayish; the vegetation abundant but closely cropped.

DEADWOOD CREEK. Deadwood Creek, also draining from the north to south, is a tributary to Lake Creek, the junction of the two streams is some 4 miles northeast of Swisshome. A farmer 2 miles above the junction stated he had caught 2 to 3 gophers each year in his garden and adjacent fields. A mile beyond I found workings on a gentle slope almost obscured by a dense growth of brake-fern. At Alpha, 7 miles upstream from the junction, one gopher was caught near the creek in sandy soil. A few other workings were scattered nearby. Hillsides were unoccupied, the soil

clayish and hard.

FIVE RIVERS. A part of the Alsea drainage, this stream flows generally from south to north. Entering from Deadwood Creek a colony of gophers was found at Paris, the first clearings encountered on Five Rivers. Old workings noticed on the grazed slope up to the road led to the location of fresh mounds 100 yards beyond in the flat valley floor. The vegetation on the slope had dried up, that on the flat was still green and succulent. The valley is rather broad, much of it given to hay with growth so rank as to make the finding of workings difficult. Some mounds, not positively identified, were found 5 miles downstream at Fisher.

LOBSTER CREEK. Lobster Creek, running more or less from east to west, is a tributary to Five Rivers. A 30 acre field extending from a low ridge above the road to the banks of Lobster Creek had gophers scattered throughout, but only sparcely so, at Wilkinson Creek, 5 miles above the Lobster-Five Rivers junction. The hay field had been recently mowed, it was covered with dry stubble and only a limited amount of green blades were present. In another field, a pasture, the workings were more concentrated, 10 to 12 gophers occupied this 10 acre field.

An old-timer, some 50 years an inhabitant of the valley, stated that when he packed into the valley with his parents to be the first settlers there, both gophers and moles were present. To the spotted gophers he applied the name "pintos".

Broad expanses of rolling fields offer <u>niger</u> ample habitat.

The valley is well to the interior and shows an increasing aridity; the decrease in the summer-green vegetation could well be approaching a limiting point. The soils of the valley floor are silt loams, those of the hillsides a clayish loam.

ADAPTATION TO THE HABITAT

DIGGING APPARATUS. The body of the pocket gopher is short, thick-set, very massive anteriorly, the head is joined to the body without any conspicious constriction at the neck. The bones of the skull are thicker, more ridged with great masses of attached muscles, which are correlated with the position, structure, and operation of the large incisor teeth. The mouth is a verticle slit protected by the furry lips which may be appressed so as to keep out the earth loosened by the projecting incisors. These incisors are the chief mechanism for digging. Instead of the hind feet being larger than the forefeet, as in most mammals, the reverse is true. The forefeet are larger, equipped with long, stout claws; the forearm and shoulder are heavily muscled. The sides of the toes are lined with rows of bristles that evidently serve in preventing dirt from passing between the fingers.

The pocket gopher, in digging, uses the powerful incisors as a pick to loosen the ground. At the same time the forefeet are active in both digging and passing the dirt back under the body where the hind feet kick it still further backward.

When the dirt has accumulated behind the animal it turns in the

burrow and using the hands beside the face, forces itself along with the hind feet. It moves by jerks, a few inches at a time, at each pause it pulls its head and hands back slightly to reassemble the load. With a final shove the soil is thrown violently out of the doorway.

While digging or moving dirt the pocket gopher's ears are closed by valves, and the eye lids fit so closely that bits of dirt cannot enter to give discomfort.

MOVEMENT. Below the surface, where the gopher is at home, it can scurry rapidly within the confines of its small tunnel. The short legs makes it unnecessary to expend additional effort in excavating a tunnel more than slightly larger than the animal's body. Turning about within this narrow confine is another problem. The gopher pokes its nose under and back between the hind legs, then turns a somersault, with a twisting motion that ends up with the animal on its feet facing the opposite direction, (6,p.429). The gopher can move backwards within its cylinder nearly as well as forwards, in this the loose, baggy skin condition is a benefit.

Above ground the gopher is definitely out of its element. Some forms will explore the surface immediately adjacent to the burrow mouth for food, seldom venturing farther than the length of the body. This has not been observed in nigrescens, in fact the area around the tunnel mouths show no cropping of the vegetation. The runway system is left on certain occasions; a male seeking out a mate in her home at breeding time, and the young of the year

leaving their parental system in search of a site of their own. Hight reports catching the Dalles pocket gopher, Thomomys quadratus, in conventional snap traps set above ground in an orchard, (22,p.42).

Where snowfall is abundant the gophers come above ground, still protected by the snow above, to forage about. When the snow melts in the spring "casts", formed by soil packed in these tunnels, are gently lowered to the ground. In this way gophers cross rocky inpenetrable areas to occupy suitable habitat beyond, (10,p.142). Since snowfall west of the summit of the Coast Range is so slight, and of very short duration, this above ground movement in the snow cannot take place.

CHEEK POUCHES. The cheek pouches are located on each side of the face just outside of the mouth. They are lined with white fur on the inside and exude a peculiar musty odor. These pouches are used exclusively in carrying food, not dirt as is often erroneously supposed. The pouches extend back as far as the shoulders and are so attached that they cannot be completely everted without rupturing the retractor muscle.

The retractor muscle, the platysma, arises in the superficial layer of the lumbodorsal fascia and the last two thoracic vertebrae, and inserts on the caudal and dorsal margins of the pouch. The portion of this muscle cranial to the scapula receives branches of the facial nerve, the more caudal portions are innervated by the terminal branch of the accessory, (14,p.160).

Merriam observed how a live Geomys manipulated food into its pouches, (18,p.19). A piece of food was seized between the incisor teeth, immediately transferred to the fore paws, trimmed if necessary, then passed rapidly across the side of the face with a wiping motion forcing the food into the open mouth of the pouch. Sometimes both forefeet were used, one set of claws would pull down and out on the flap of the pouch while the other forced the food inside. The pouches were emptied by drawing the forefeet back to the rear of the pocket then carried rapidly forward, dumping the contents of the sack in front of the animal. Sometimes several strokes were necessary.

Numerous trapped animals died with sections of roots or herbs left in the cheek pouches. Evidently such material may be carried for some time before the location is reached where it is expelled for storage.

RECEPTIVE EQUIPMENT

VISION. The pocket gophers are deficient in regards to the sense of vision. The bright black eyes are about the size of a glass-headed pin, extremely small in comparison to other mammals. Living most of its life in total darkness underground keen eyesight is not essential, but when venturing forth at the mouth of his tunnel, it is seriously handicapped. A person slowly approaching from downwind of a feeding gopher may come within a few feet before being detected. Perhaps this lack of keen vision is in part responsible for the

pugnaceous actions of the gopher.

HEARING. Grinnell states: "Its hearing is likewise below average and seems to be keenest for sounds of very low rate of vibration, such as jarrings of the ground." (10,p.141). A soft tamp of the foot on the ground is sufficient to send a gopher, busy throwing dirt from his doorway, scurrying for the protection of greater depths. Not only is this sense valuable in protecting it from predatory enemies, it must also save the gopher from trampling by cattle which often cave through the surface feeding runways.

SMELL. The sense of smell is reported as acutely developed. This enables the gopher not only to detect food in its unlighted domain but also to detect its enemies that may enter its runway. A gopher snake, Pituophis, entered a gopher hole and in a few minutes the gopher, Geomys lutescens, burst out from the other end of a line of hills. The gopher evidently had only scented the snake for the latter soon came out the hole it had entered and glided off in another direction, (13,p.18).

TOUCH. Long vibrissae aid the gopher in sensing its position in the tunnel system. In addition tactile sense endings on the nearly hairless tail informs the gopher when moving backwards along its corridors.

AWARENESS OF TRAPS. The black pocket gopher shows little awareness of the presence of traps. The metal of the trap must often be contacted, as well as the scent of the handler thereon, before the trigger is released. Even in the case of a miss in which the gopher is slightly scratched, it will tumble to a reset

as readily as the first set. This behavior is in contrast to the extremely careful activities of the mole. An identical type of set will but seldom take the latter, and any metal in the runway will not only a well buried trap.

RUNWAY SYSTEMS

EXTENT. The runway system, as indicated on the surface by the mounds, may vary in size from small areas only 5 by 10 feet in size to more extensive systems as large as 15 feet in width and 30 feet in length. The system usually consists of one to several main trunk lines from which short side branches ascend to the surface for the deposition of the excavated materials. The tunnels are just large enough to accomodate the body of the gopher, usually one and one-half to one and three-quarters inches in diameter. The tunnels are divided into two parts, the shallow foraging tunnels from 4 to 8 inches below the surface, and the deeper living, storage and toilet level that lies well down in the soil. In excavating a system in summer it will be found that many of the lateral branches have been filled with soil in which is mixed cut pieces of vegetation scraped up from the floor in the movement of the dirt or added as storage. Abandoned trunks as well may be plugged for much of their length. This filling of old tunnels reduces the amount of exposure necessary if the dirt was all to be dumped as mounds above ground.

Usually near one flank of the system fresh mounds will be found grouped together, a sign that new extension of the tunnels is being made in that direction.

The mounds themselves are typically cresent-shaped from the various loads of dirt being thrown out in different directions with a final load plugging the hole in the hollow of the cresent. Another point of interest is the almost invariable presence of cut particles of roots, stems, and leaves mixed with the soil. A great amount of confusion is caused by the mounds thrown up by moles. The typical gopher mound as described is not always readily found and badly weathered mole and gopher mounds are truly difficult to distinguish with certainty. Fresh mole mounds are readily identified by their volcanic appearance, the mighty mole bulldozes all his dirt out of the tunnel without ever appearing at the surface. The result is a taller mound of less loosened dirt, in fact often the dirt that has been compacted in the tunnel while being pushed out retains its cylindrical form to lie on top and sides like short pieces of tooth-paste squeezed from a tube.

PROXIMITY TO OTHER SYSTEMS. In viewing a colony of gophers it is rather surprising to note that while the mounds are laid out rather helter-skelter, still no two systems come in contact, quite the contrary, each system is a definite unit seperated spatially from all neighbors. The pocket gophers are not sociable animals, their pugnaceous nature would make any contact of individuals disagreeable. Undoubtedly the transmitted vibrations resulting from activity is sufficient to detour the extension of other systems from their direction. This behavior is much different from that of many other mammals where social contact is common. It would seem that this

behavior pattern limits the number of gophers occupying favorable habitats. Surely, more than enough food is available throughout the year for each gopher, and aside from their inherent nature more individuals could survive.

MOVEMENT OF SYSTEMS. Each gopher slowly moves its system about by the abandonment of sections and extension of others. As well as the forage systems shifting, an accompanying new set of deeper living chambers must be constructed. At Paris, on the upper Five Rivers, old workings were located on the slope just beneath the road, but no fresh mounds were present. Casting about, fresh mounds were found 100 yards away on the flat below. The move had evidently been promoted by the drying up of vegetation on the slope and a subsequent migration downward and outward into the area where green forage was present.

WATER RELATIONSHIP. As one travels from colony to colony it becomes increasingly apparent that the situations occupied are absolutely free from danger of immediately rising water table or flooding. While not all well drained, grassy habitats are supporting gophers by any means, still the gophers are not to be found in poorly drained or barren situations. Benches just above the valley floor are favorite locations. If the bench be large, the side abutting against the rising hills usually has swampy tendencies; here the gophers will be found out near the brink where the water table has dropped deep below to the stream.

Only on two occasions during the summer were gophers found on

bottomlands that would be flooded in winter. In both cases only a short distance separated the gophers from the refuge of higher ground. In these cases it is probable that search for green vegetation prompted the exodus to the fields, and a quick return to the protection afforded by the slopes with the first winter rains is likely. Unfortunately the winter rains made the roads to these areas impassable and a further check was impossible.

ACTIVITY

The rotation of the earth past the sun has little effect on the life of the pocket gopher. It would seem that these rodents work or sleep when the spirit moves them. They were trapped at all times of the day, and the fresh mounds to be seen in early morning attest to activity in the night. New mounds are found under construction in the daytime too. It is extremely difficult to formulate the pattern of activity when the animal is separated from the observer by 6 inches of earth.

Throughout the summer the gophers are very active in extending their systems. Fresh mounds are more abundant after showers, perhaps the moistening of the soil promotes renewed activity. Unfortunately, observations could not be carried on throughout the winter, but in March the activity was far below that of the previous summer. A few fresh mounds were found but most of the activity was confined to repairing tunnels trampled by livestock. Winter rains also tend to quickly wash away fresh mounds, leaving only the most recent to indicate the presence of the gophers.

FOOD

Difficulties in determining the food of niger were encountered. The food is well masticated before swallowing. Merriam, (18,p.97), computes the strokes of the jaw per minute multiplied by the number of enamel cutting surfaces reaches a total of 13,200 cuts each minute while the jaws are in active motion. Upon passing this cutting mill the identity of the food is completely destroyed. A lot of short cut pieces of roots, stems, and leaf blades are found in the mounds. This is hardly an indication of what is eaten as it may be only the discard. Since niger does not feed around its doorways the food must consist of roots encountered in tunneling and of plants pulled down by the roots from the ceiling. This thinning of the surface vegetation progresses without any visible indication from the above surface. One might ask, then, what plants are available for selection as food?

A section of meadow in the vicinity of several workings on Big Creek was closely examined. Using the phytosociological classification of plant ecologists the abundance classes of very sparse, sparse, infrequent, abundant and very abundant were applied.

Small hop clover	Trifolium dubium	infrequent
White clover	Trifolium repens	abundant
Black plantain	Plantago lanceolata	abundant
False dandelion	Hypochoeris radicata	very abundant
Purple owls-clover	Orthocarpus bracteosus	infrequent

June grass	Poa pratensis	abundant
Velvet grass	Holcus lanatus	abundant

ASSOCIATED MAMMALS

The gopher is extremely pugnacious and there is little doubt he does not allow other mammals in his system. Abandoned systems do offer movement in safety to small mammals which make extensive use of these fortuitous tunnels. At Mercer Lake an Oregon creeping mouse, Microtus oregoni oregoni, was caught in a Macabee gopher trap. No gopher activity was observed in the apparently abandoned system. Other mammals that may utilize these tunnels are the vagrant shrew, Sorex vagrans vagrans; Baird's dusky shrew, Sorex obscurus bairdi; ruddy deer mouse, Peromyscus maniculatus rubidus; and the small Gibb's mole, Neurotrichus gibbsii gibbsii. All of these forms I have taken from abandoned mole runways in Tillamook county and feel the same utilization would be made in the area of niger.

The Townsend's mole, Scapanus townsendii, is far more numerous throughout this section of Western Oregon than niger. Often the systems of these two mammals occur in close proximity, on Big Creek only 5 feet separated the two in one field. The mole, being almost entirely insectiverous does not compete with the gopher in any way for food.

POTENTIAL ENEMIES

No signs of natural predation was observed in the area,

therefore, we can only survey the forms present that might feed on mice if the opportunity presented itself.

BIRDS. Diurnal birds of prey that frequent the area are the sharp-shinned hawk, Accipter velox velox, and the western red-tailed hawk, Buteo borealis calurus. At night the owls are potential enemies, the barn owl, Tyto alba pratincola, and the dusky horned owl, Bubo virginianus saturatus.

MAMMALS. The Oregon bobcat, Lynx rufus fasciatus, hunts mainly under the cover of dense forest and brush, but may venture short distances into clearings to capture pocket gophers amongst other small mammals. Two weasels are found in the Coast section, the long-tailed weasel, Mustela frenata altifrontalis, and the Puget Sound weasel, Mustela cicognanii streatori. The western mink, Mustela vison energumenos, frequents the streams and may range out into the adjoining fields. The Oregon spotted skunk, Spilogale phenax latifrons, is also found in the area. Domestic dogs and especially domestic cats may take a toll of gophers.

On Tenmile Creek a trap and captured gopher was dug out and dragged downhill. The anchor stick was found 10 feet downhill and 5 feet farther the remains were located, still in the trap. The skin around the middle of the body and the internal organs had been eaten, the front and rear portions were untouched. This was probably the work of either a spotted skunk or a mink. Mr. Miller, who lives nearby, said he had seen a mink chase and catch a Douglas's ground squirrel, Citellus beecheyi douglasii, a few hundred yards away.

Due to the short period, only a few seconds in duration, that the gopher appears at the mouth of its tunnel, predation can only be slight. However, the small size of the Puget Sound weasel would enable it to enter the runway systems to capture a gopher. That it does so has not been determined.

PARASITES

Fleas taken from Thomomys niger have been identified by Dr. Hubbard as Dactylopsylla comis and Foxella ignota regula. Dactylopsylla comis is a large flea, male 4.5 mm., female 5.0 mm., rare, a true gopher flea but also found on pocket gopher carnivores and other small animals which run the burrows of gophers. The range includes the Siskiyou Mountains eastward to the Cascades, thence northward into British Columbia, (15,p.186-187). This is a new record for the flea on the coast north of the Siskiyous.

Foxella ignota regula is another typical gopher flea, smaller, males 2.75 mm., females 3.00 mm., abundant. The range includes most of the Northwest; in Oregon it is common east of the crest of the Cascades, then jumps the Willamette Valley and is again found along the coast on Thomomys hesperus, Thomomys monticola helleri, and Thomomys niger. This flea has not yet been proven a vector of bubonic plague, (15,p.176). These pocket gophers are relatively free from fleas, fresh caught specimens will usually yield but 2 to 4 fleas, more may be present in the runway system and nest.

Lice, of undetermined species, are abundant on the gopher,

especially concentrated around the head region. A few days after preparation of the scientific skin, the lice loosen their hold and are visible wandering about the hairs.

Three specimens collected on the Yachats River in March were examined by Mr. Donald Twohy, graduate student in Zoology, Oregon State College; no endoparasites were found.

REPRODUCTION

RELATIONSHIP OF MATES. Throughout most of the year no two adults occupy the same burrow system but as the spring breeding season approaches the males desert their own systems and move out in search of mates. It is likely that enough scent is left on the mounds constructed by any gopher to serve for identification. A male could then search out the female without the danger of an unhealthy encounter with some other male. From data gathered we see that 35 males and 54 females were collected, a ratio of 3 females to each 2 males. Some females, then, must not be fortunate enough to attract a mate. Soon after mating the male leaves the female, or is ejected, returning to his system or constructing a new one.

BREEDING SEASON. Two males collected March 24 displayed enlarged testes as did 5 caught April 10. A female taken March 21 did not show any enlargement of the genital organs but in one taken April 10 the organs were greatly enlarged, both internally, the vagina and horns of the uterus were thickened and distended, and externally, the nipples were obvious and the external genitalia

greatly enlarged. No embryos were present. This condition is typical of proestrum and heat (2,p.227).

There is a gap in the present data between April and July. One female was taken July 3 with embryos, the only record of pregnancy. Breeding and parturition must occur in the intervening lapse of time, breeding in late April and May could be expected, with birth of young in May and June. Not more than one litter could be produced in this time.

The one pregnant female examined contained 3 embryos. A system in which a female had been trapped yielded 3 nearly grown young. Naturally these two minor items are insufficient evidence upon which to base any generalities as to the number of young produced each litter. In other pocket gophers the average litter of 4 is approached (2,p.227).

PARENT-YOUNG RELATIONSHIP. Cahalane (6,p.430) describes the newborn gopher as a fat, stubby creature with short legs and tail. The skin hangs loosely in wrinkles and folds; eyes and ears are sealed shut; the cheek pouches are but slight folds in the skin. The eyes do not open until they are five weeks old. The young remain under parental care until they are six weeks to two months old. When they are sufficiently developed to move about the young ascend to the foraging tunnels for food, and may be taken in traps when their instinct leads them to plug an opening.

In an attempt to determine if more than one animal occupied a single system, 12 sets were left in place for up to a week during

August. Three juveniles were removed from the same system as a mature female, the total lengths of these were 172, 165, and 170 mm.. During the same week another curious incident occurred. Checking the sets one morning, the pan of a trap was found pushed inward, with a light plug of dirt pushed up from the inside. A mature male had been taken from the set two days earlier. Clearing out the set it was left and checked again in the afternoon, yielding an immature gopher 173 mm. in length. Evidently this individual had left home, and while scouting around, sensed the abandoned system, pressing past the trap it had made itself at home, plugging the hole by which it had entered. Thus it was saving the labor of constructing a new system of its own.

Surprisingly no definite age group can be assigned from the external measurements. Specimens approaching the minimum size were taken both in early July and late August and the intermediate size groups show no relationship to dates. This could be expected if, as suggested, the breeding season extends over a two month period. Furthermore the adult size of 190 mm. or larger seems quickly attained. Only 6 specimens with a total length of less than 190 mm. were taken during the period when at least half of the population should have been juveniles. Perhaps the catch of the younger gophers was reduced somewhat by the capture of the more active and alert females and removal of the trap leaving the immatures behind.

Sexual maturity is reached in one year although growth still

continues, perhaps through most of the lifetime. At one year the average length of the females is more than 200 mm., and males 210 mm. or over.

POPULATION NUMBERS

It is always interesting to diverge from strict facts and do a little delving into the unknown; this we must do if we wish to learn the approximate population number of the species. It is rather easy to estimate the number of gophers in a single colony from the workings displayed, but the total of a single valley is not so easily estimated. Then add the remainder of the range of the species and our accuracy can be but low. Especially is this true when the habitat is extremely discontinious and erratic in distribution. The percentage of the total colonies found is unknown quantity. Reviewing the past year's excursions through the area I have jotted down generous estimates for each drainage in which gophers were found, this totals 2,000. This figure is selected as a minimum and, allowing for considerable error, a figure of 5,000 maximum can be selected. Thus we arrive at an estimate of between 2,000 and 5,000 individuals of Thomomys nigar present in the range of the species, some 700 square miles in extent. Dice has concluded that the 4,968 square miles of territory in the Black Hills of South Dakota were inhabited by between one million and five million mice, Peromyscus maniculatus osgoodi, (6,p.169). Our figures then serve as a yard-stick for comparison though the errors in calculation be great.

POPULATION MOVEMENTS

We have already discussed some phases of population movements, that of a colony from dried up to green vegetation, and of movement into newly improved habitat opened by cultivation and grazing. Now we shall look at the problem in a broader sense. The movement of a population is accomplished by individuals so we must look first to them. If minor movements about a colony can be disregarded we might ask: "Why should a pocket gopher move any great distance, often through unfavorable habitat?" Over a period of time considerable movement, for which we have no direct evidence, must take place.

When the young of the year emerge to seek homes of their own they will find the most favorable sites already occupied by the mature members. As they wander about, searching for a home they desire, they must stray off into unfavorable areas and once started keep moving until one is found or they perish. If the new area is only a few hundred yards removed it is understandable that this would be quickly found and utilized. But larger journeys also must be successfully completed, even if less frequently so. Even in dense woods enough vegetation is present to sustain life, and if the animal is fortunate enough to escape disaster in the form of some predator, considerable distance may be covered. Of course, if a new colony is to be established when finally a home site in new territory is selected, a mate must also make the trip during the lifetime of the individual.

The frequency of establishment would be reduced with an increase of the distance, a clearing 100 yards removed would be occupied in one year or at most before many had passed but a large area 5 miles away might require not many years but centuries before the fortunate combination would be attained. The clearing of vegetation by man in the last century has increased the available habitat far beyond the ability of the gopher to expand over the intervening undesirable territory. True, populations would increase in size and extent, but the movement between watersheds is so slow that time has not yet allowed maximum expansion.

UNSOLVED PROBLEMS

As with most studies the limitation imposed by time leaves problems still unsolved, problems not only of the species involved but which, if answered, would help our understanding of mammals as a group.

TAXONOMIC RELATIONSHIP. Thomomys niger now stands as a monotypic species, the affinites to surrounding species have not been adequately surveyed, the differences have been noted in the original description and now, with our increased knowledge of ranges and habits, it is necessary to consider the similarities and possible relationships. Perhaps niger would still stand as a species but the test should be made.

GENETICS. The genetics of both the black coat color and

spotting mutations have been explained in this paper by inferrence, not by actual experiments. This species offers excellent material for a genetical study. Before such can be conducted techniques of catching the animal alive, maintenance of health and vigor over a long period in captivity, insemination, whether natural or artificial, and the rearing of offspring to maturity must be developed. An ever present danger with wild species in the laboratory is the eating of young by the mother, if the young are removed shortly after birth then they must constantly be fed and tended until able to care for themselves.

EXTENT OF RANGE. We now have additional information, materially extending the range of niger. The limits have not been reached, how high on the mountains does it go, has the northern, eastern, or southern limits been reached? Nothing short of a lot of travelling in the field will answer these questions.

FOOD. We do not know exactly what foods are eaten, what are preferred, what are rejected. Further indication would be obtained by examination of food caches down at the living level of tunnels. More indication would be derived from feeding and condition experiments on captured animals.

REPRODUCTION. Actually very little has been advanced pertaining to the reproduction of the species. More data on when the females become pregnant, gestation period, and size of the litter is desirable. Both field collecting and raising gophers in captivity is advisable.

BEHAVIOR STUDIES. Tests as to the ability of the gopher to hear, see, smell, its patterns of behavior, its ability to learn, these have not been determined. Here we could pry into the animals mental and psychological makeup.

The above are but a few of the possibilities and the most desirable at the present. However, the problems that could be undertaken are limited only by the temperment, training, and ingenuity of the investigator.

SUMMARY

1. A series of specimens of Thomomys niger were collected from throughout the range of the species between July, 1948, and April, 1949.

2. The published range was extended northward from near the Siuslaw River to the Yachats River and Five Rivers and Lobster Creek drainage of the Alsea River.

3. Corrections of the published range are as follows:

(a) Seaton was located 2 miles northwest of Mapleton, on the Siuslaw River, not on the Umpqua as recorded in the original description and subsequent literature.

(b) Thomomys niger is not found at Scotteburg on the Umpqua, the record was from erroneous identification of an albino specimen. The area is occupied by Thomomys bottae leucodon instead.

(c) No valid record of niger exists south of the Siuslaw River.

4. The coat color of 175 specimens known is black; this is not a dichromatic species. The genes responsible for the black condition may be either non-agouti (aa) or extension genes (E^D).

5. The fixation of the coat color has likely been by chance, scattering of variability, working in a small population.

6. Thirty-eight percent of the specimens examined exhibited a certain amount of white spotting. Castle's Dutch genes have been applied but Grüneberg's explanation of spotting genes, both "s" and the "k" complex is more tenable.

7. Thomomys niger exhibits certain habitat requirements, well drained situations and ample green grass and herbs. The extent of areas meeting these requirements were originally limited but have been greatly increased since the advent of white man. Now more habitat is available than the species has been able to occupy due to reproductive limitations and low motility.

8. Seldom subjected to control, this gopher is largely beneficial, improving the soil fertility in most of its range.

9. Few predators are offered any opportunity to prey on this gopher, it seldom appears above the surface and does not feed around the mouth of its burrow as do other species.

10. Thomomys niger is relatively free from parasites. No endoparasites were found. Two species of fleas, Dactylopsylla comis and Hoplia ignota recula, and lice do parasitise this species.

11. The breeding season extends from April to May, the young are born in May and June. Only one litter is produced each year.

12. A rough estimate places the total population numbers of this species somewhere between 2,000 and 5,000 individuals.

PLATE 1

Range of the pocket gophers of Western Oregon exclusive of Thomomys bulbivorous. After Bailey, 1936, in part.

1 West Coast Pocket Gopher, Thomomys hesperus.

2 Black Pocket Gopher, Thomomys niger.

3 Heller's Pocket Gopher, Thomomys monticola helleri.

4 Mazama Pocket Gopher, Thomomys monticola mazama.

5 Douglas's Pocket Gopher, Thomomys douglasii douglasii.

6 Oregon Pocket Gopher, Thomomys douglasii oregonus.

7 White-toothed Pocket Gopher, Thomomys bottae leucodon.

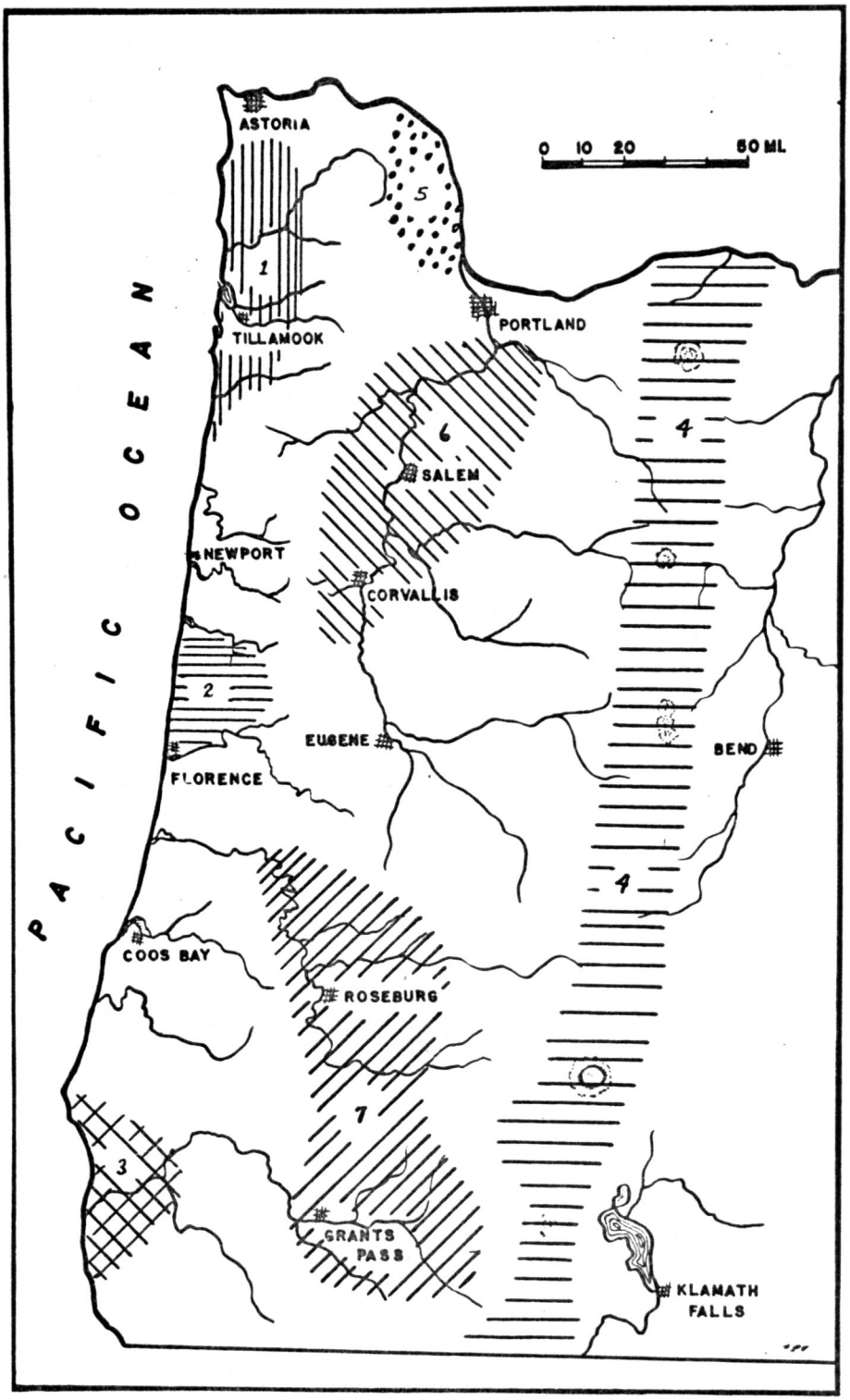
ASTORIA
TILLAMOOK
PORTLAND
SALEM
NEWPORT
CORVALLIS
EUGENE
FLORENCE
BEND
COOS BAY
ROSEBURG
GRANTS PASS
KLAMATH FALLS
PACIFIC OCEAN
0 10 20 50 ML
1
2
3
4
5
6
7

PLATE 1

PLATE 2

Routes covered in this study. Additional area surveyed, both north and south, yielded no colonies of *Thomomys niger*.

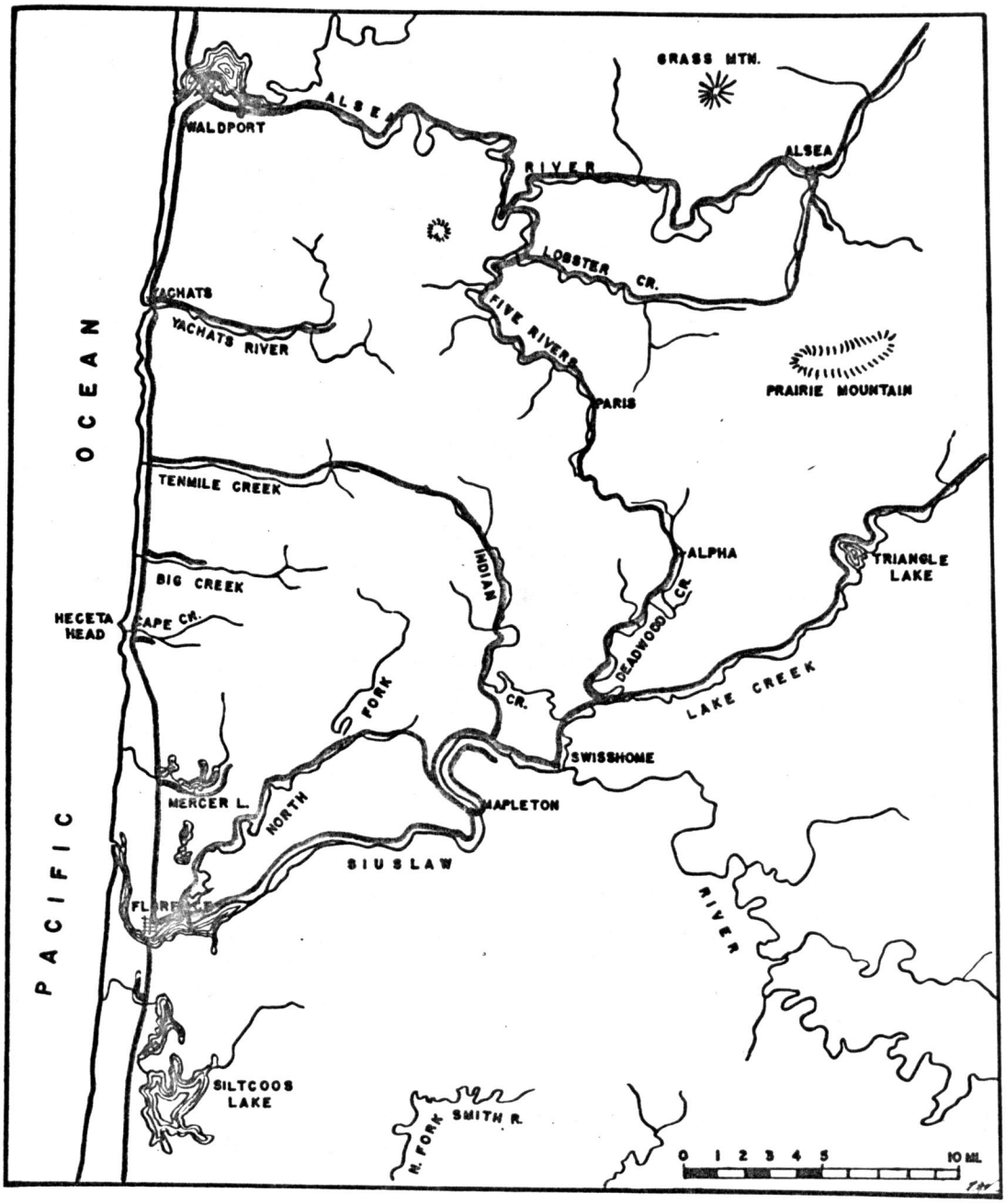
GRASS MTN.
ALSEA
WALDPORT
ALSEA
RIVER
LOBSTER CR.
YACHATS
YACHATS RIVER
FIVE RIVERS
PARIS
PRAIRIE MOUNTAIN
OCEAN
TENMILE CREEK
ALPHA
TRIANGLE LAKE
BIG CREEK
INDIAN
DEADWOOD CR.
HECETA HEAD
CAPE CR.
FORK
CR.
LAKE CREEK
SWISSHOME
MERCER L.
NORTH
MAPLETON
SIUSLAW
PACIFIC
RIVER
SILTCOOS LAKE
N. FORK SMITH R.
0 1 2 3 4 5 10 MI.

PLATE 2

PLATE 3

Detailed distribution of Thomomys niger. For discussion of various areas see pages 38 to 44.

▲ Recorded in literature.

● Collected in this study.

))) Workings observed, no specimens taken.

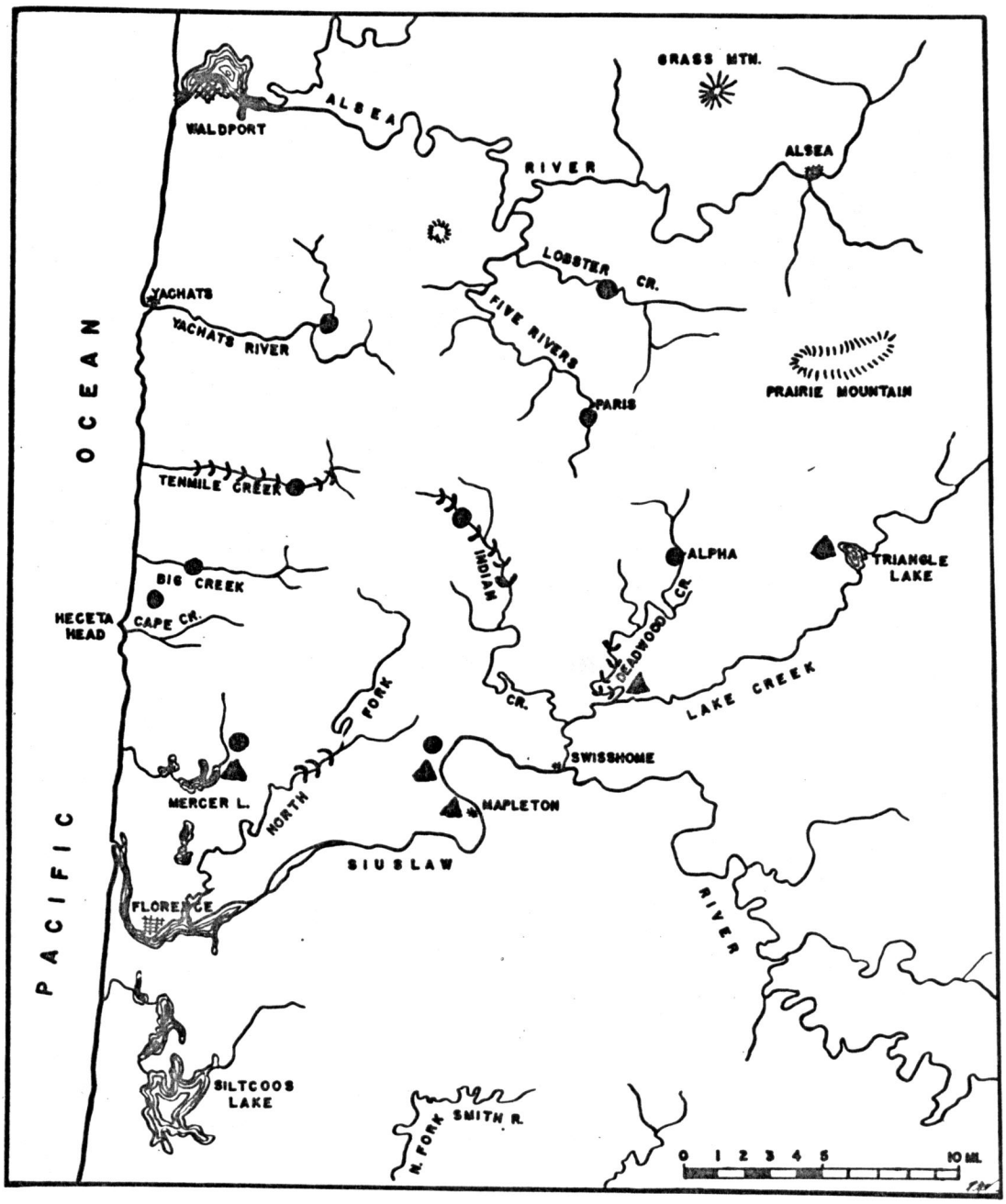
GRASS MTN.
WALDPORT
ALSEA
RIVER
ALSEA
LOBSTER CR.
YACHATS
YACHATS RIVER
FIVE RIVERS
PARIS
PRAIRIE MOUNTAIN
OCEAN
TENMILE CREEK
INDIAN
ALPHA
TRIANGLE LAKE
BIG CREEK
HECETA HEAD
CAPE CR.
DEADWOOD CR.
LAKE CREEK
FORK
CR.
SWISSHOME
MERCER L.
NORTH
MAPLETON
SIUSLAW
PACIFIC
FLORENCE
RIVER
SILTCOOS LAKE
N. FORK SMITH R.
0 1 2 3 4 5 10 MI

PLATE 3

PLATE 4

Juvenille Thomomys niger at mouth of burrow. The black coat color contrasts with expelled soil in daylight; perhaps is of slight advantage during darkness. Still the selective advantage, if any, working alone is hardly sufficient to cause fixation of this abnormal coat color. Posed with dead specimen.

PLATE 4

PLATE 5

Molt in Thomomys niger. The top specimen has not yet begun the summer molt. The second displays a single eccentric cresent wave, the third two such waves. In the bottom specimen two waves have begun running together posterior portion of the body while anteriorly another wave is commencing.

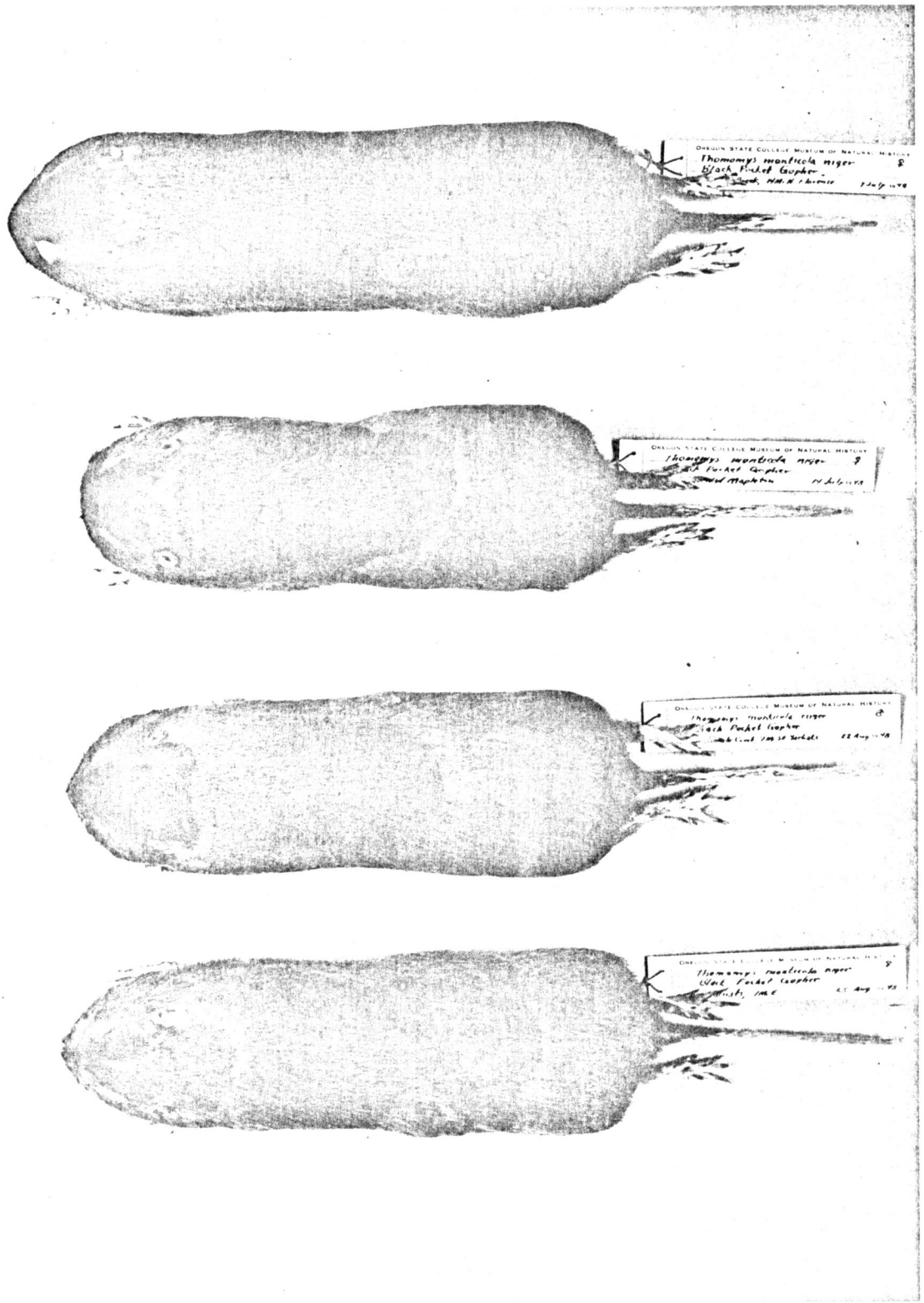

PLATE 5

PLATE 6

Spotting was present in 38 percent of the specimens collected. The top individual is the normal type; solid black coat with distal portions of feet and tail white. The mutants varied from a single small ventral spot to extensive ventral spotting and a mid-dorsal stripe on the head.

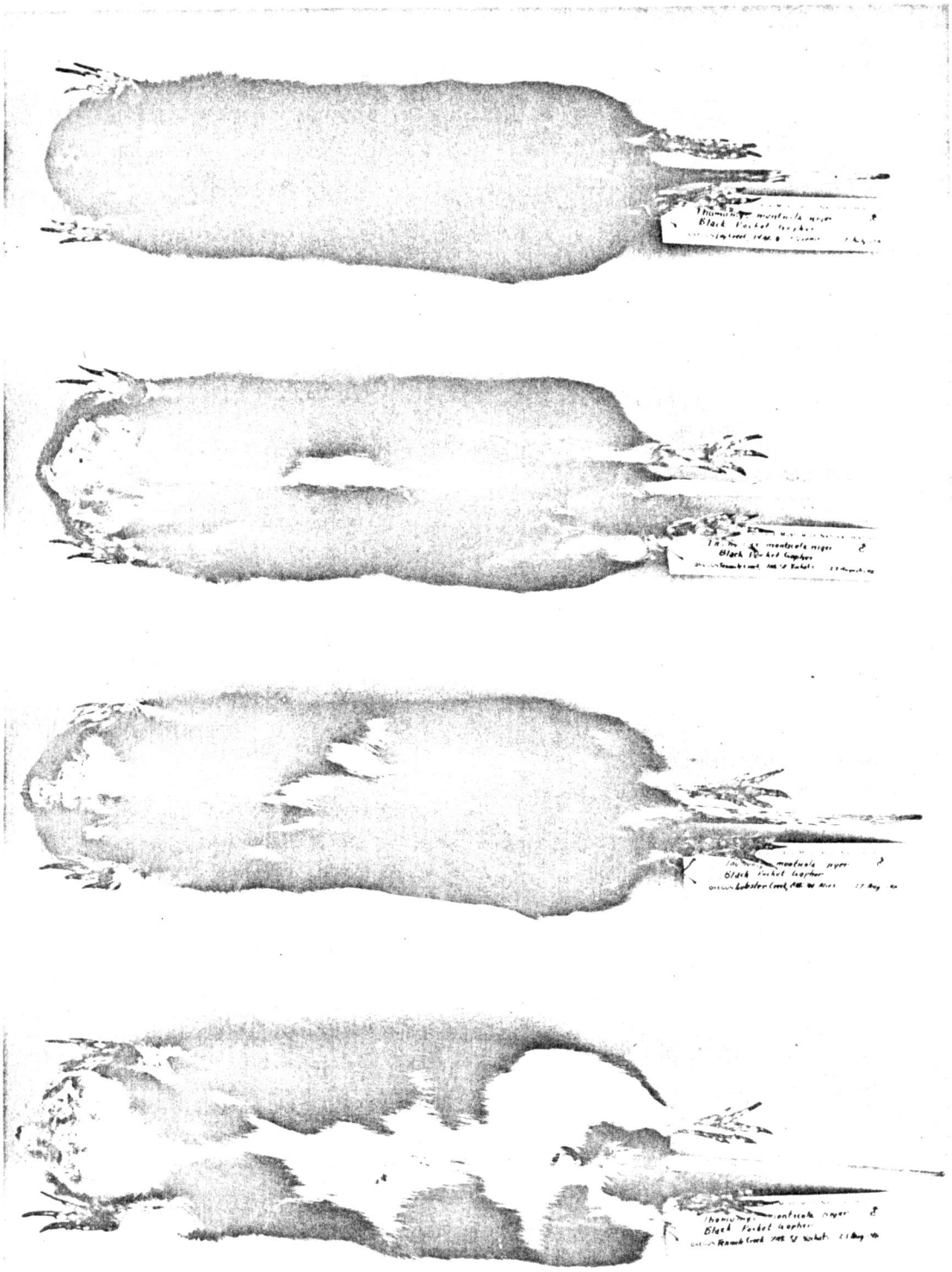

PLATE 6

PLATE 7

Anterior view of (left to right) normal condition, restricted mid-dorsal stripe, and extended mid-dorsal stripe. The stripe is always accompanied by extensive ventral spotting.

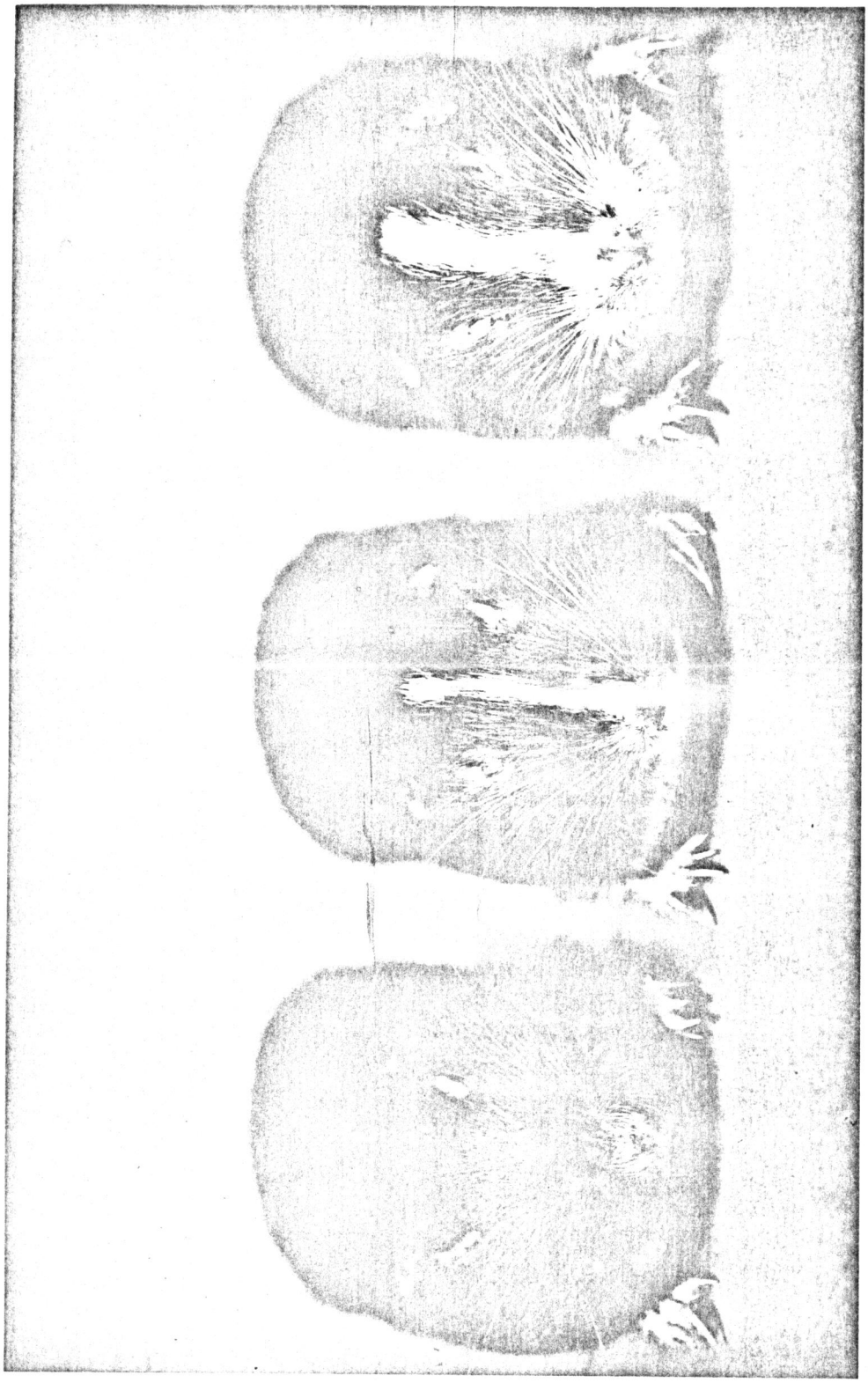

PLATE 7

PLATE 8

Dichromatism in *Thomomys hesperus*. Normal dark brown specimen at bottom, extremely dark individual at top. Two center gophers show intermediate amounts of extension of the dark chocolate pigment. The gene for extension of the dark pigment, E^D is thought operative here.

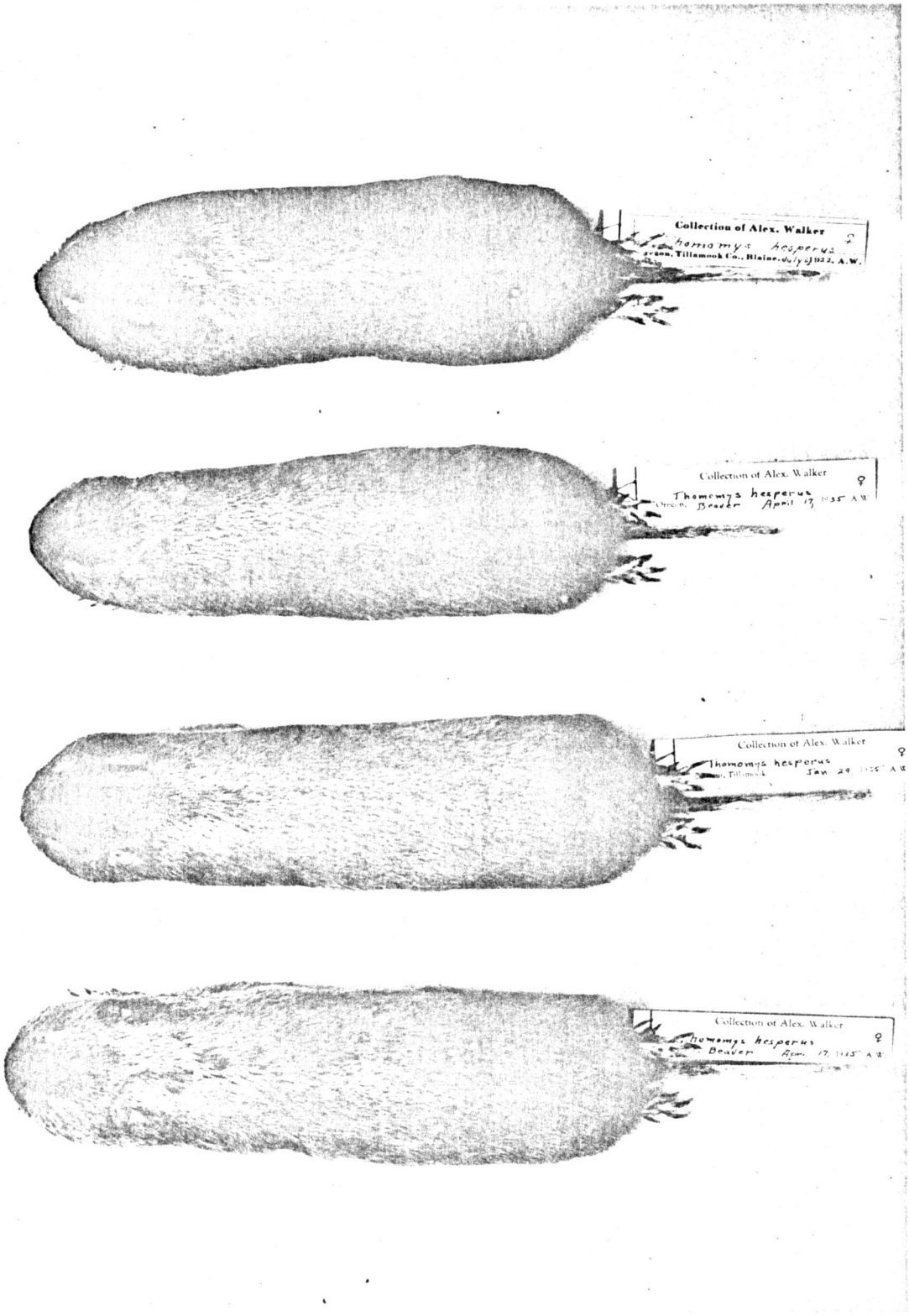
Collection of Alex. Walker
Thomomys hesperus
Collection of Alex. Walker
Thomomys hesperus
Collection of Alex. Walker
Collection of Alex. Walker

PLATE 8

PLATE 9

Open areas immediately adjacent the ocean do not harbor Thomomys nigrer. Such areas occur occasionally along the headlands and adjacent hills where the rigorous microclimate excludes the chapparal and forest species. Cape Perpetua, 2 miles south of Yachats, Oregon.

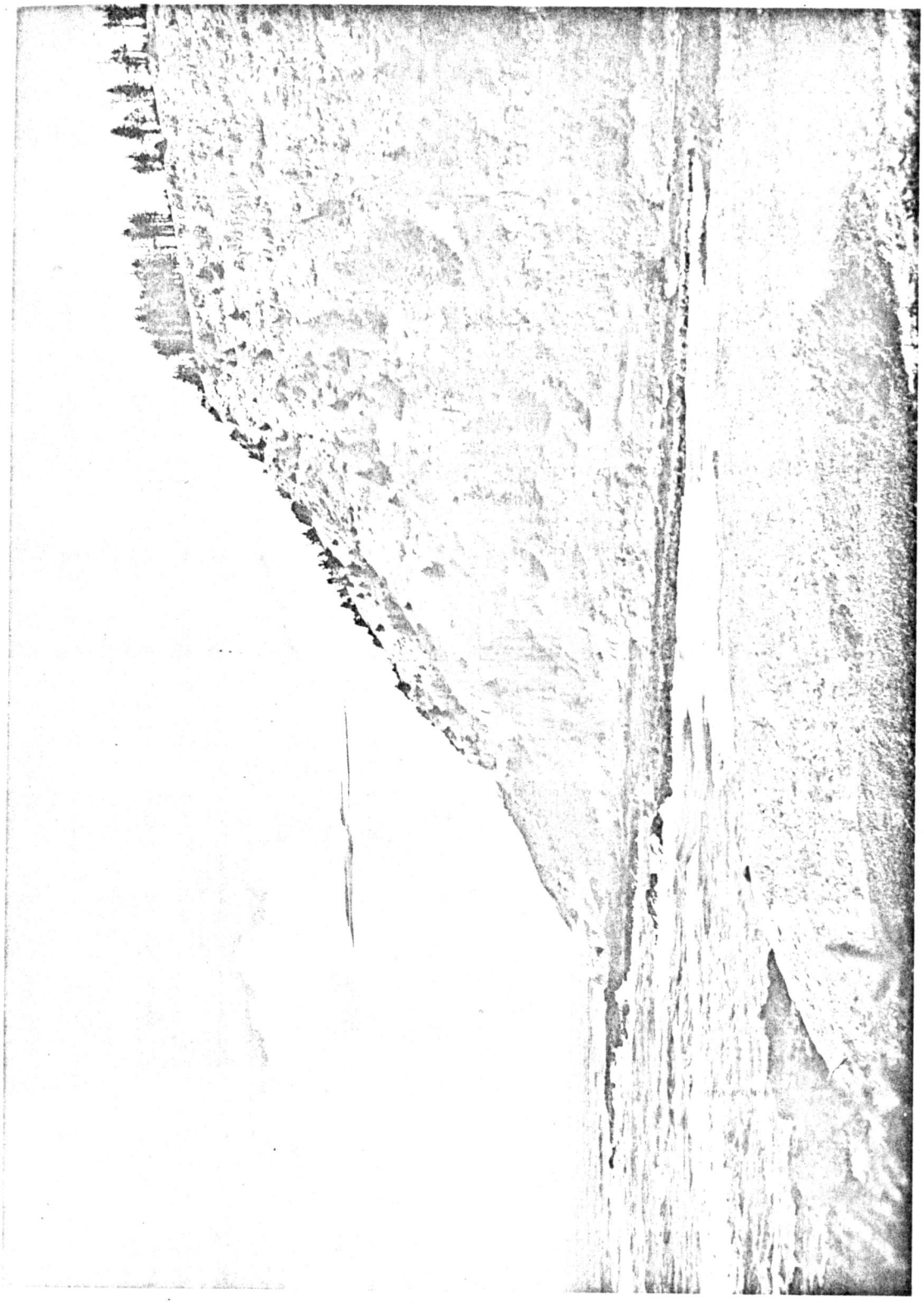

PLATE 9

PLATE 10

The coastal chapparal strip with typical huckleberry, manzanita, and small pines. On sandy soil this strip is not entered by pines. The more distant hills show the older stage of succession following either lumbering or fire, or both. Near China Creek, 13 miles north of Florence, Oregon.

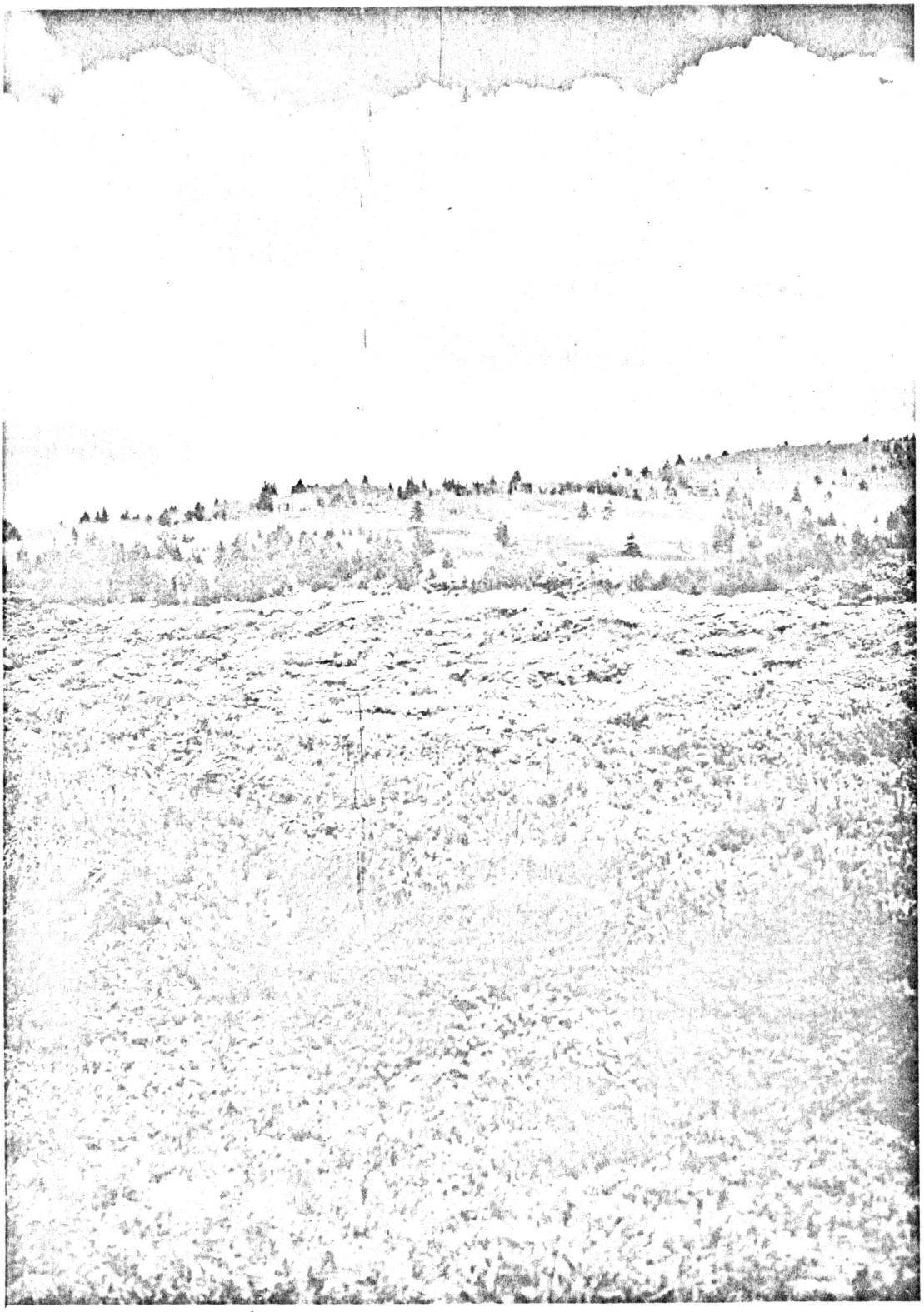

PLATE 10

PLATE 11

The soggy bottomlands offer no habitat to the gopher. Here the skunk cabbage and rush, in the foreground, indicate the swampy condition. Near mouth of Tenmile Creek, 6 miles south of Yachats, Oregon.

PLATE 11

PLATE 12

A view of excellent gopher habitat. The steep slope insures ample drainage throughout the year and proximity to the ocean, and the accompanying summer fogs yield ample green vegetation even in late summer. On Tenmile Creek, 7 miles southeast, Yachats, Oregon.

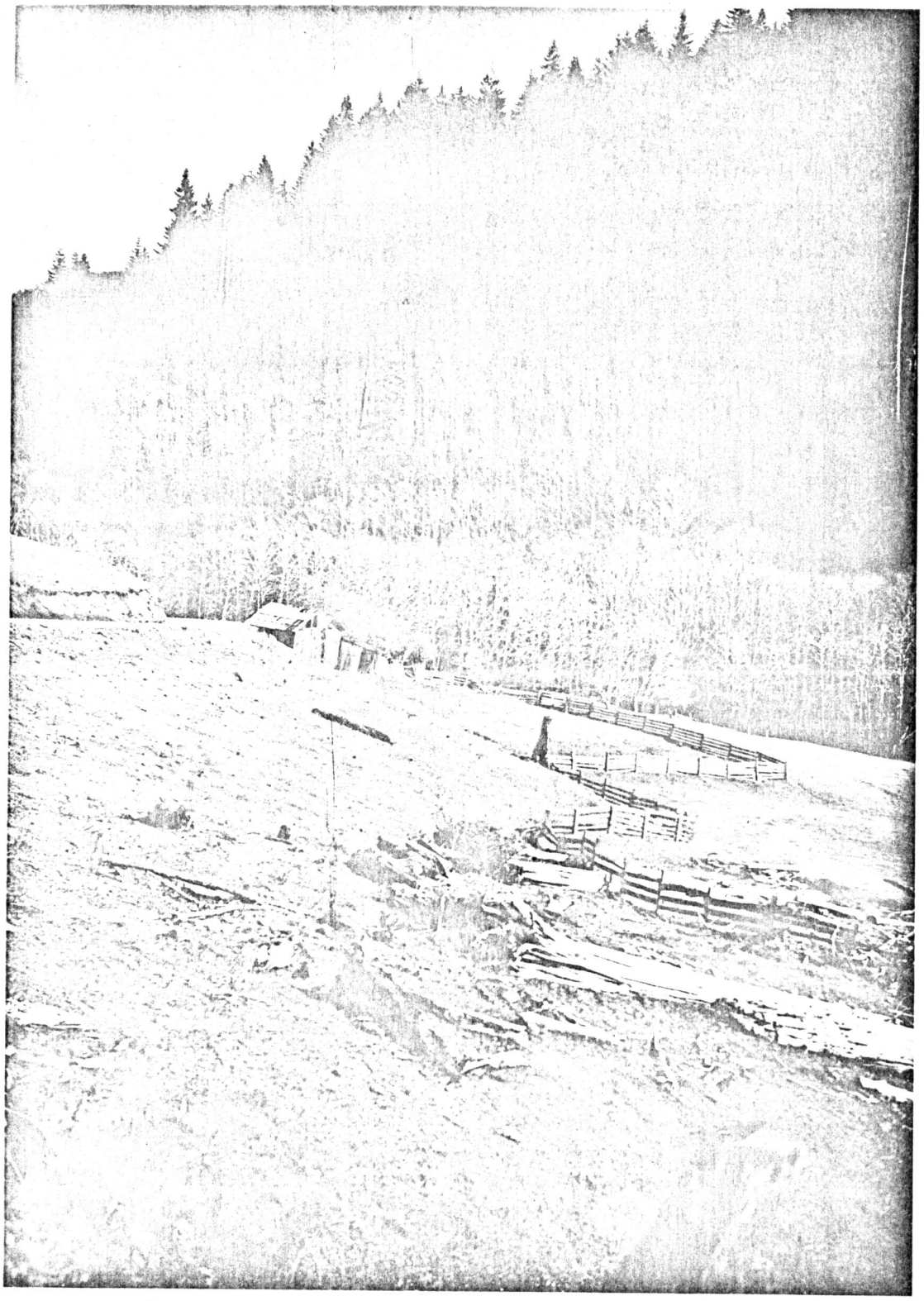

PLATE 12

PLATE 13

This small bench supports a high concentration of *Thomomys nigrer*. Tenmile Creek, 8 miles southeast of Yachats, Oregon.

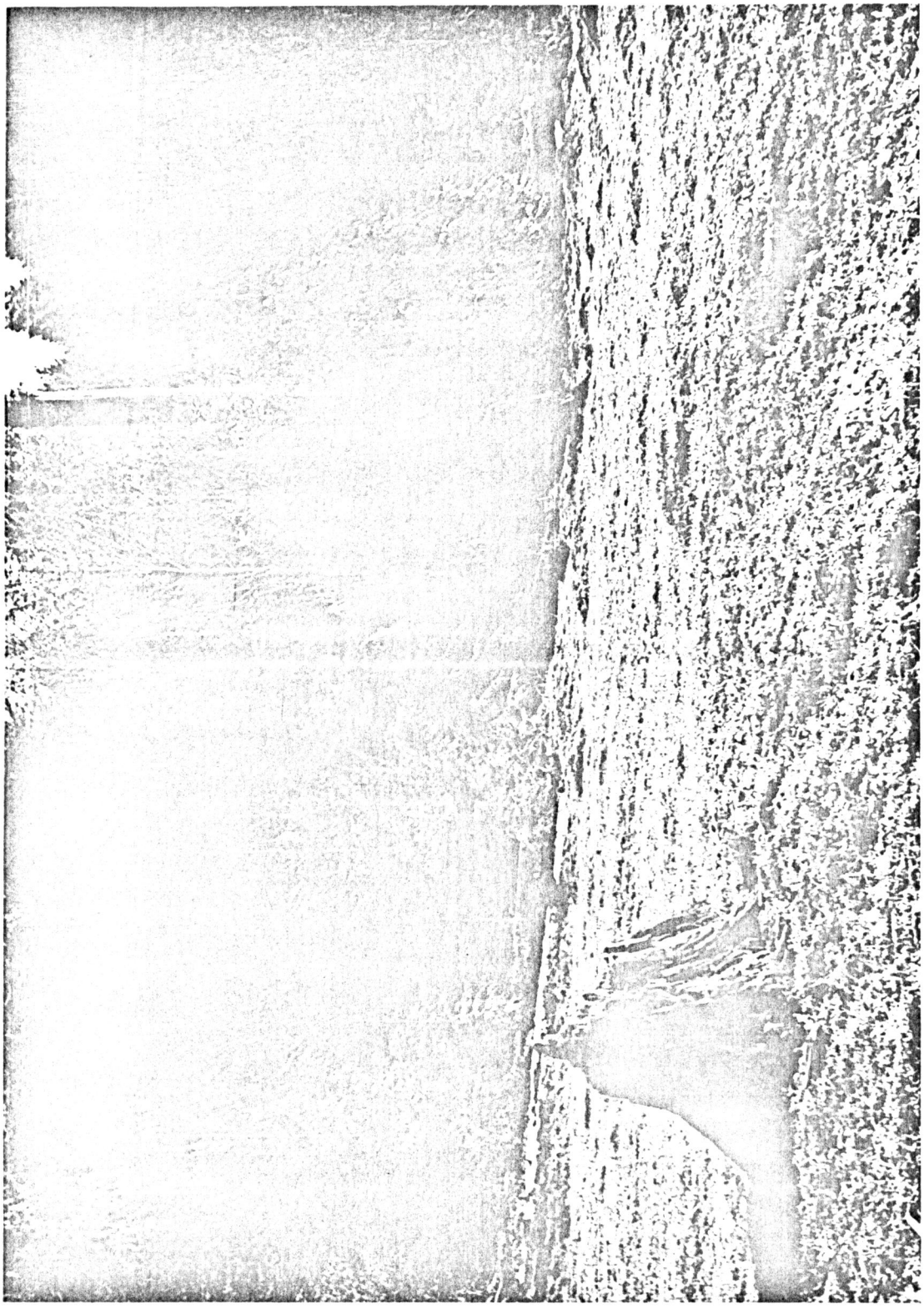

PLATE 13

PLATE 14

Surrounded by marshy ground this knoll sheltered numerous gophers. Temnile Creek.

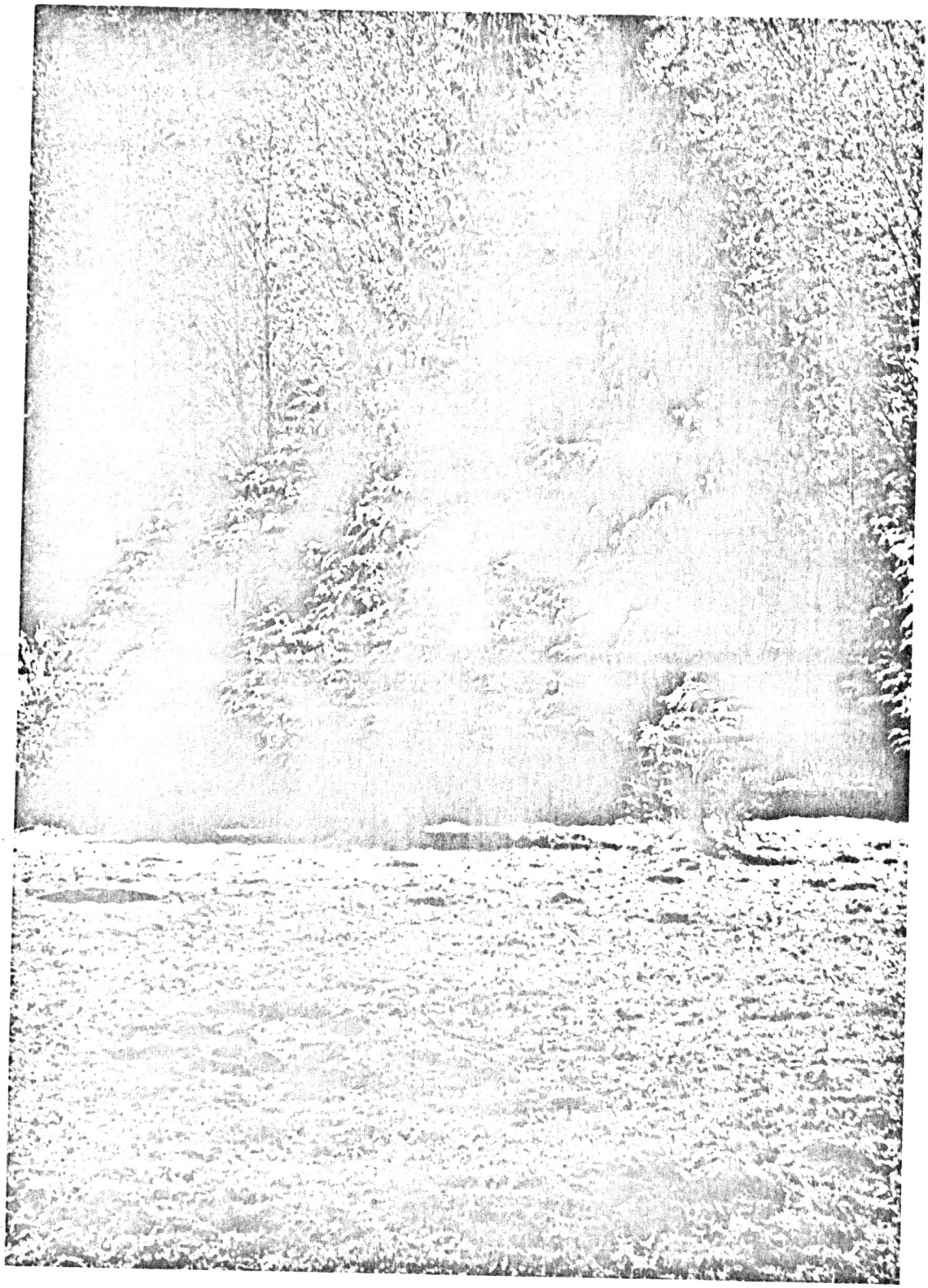

PLATE 14

PLATE 15

Typical of the sub-marginal lands bordering many of the small coastal streams is this abandoned farm now in ruins. The roof of the farmhouse is seen on the right, the barn once stood further to the left rear. Once cleared, constant grazing has held vegetative succession in check, thus preserving excellent gopher habitat. Big Creek, 14 miles north of Florence, Oregon.

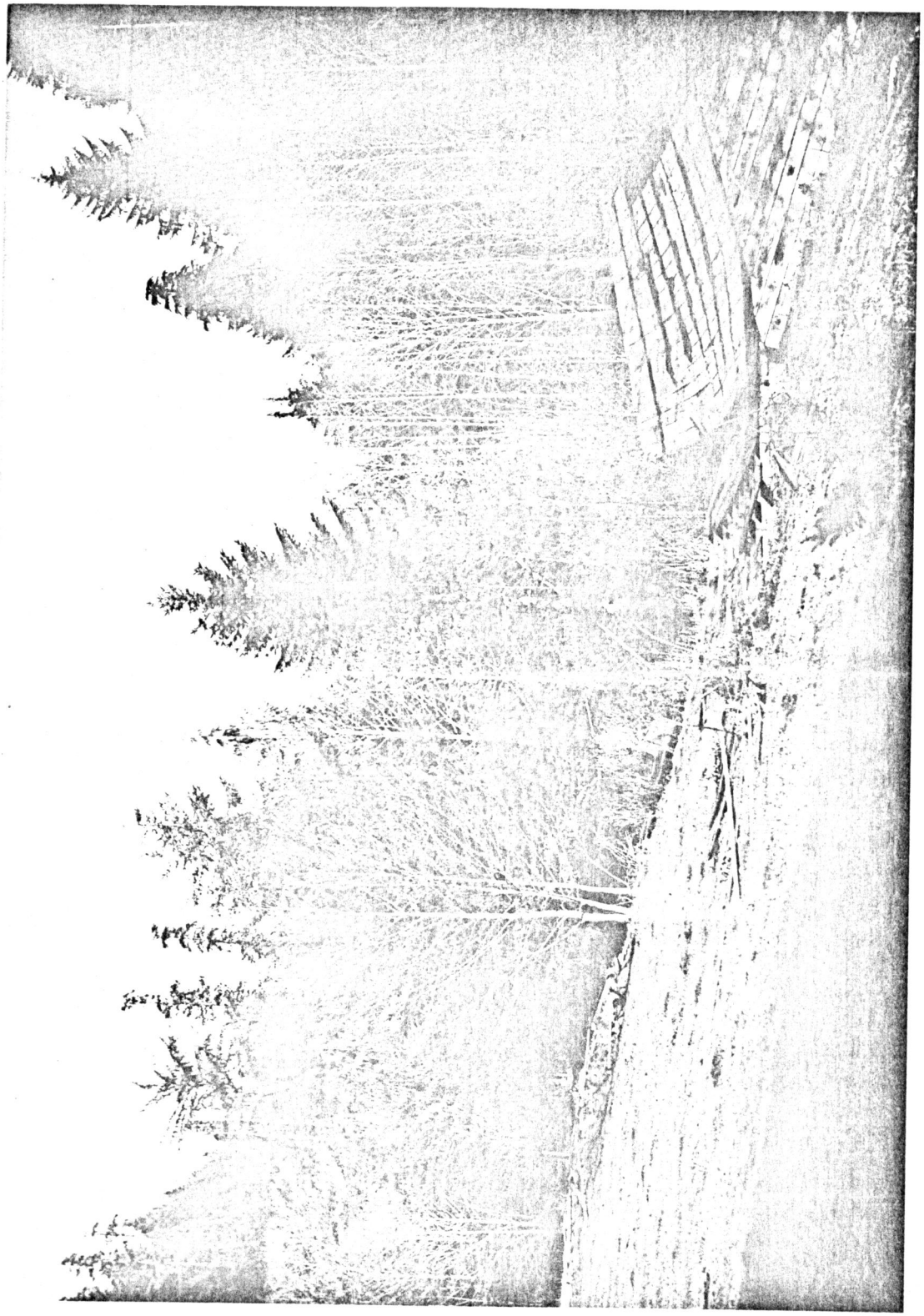

PLATE 15

PLATE 16

An extensive bench above Big Creek. Near the creek side, in the foreground, gopher workings were abundant but the soggy area near the hill was avoided. Horses and cattle keep the vegetation closely cropped.

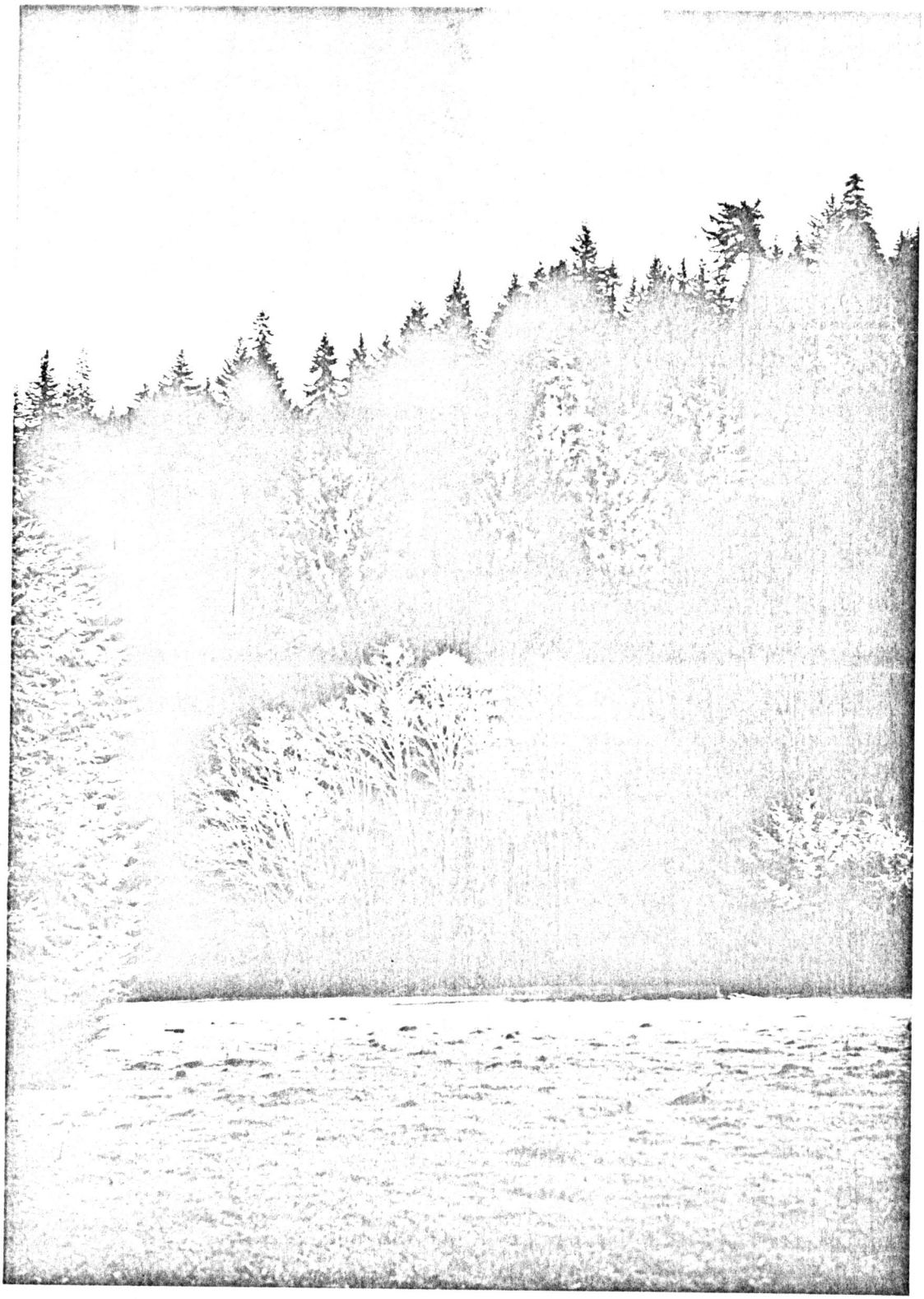

PLATE 16

PLATE 17

Another view of the bench on Big Creek (see plate 16). Note how the system in the foreground follows the rotting limbs. Down logs are often used for protection of systems from trampling by livestock.

PLATE 17

PLATE 18

A U.S. Forest Service plantation of Port Orford Cedar on an old logging site. Alders in the background have followed the disturbance. Grazing keeps the plantation clear and most systems are confined to the protection of the trees. How the gophers invaded this cleared area surrounded by dence fir forests is a question. Recorded from Seaton, only a mile away in the Suislaw Valley, perhaps a few gophers wandering through the forest were fortunate enough to reach the area and establish a colony.

PLATE 18

PLATE 19

Gopher mound viewed from above. Note the typical cresent-shape created when loads of dirt have been thrown out in different directions. The tunnel entrance has been plugged by a final load to keep out rain or invaders. To compare with mole mound see Plate 23.

PLATE 19

PLATE 20

Viewed from the side the low outline of the gopher mound is noticeable. The soil has been well loosened and tumbles smoothly down the sides. See Plate 24 for a similar view of a mole mound.

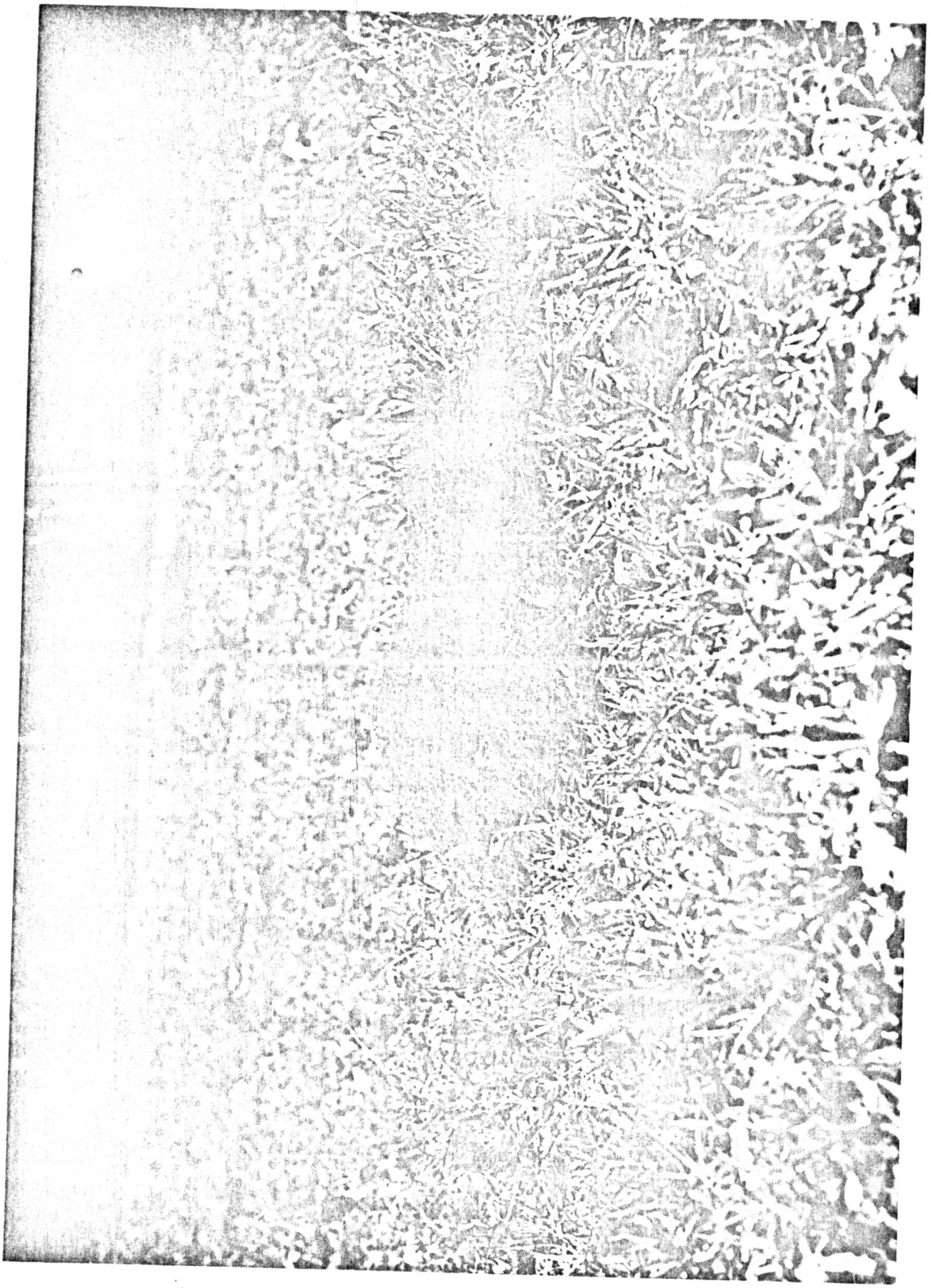

PLATE 20

PLATE 21

A set of gopher workings newly constructed in April. This group of mounds represents an extension of a system that had been occupied through the winter with little building activity. Hunting knife in center indicates relative size of mounds and area.

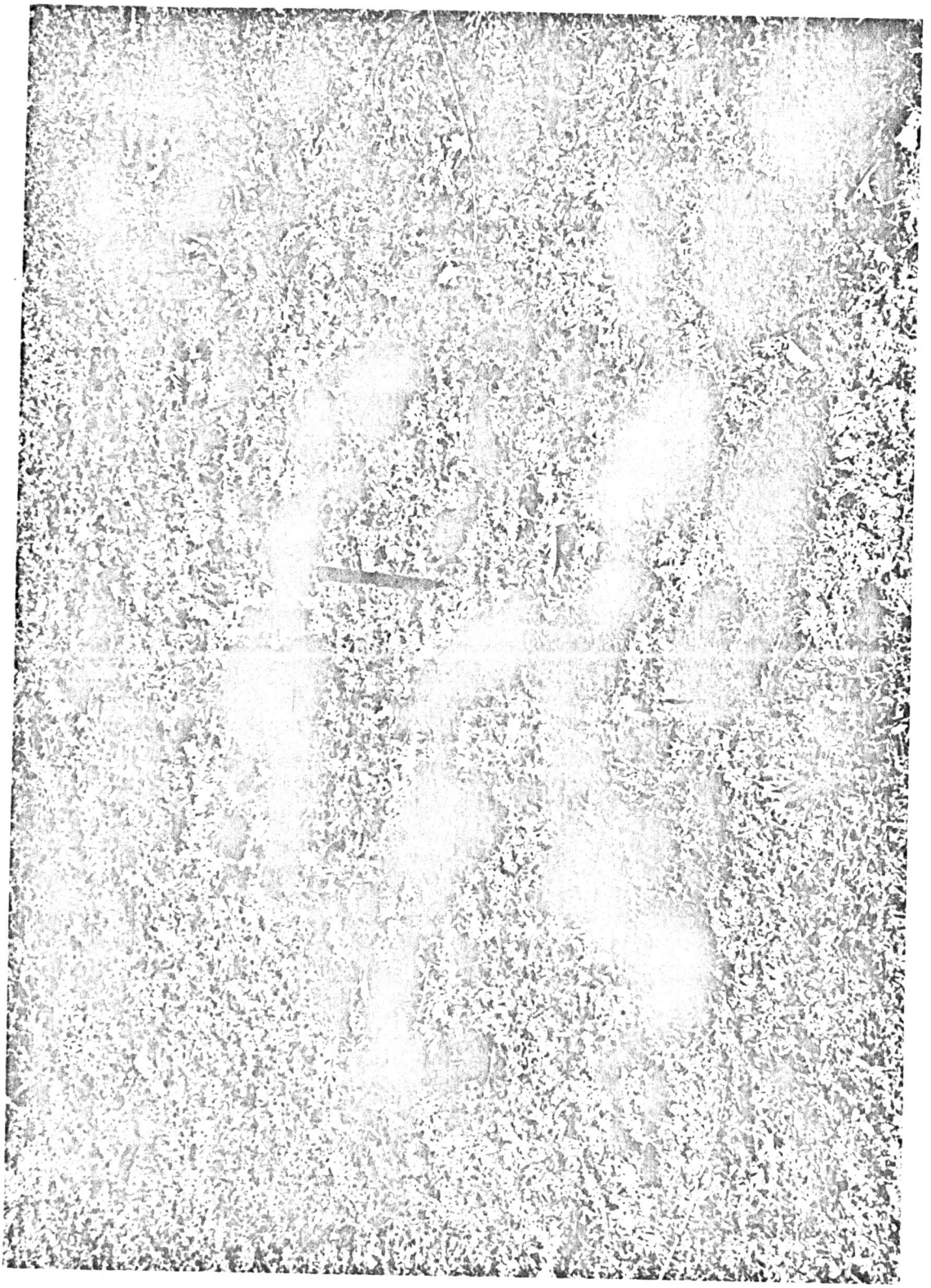

PLATE 21

PLATE 22

Diagramatic sketch of foraging system, excavated in August, 1948. The tunnels, one and one-half to one and three-fourths inches in diameter, were all between 4 and 6 inches beneath the surface, except the vertical shaft to the living area. As indicated by the mounds, the series at the lower corner were rather old. The ones above the center were the results of recent activities. The tunnel to the left may have extended further at one time but plugging with dirt and erosion of mounds makes tracing impossible.

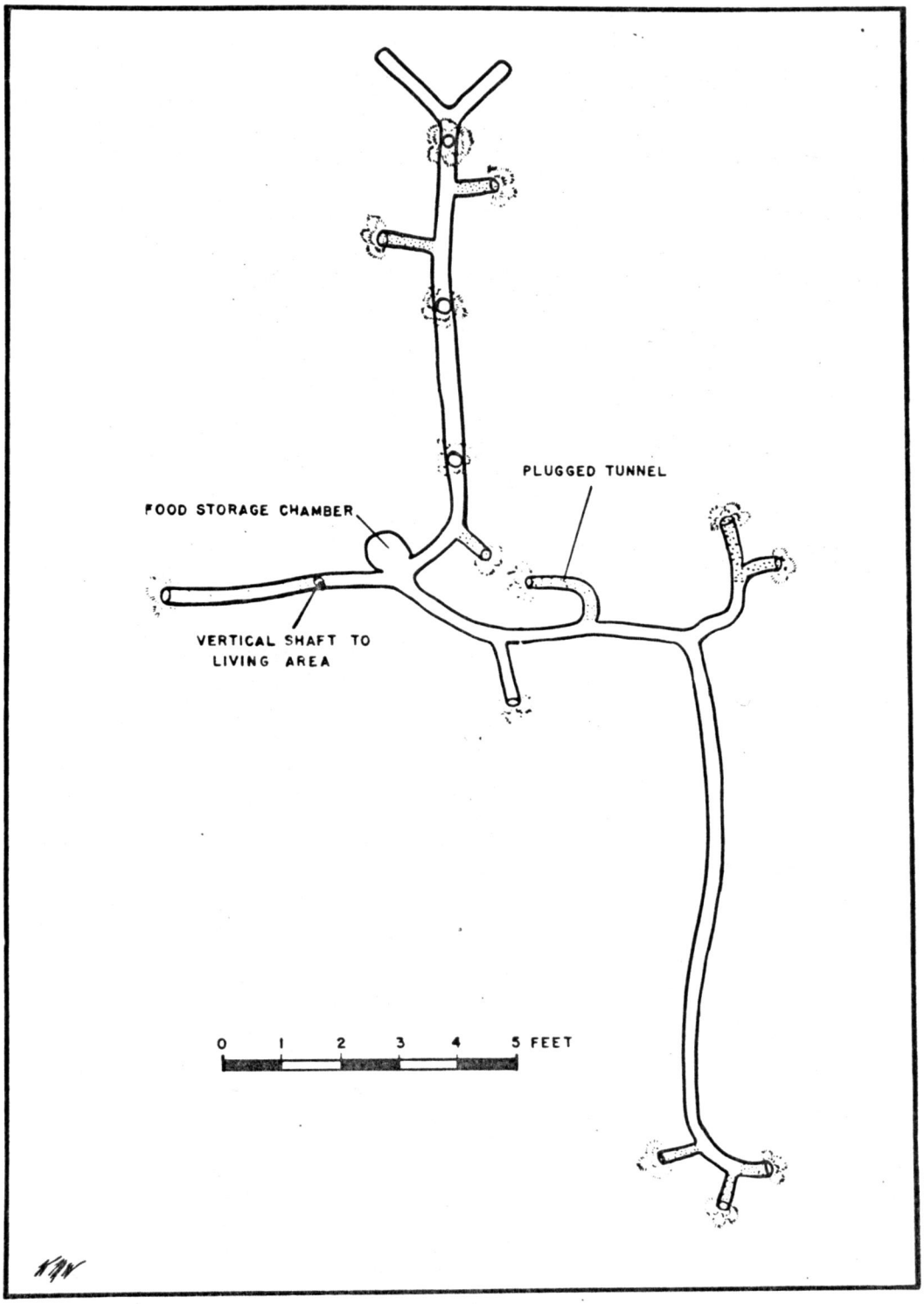
PLUGGED TUNNEL
FOOD STORAGE CHAMBER
VERTICAL SHAFT TO
LIVING AREA
0 1 2 3 4 5 FEET

PLATE 22

PLATE 23

Typical mole mound viewed from above. Circular in form with the tunnel located in the center, this is readily distinguishable from the gopher mound in Plate 19.

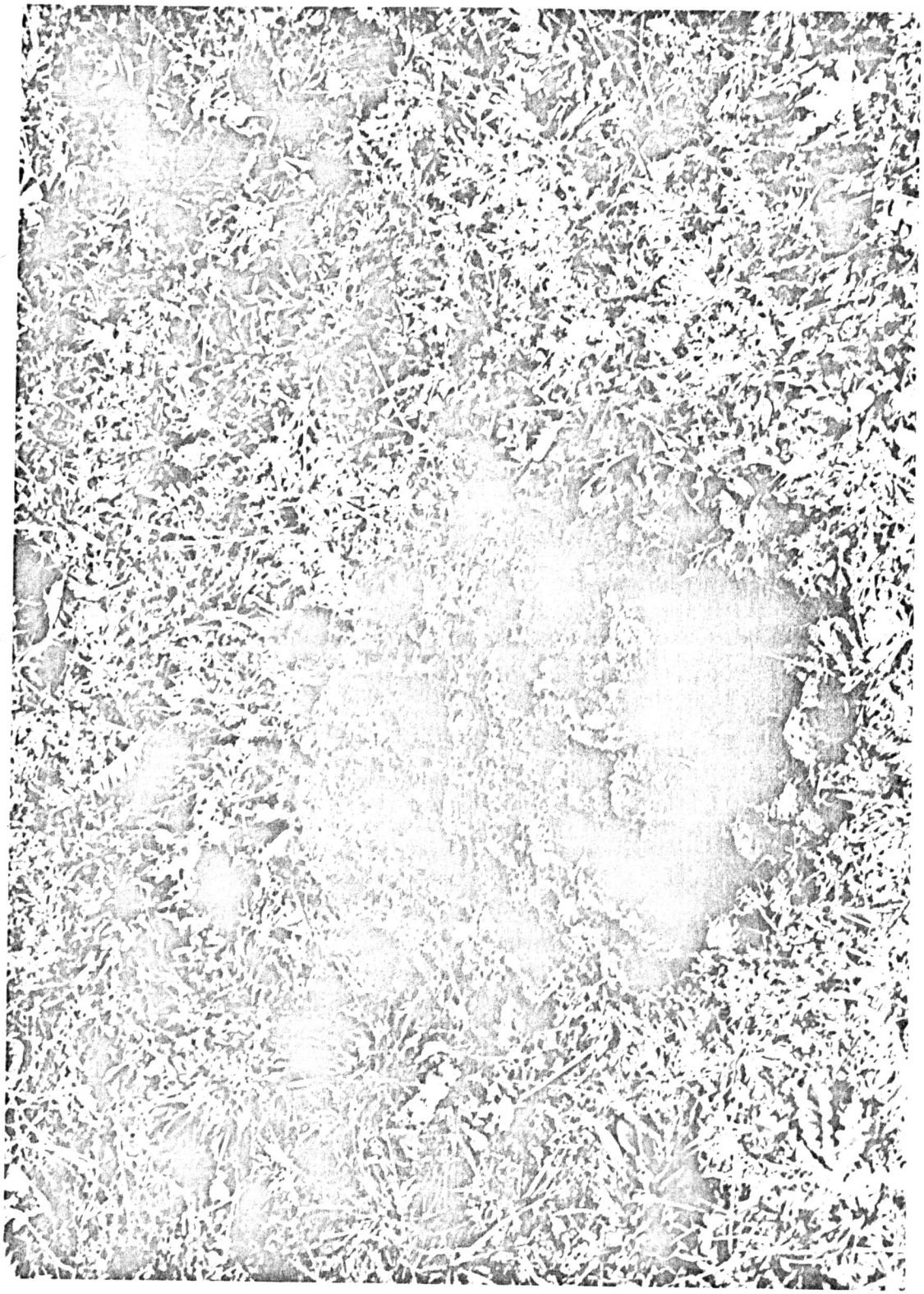

PLATE 23

PLATE 24

A mole mound as seen in outline. This mound stands high and is rugged in form due to the cylinder of packed dirt tumbling from the top. See Plate 20.

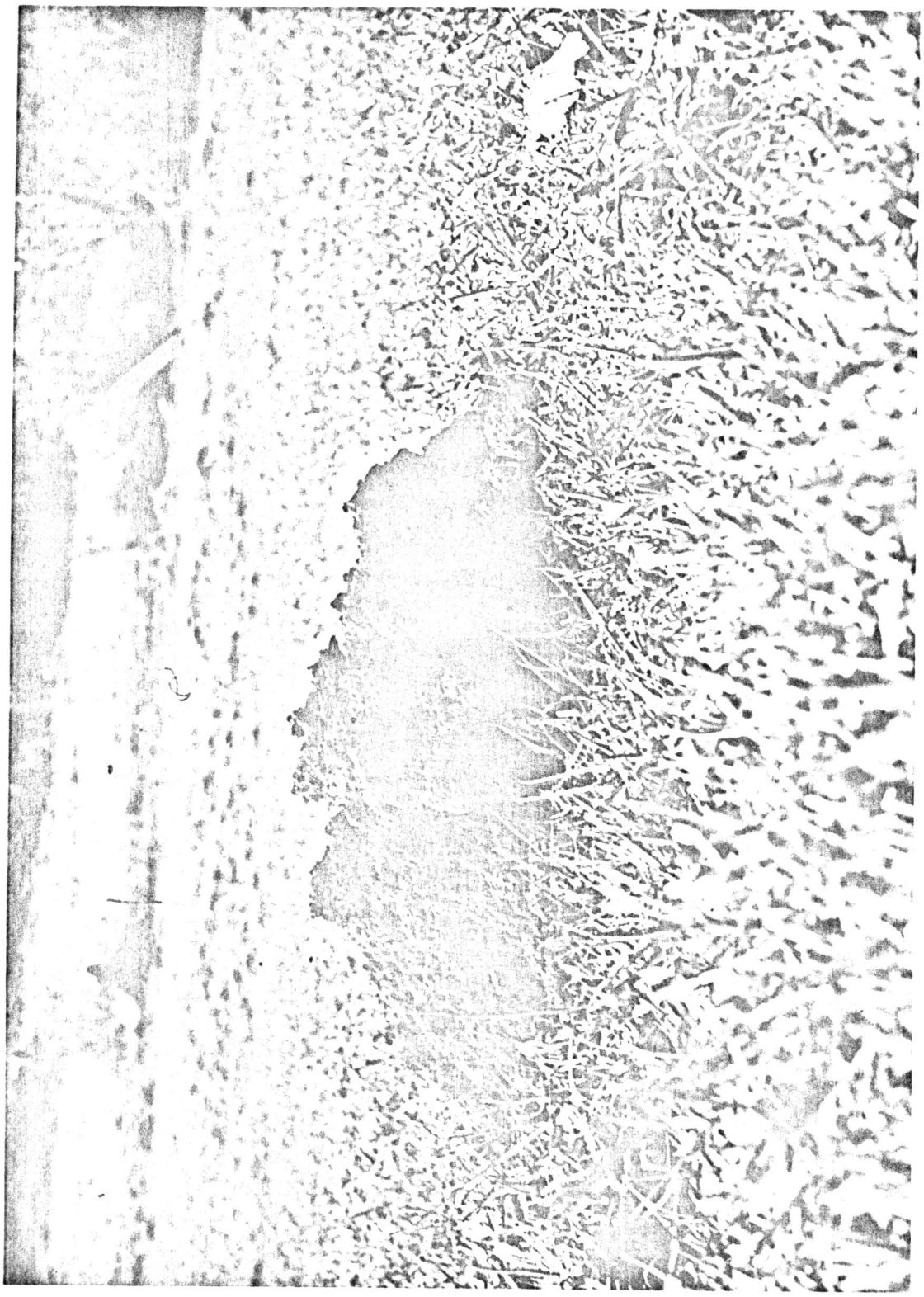

PLATE 24

PLATE 25

Part of a series of mole mounds showing the high broken form. The mole is also an important animal in the processes of soil formation, its greater abundance in the coastal area eclipses the role played by the pocket gopher.

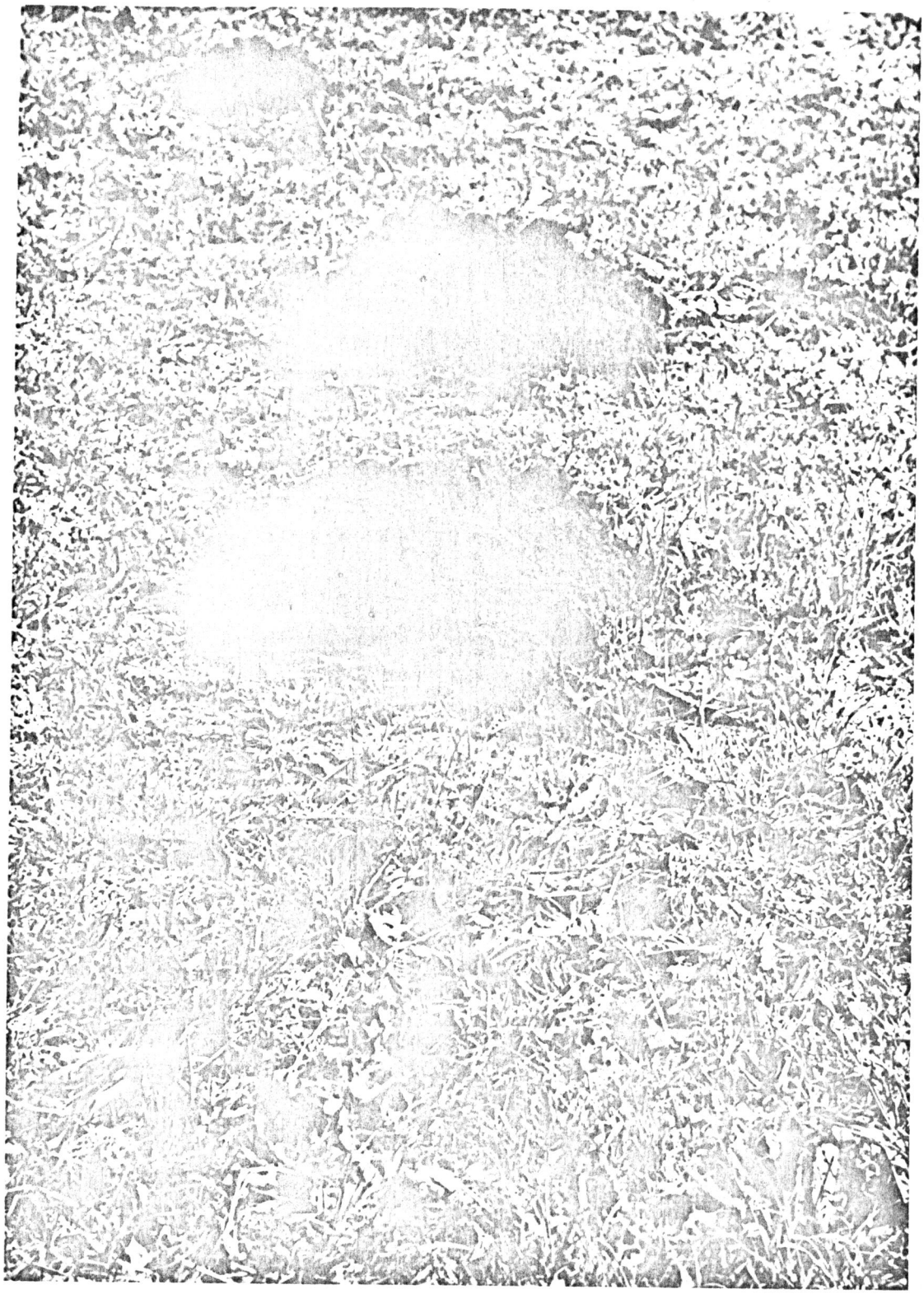

PLATE 25

SELECTED BIBLIOGRAPHY

1. Anthony, H. E. Field book of North American Mammals. New York, G. P. Putnam's Sons, 1928. 674p.
2. Asdell, S. A. Patterns of mammalian reproduction. Ithaca, Comstock Publishing Co., 1946. 437p.
3. Bailey, Vernon. Revision of the pocket gophers of the genus Thomomys. North American Fauna No. 39:1-136, 1915.
4. _____ Mammals and life zones of Oregon. North American Fauna No. 55:1-416, 1936.
5. Burto, Elizabeth, and Huestis R. R. Inheritance of a white star in the deer mouse. Journal of Heredity 24:245-248, 1933.
6. Cahalane, Victor H. Mammals of North America. New York, The Macmillan Co., 1947. 682p.
7. Castle, W. E. English and Dutch spotting and the genetics of the Hotot rabbit. In Contributions to the genetics of the domestic rabbit, Carnegie Institution of Washington Publication No. 427:3-13, 1932.
8. Dobzhansky, Theodosius. Genetics and origin of species. Second edition, revised. New York, Columbia University Press, 1947. 446p.
9. Fenneman, Nevin M. Physiography of western United States. New York, McGraw-Hill Book Co., 1931. 534p.
10. Grinnell, Joseph. Burrowing rodents of California as agents in

soil formation. Journal of Mammalogy 4:137-149, 1923.

11. _____ Geography and evolution in the pocket gopher. University of California Chronicle 18:247-262, July, 1926.

12. Grüneberg, Hans. Genetics of the mouse. London, Cambridge University Press, 1943. 412p.

13. Hansen, Henry P. Postglacial forest succession, climate, and chronology in the Pacific Northwest. Transactions, American Philosophical Society, new series, 37:1-130, 1947.

14. Hill, John E. The rectractor muscle of the pouch in Geomyidae. Science, new series, 81:160, 1935.

15. Hubbard, C. Andresen. Fleas of Western North America. Ames, Iowa, Iowa State College Press, 1947. 533p.

16. Mayr, Ernst. Systematics and the origin of species. New York, Columbia University Press, 1947. 334p.

17. Merriam, C. Hart. Revision of the pocket gophers, family Geomyidae, exclusive of the species of Thomomys. North American Fauna No. 8:1-258, 1895.

18. _____ Descriptions of twenty-three new pocket gophers of the genus Thomomys. Proceedings of the Biological Society of Washington 14:107-117, 1901.

19. Storer, Tracy I., and Gregory, Paul W. Color aberrations in the pocket gopher and their probable genetic explanation. Journal of Mammalogy 15:300-312, 1934.

20. United States Department of Agriculture. Soils and men. Yearbook of Agriculture, Washington D.C., United States Government Printing Office, 1938. 1232p.

21. _____ Climate and man. Yearbook of Agriculture. Washington D.C., United States Government Printing Office, 1941. 1248p.

22. Wight, H. M. Breeding habits and economic relations of the Dalles pocket gopher. Journal of Mammalogy 11:40-48, 1930.