Evaluation of a method to determine presence of the Mazama Pocket Gopher, *Thomomys mazama*, and other fossorial mammals in the south Puget Sound, Washington based on the collection and identification of hair samples

By

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ABSTRACT

Evaluation of a method to determine presence of the Mazama Pocket Gopher, *Thomomys mazama*, and other fossorial mammals in the south Puget Sound, Washington based on the collection and identification of hair samples

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Inventorying and monitoring the south Puget Sound prairie species is essential to ensure their survival, as well as the survival of the prairie habitat itself. It is important to assess how species abundance and their distribution are responding to changes in habitat and management practices. To do this, one needs to first know the current distribution of the species. One such species is the Mazama (Western) pocket gopher (*Thomomys mazama*). Due to habitat loss, the distribution of *T. mazama* is unclear. To address this uncertainty, biologists need a simple method to identify the location of the pocket gopher, to begin more studies. Mound observations may provide a simple way to determine if the gopher still inhabits the prairie habitat it once occupied, however this area is often home to other fossorial mammals, including moles, which may have similar looking mounds, especially in a wet climate. Techniques for inventory of the Mazama pocket gopher must be cost-effective, non-labor intensive, and less intrusive than trapping. The goal of this study was to develop a method of hair collection to verify Mazama pocket gopher presence in the south Puget Sound. Experiments were performed to determine the best hair collection material, the best hair collection device, and a technique to collect hair directly from a pocket gopher passing through its burrow system. The best hair collection device was a block/plywood piece with double-sided Scotch clear tape affixed to it, attached to a square piece of hardware cloth. The hardware cloth rested flat on top of the soil holding the block piece which hung down into the dug out burrow runway. The device was covered with black plastic and soil. It was tested to see if when a pocket gopher ran through its runway and passed the device, the tape on the block collected hair. This device was "plugged" often with dirt, concluding that this device and technique was not successful in collecting hair from a burrow system and may be too intrusive. Examination of individual hairs using a microscope (400X magnification) from various mammals revealed unique features that were species specific. Hair examination thus can be an effective way to determine the identification of mammals in the field. Further recommendation arising from this thesis include conducting more studies to determine if modification can be made to the hair collecting device to make it more effective. Currently, the best method to detect the presence of the Mazama pocket gopher may be through the identification of its unique mound structure.

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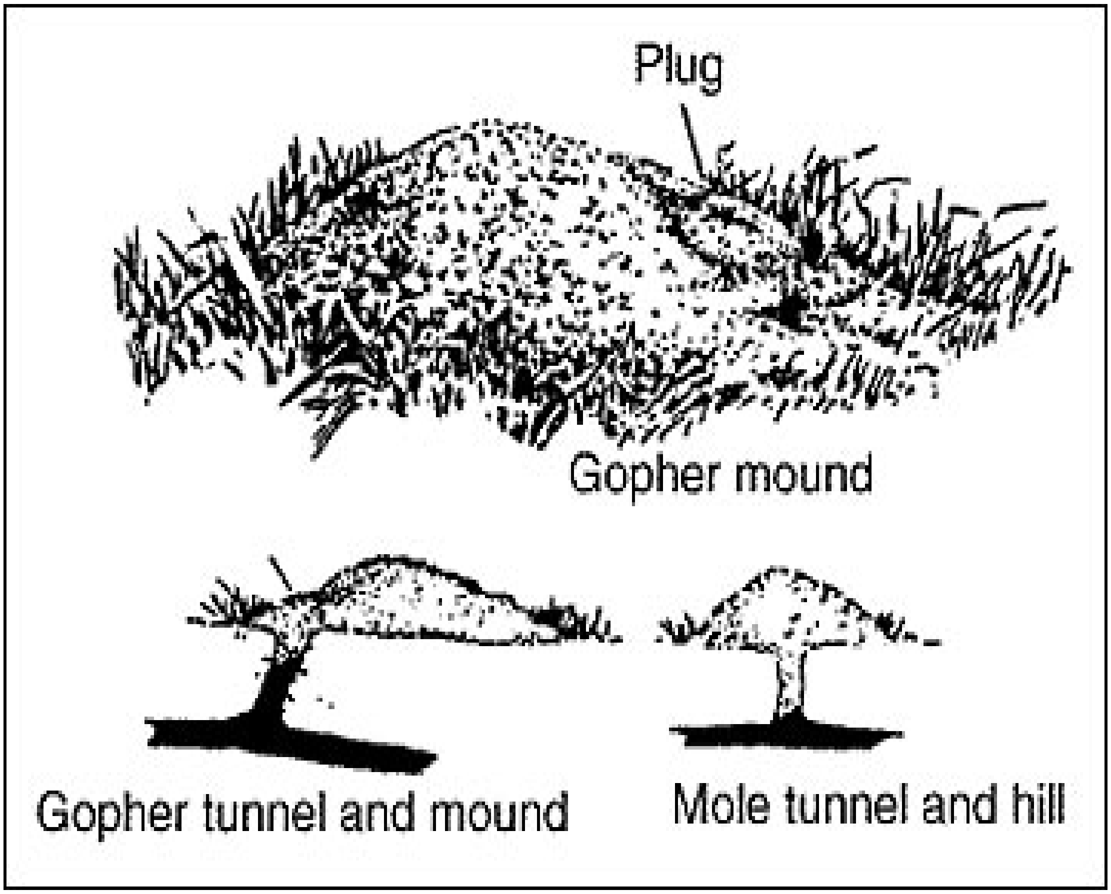
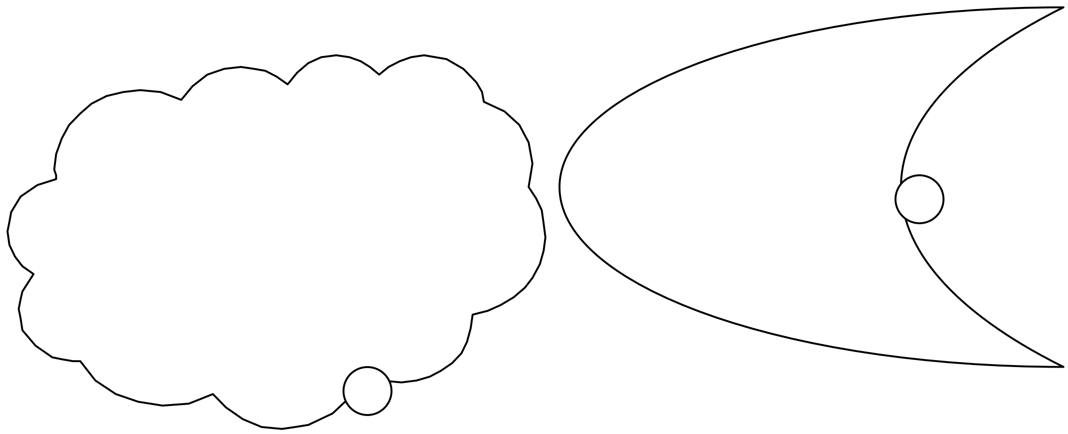


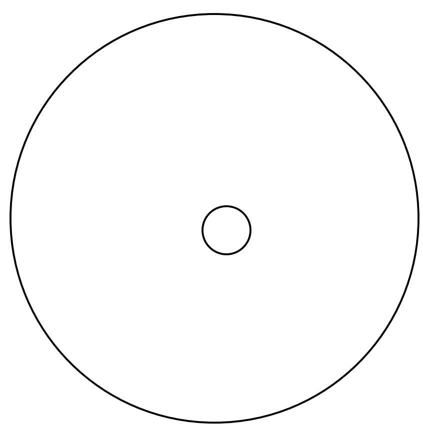
[1] From the University of Missouri, Agriculture Department

Figure 3. Mound Shapes

Gopher mound shapes

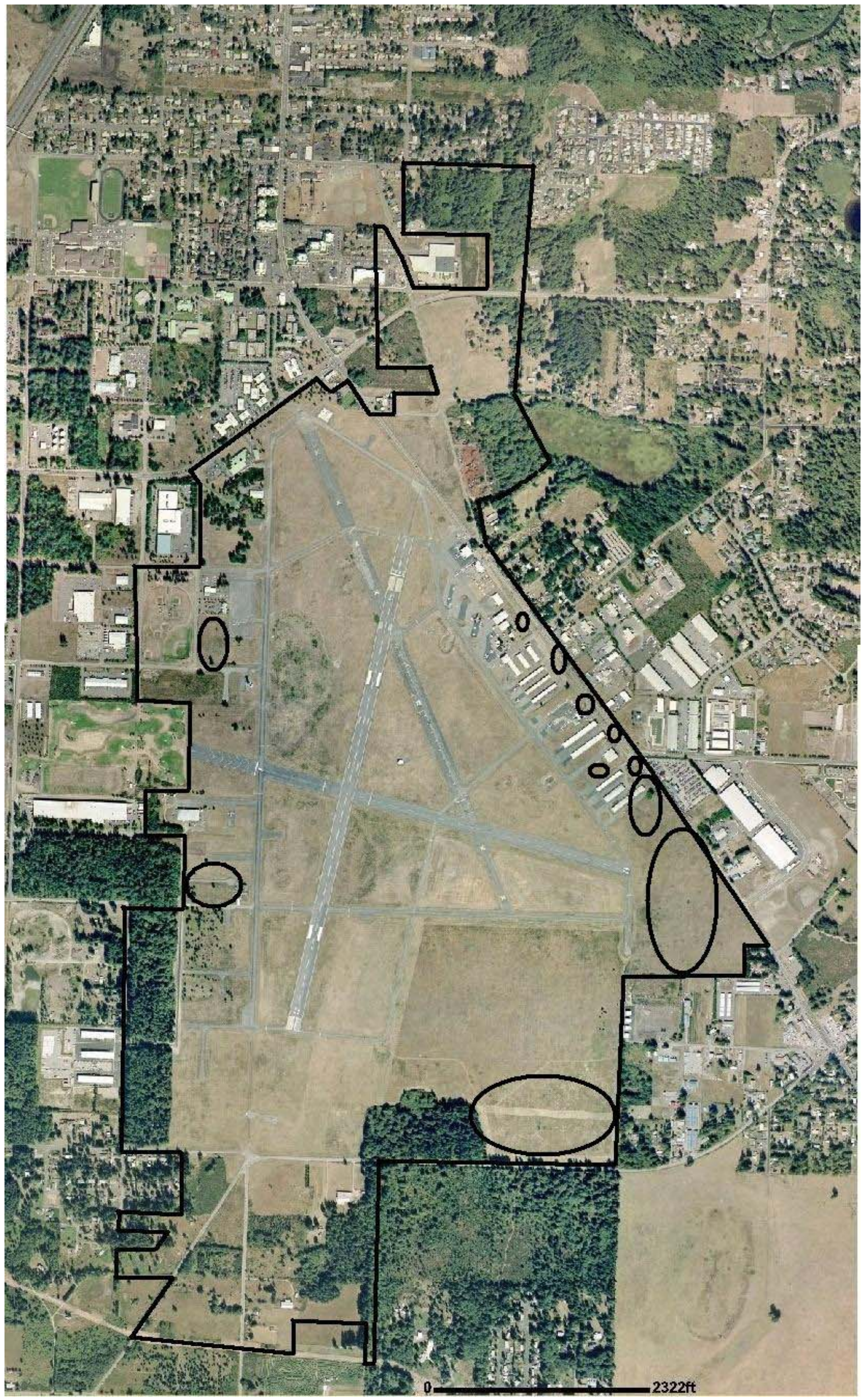


Mole shape mounds



The smaller circles represent the "plug" or exit hole of the mound. Pocket gophers have plugs off to the side of the mound. With the "cloud shaped" gopher mound there was either a plug off to the side, or more often a plug that wasn't visually obvious.

Figure 4. Olympia Washington Regional Airport



Gopher trapping locations located within the circles.

Figure 5. Methods

<u>EXPERIMENT 1: HAIR COLLECTION MATERIAL</u>

1a: Pre-test

11 hair collection materials; tested 5 times each. Pocket gopher went through tube with test material, if hair was collected, the material was then tested further.

1b: Test

Quantitative test:

Test of final hair collection materials; tested 4 times each. Number of hairs collected counted.

Qualitative tests:

- How easy hair was seen on material
- How easily hair was removed from material
- How easy material was used in the field

↓

<u>EXPERIMENT 2: PCV HAIR COLLECTION DEVICE CONTROL</u>

2a: Glass walled soil enclosure

Test of the PVC hair collection device with final hair collection material in a glass walled soil enclosure. It was recorded if the device collected gopher hair or not. The behavioral response to the device was also observed and video taped.

2b: Outdoor pens

Test of the PVC hair collection device with final hair collection material in 4 outdoor dirt pens. It was recorded if the device collected gopher hair or not. The "plugging" of the device was also recorded.

↓

<u>EXPERIMENT 3: DIFFERENT DEVICES – FIELD TESTS</u>

3a: PVC hair collection device

Test of the PVC hair collection device with final hair collection material in the field. It was recorded if the device collected gopher hair or not. The "plugging" of the device was also recorded.

3b: Block hair collection device

Test of the Block hair collection device with final hair collection material in the field. It was recorded if the device collected gopher hair or not. The "plugging" of the device was also recorded.

3c: Hardware cloth/block hair collection device

Test of the Hardware cloth and block hair collection device with final hair collection material in the field. It was recorded if the device collected gopher hair or not. The "plugging" of the device was also recorded.

Figure 6. Summary of Results

EXPERIMENT 1: HAIR COLLECTION MATERIAL

1a: Pre-test

Of the 11 pre-test material, Scotch double-sided exterior mounting tape, Scotch double-sided clear permanent tape, pet hair pic-up tape, and Velcro exterior moved on to the test experiment.

1b: Test

Quantitative test:

Of the 4 test material, **Scotch doubled-sided clear permanent tape** collected the most hair.

Qualitative tests:

Scotch double-sided clear permanent tape was easiest to see hair on, easiest to remove hair from, and easiest to use in the field.

↓

EXPERIMENT 2: PCV HAIR COLLECTION DEVICE - LAB

2a: Glass observation chamber

The PVC device **did not collect any gopher hair**. It was observed that the gopher "plugged" the device in all three trials.

2b: Outdoor pens

The PVC device **did not collect any gopher hair**. It was observed that the gopher "plugged" the device in all four trials.

↓

EXPERIMENT 3: DIFFERENT DEVICES – FIELD TESTS

3a: PVC hair collection device

The PVC device **did not collect any gopher hair** in the field. It was observed that the gopher "plugged" the device in all five trials.

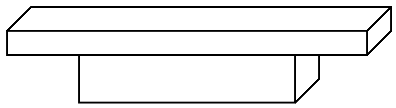
3b: Block hair collection device

The Block device **did not collect any gopher hair** in the field. It was observed that the gopher "plugged" the device 2/6 trials.

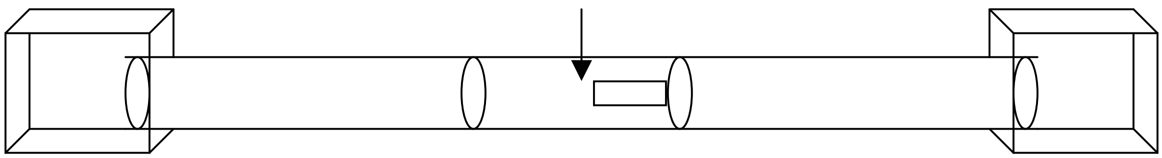
3c: Mesh and block hair collection device

The Mesh and block device did not collect any gopher hair in the field. It was observed that the gopher "plugged" the device 4/7 times.

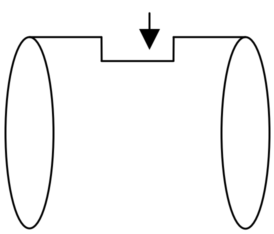
Figure 7. Experimental Equipment



Hair collection block used throughout the experiments and devices:
This block was used to hold the hair collection materials in all the experiments, including the final devices. Measurements: 6.4 cm x 3.8 cm (2.5 inch x 1.5 inch), 1.9 cm (0.75 inch) thick wooden block affixed to a piece of 7.6 cm x 6.4 cm (3 inches x 2.5 inches), 0.6 cm (0.25 inch) thick plywood.

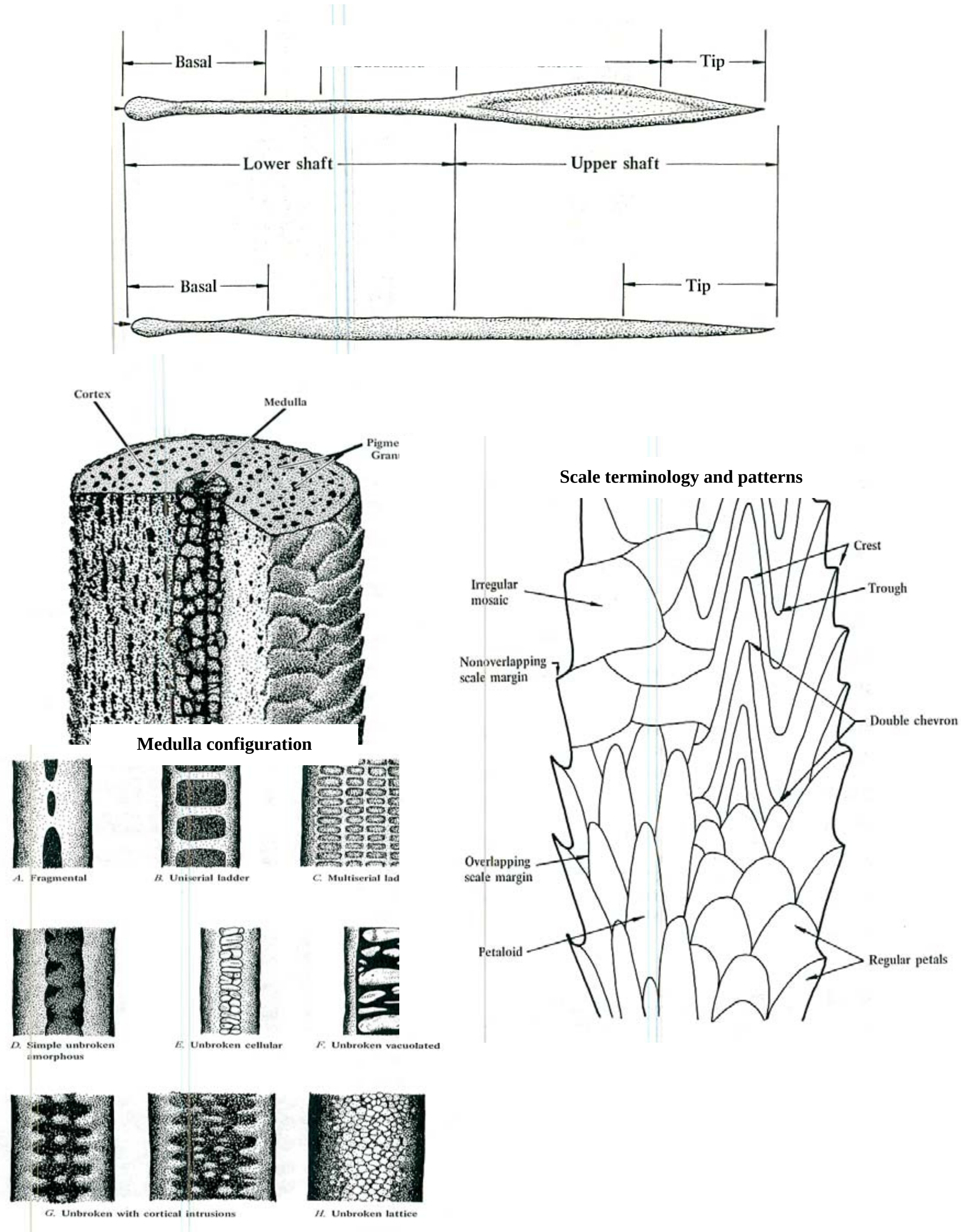


Experiment 1: Test runway for the hair collection material tests
This is a top view of the test runway in experiment 1. It consisted of an entry point box where the gopher began, a series of 5 cm diameter clear PCV pipes the gopher ran through, and an exit box where the gopher was taken from. The middle PCV had a hole cut in it to allow the block (from above) with the hair collection test material to be inserted in the test runway (at the arrow) to test what material worked the best at collecting hair. When the gopher ran past the block with the test material, it was determined if hair was collected or not. The whole runway was approximately 104 cm in length (40 inches).



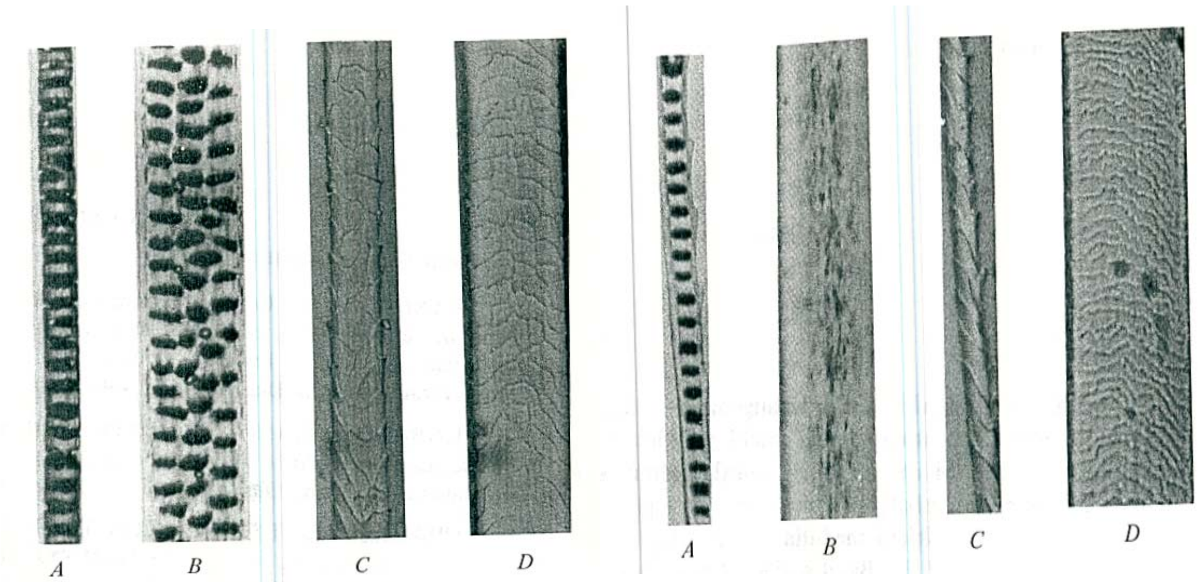
Experiment 3: The PVC hair collection device.
This device was a modified device from the "hair tube surveys" from Gurnell et al. 2001. It consists of a black PCV pipe 7.6 cm (3 inch) in diameter by 7.6 cm in length. The bottom of the pipe was cut off to allow for a natural dirt bottom when the device was placed inside a burrow system. Again, the block with the hair collection material used throughout the experiment was inserted at the arrow.

[2]Figure 8. Hair Structure



[2] Taken from "Identification of the dorsal guard hairs of some mammals of Wyoming" Moore et al. 1974

Figure 9. Pocket Gopher vs. Mole Hair



Northern pocket gopher (*Thomomsy talpoides*)

Eastern Mole (*Scalopus aquaticus caryi*)

[3]<u>Medulla</u> A: basal medulla; B: shield medulla. <u>Scales</u> C: basal; D: upper shield

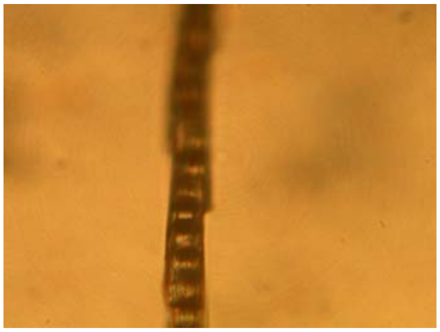
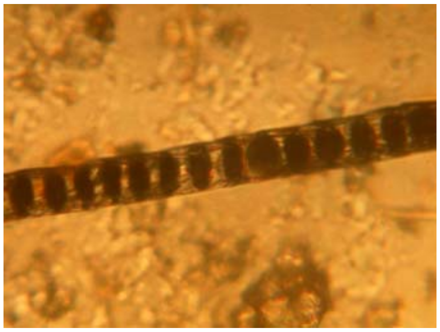
Pocket gophers have a shield medulla (B); moles usually lack a shield medulla in the upper region of the hair (B). There is a very slight difference of the basal medulla (A) as seen here and in Figures 10 and 11. For the untrained eye, the shield medulla is a better indicator of a pocket gopher vs. a mole.

[3] Taken from "Identification of the dorsal guard hairs of some mammals of Wyoming" Moore et al. 1974

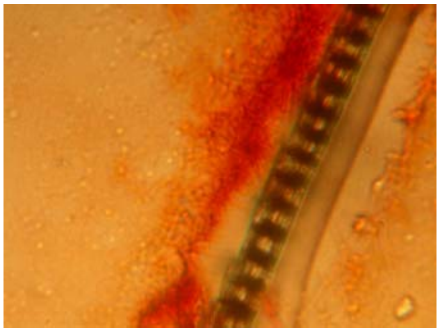
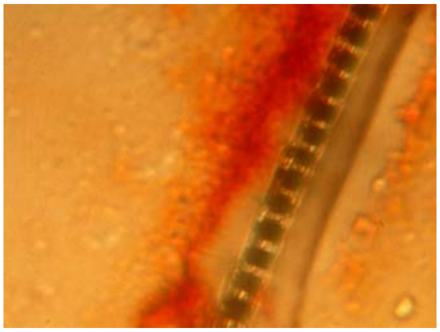
[4]Figure 10. Microscope Slides

Fossorial Mammals of the South Puget Sound:

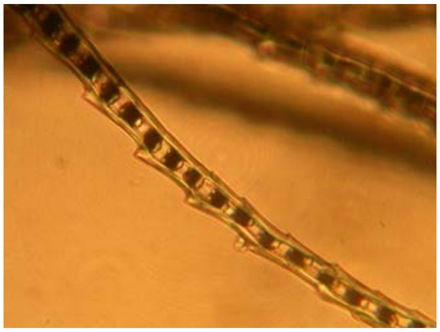
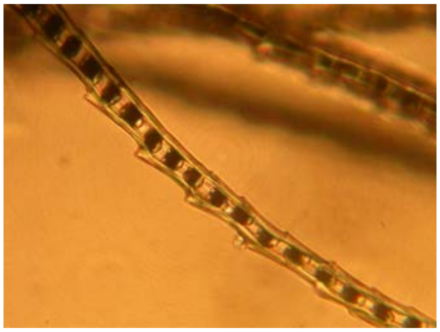
Basal medulla samples of the Mazama pocket gopher (*Thomomys mazama*)

Basal medulla samples of the Townsend mole (*Scapanus townsendi*)

Basal medulla samples of the Coast (Pacific) mole (*Scapanus orarius*)

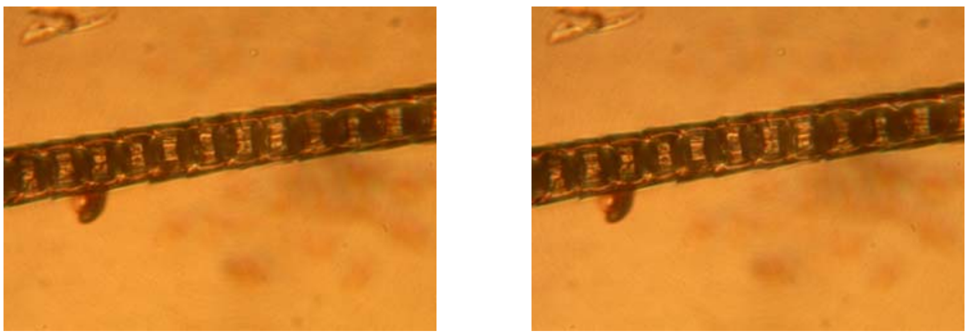
[4] Photos taken by Ladd Rutherford, TESC microscope lab

Figure 11. Microscope Slides[5]

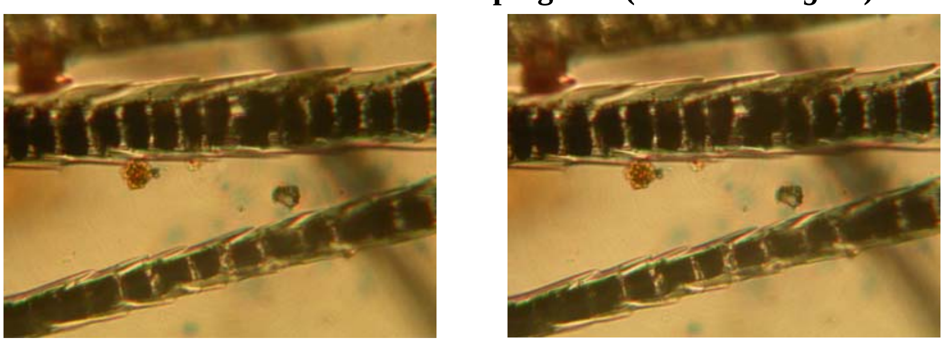
Some Burrowing Mammals of the South Puget Sound:

Again, there is a very slight difference in comparing basal medulla between species. The deer mouse and pocket gopher basal medulla seem similar. One then should compare other hair characteristics such as the length and the basal scales. The mice (Cricetidae) have irregular petal scales and gophers (Geomyidae) irregular-waved mosaic scales.

Basal medulla of the Deer mouse (*Peromyscus maniculatus*)



Basal medulla of the Creeping vole (*Microtus oregoni*)



[5] Photos taken by Ladd Rutherford, TESC microscope lab

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TABLE 1: HAIR COLLECTION MATERIAL TRIALS RESULTS

Table 1.1 Pre-Test: Collected Mazama Pocket Gopher Hair

Yes Or No

Hair Collection Material	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Scotch exterior tape	No	No	**Yes**	**Yes**	**Yes**
Pet tape	No	Yes	**Yes**	**Yes**	**Yes**
Velcro	No	**Yes**	No	No	No
Scotch clear tape	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Fly Paper	[6]Yes				
Wax strip	7Yes				
Pet Brush	No	No	No	No	No
Toothbrush	No	No	No	No	No
Blade	No	No	No	No	No
Brillo	No	No	No	No	No
Static cloth	No	No	No	No	No

Table 1.2 Quantitative Tests To Collect Mazama Pocket Gopher Hair

Yes Or No; Hair Number

Hair Collection Material	**Trial 1**	**Trial 2**	**Trial 3**
Scotch exterior tape	Yes 1 hair	Yes 2 hairs	Yes 10 hairs
Pet tape	**Yes >25 hairs**	Yes 5 hairs	Yes 10 hairs
Scotch clear tape	**Yes >25 hairs**	**Yes >25 hairs**	Yes 2 hairs
Velcro	No	No	No

Table 1.3 Qualitative Tests To Collect Mazama Pocket Gopher Hair

Yes Or No

Hair Collection Material	**Easy to see hair**	**Easy to remove hair**	**Easy to use in the field**
Scotch exterior tape	No	**Yes**	**Yes**
Pet tape	**Yes**	**Yes**	No
Scotch clear tape	**Yes**	**Yes**	**Yes**
Velcro	No	**Yes**	**Yes**

[6] Material too adhesive, posing risk to animals

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INTRODUCTION

Targeted Thesis Study Species

The Mazama (Western) pocket gopher (*Thomomys mazama*) is a small fossorial mammal of western Washington, western Oregon, and part of California. In Washington, the Mazama pocket gopher resides in the south Puget Sound prairie. However, this species, as well as other prairie species, may be declining in abundance due to habitat loss. The Mazama pocket gopher is the focus of this thesis.

Washington State's South Puget Sound Prairie Habitat and Prairie Species

The south Puget Sound prairie and oak woodlands are the result of continental glaciations that flowed over the northern half of Washington State over 15,000 years ago. The glacial outwash brought silt, rock, and gravel to the area, leaving a deep porous soil. The prairie plant community established itself in the warmer climate and quick-draining soil. Native Americans maintained the south Puget Sound prairie by burning the land to increase their food source of camas and game animals. Two centuries ago, prairie and oak woodland covered much of the south Puget Sound counties of Thurston, Pierce, Mason, Lewis, and Grays Harbor. Today approximately 3 percent of native prairie is left. Most of the prairie has been lost to farms and urban development, and the remaining prairie is being consumed by invasive species such as Douglas fir (*Pseudotsuga menziesii*) and scotch broom (*Cytisus scoparius*). Native prairie vegetation includes grasses such as native fescues – Roemer's fescue (*Festuca roemeri*). This prairie is also covered by wildflowers, including the state-endangered golden paintbrush (*Castilleja levisecta*); early blue violets (*Viola adunca adunca*); Oregon sunshine/woolly sunflower (*Eriophyllum lanatum*); chocolate lilies (*Fritillaria lanceloata*); purple asters (*Aster *ascendens*); Puget balsamroot (*Balsamorhiza deltoidea*); harvest brodiaea (*Brodiaea cornonaria*); Henderson's shooting stars (*Dodecatheon hendersonii*); common camas (*Camassia quamash*); and white-top aster (*Aster curtus*). The tree, the Garry (Oregon white) oak (*Quercus garryana*) is also a species in this habitat (The Nature Conservancy 2004).

Current prairie habitat can be found on the local military bases: Fort Lewis and McChord Air Force Base, and on two state-managed sites: Scatter Creek Wildlife Area and the Mima Mound Natural Area Preserve. Patches of prairie can also be found around the Washington towns of Tenino, Oakville, Rainier, Chehalis, Woodland, Littlerock, Yelm, Lacey, and Olympia. One such location is the Olympia airport. Loss of the south Puget Sound prairie habitat has resulted in a loss in bird, butterfly, amphibian, and small mammal species. [7]State candidate butterflies include the Taylor's (Whulge) checkerspot (*Euphydryas editha taylor*), valley silverspot (*Speyeria zerene bremneri*), and Puget blue (*Plebejus icarioides blackmorei*); the mardon skipper (*Polites mardon*) is endangered in Washington. State candidate prairie bird species include the Streaked Horned Larks (*Eremophila alpestris strigata*) and the Oregon vesper sparrow (*Pooecetes gramineus*). The state-endangered western pond turtle (*Clemmys marmorata*) inhabited important wetlands surrounding the prairie. And the small, prairie-dwelling Mazama pocket gopher is a federal and state species of concern.

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[7] A candidate species is defined in Washington Department of Fish and Wildlife Policy M-6001 to include fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive.

Some argue that the above species can be considered keystone species of the prairie environment. Keystone species have widespread impacts on the rest of the biotic community and the entire ecosystem. "The significance of a keystone species is often obscure until they are missing from an ecosystem. Because of the sheer numbers and potential importance of rare species, ecosystem managers should understand them better than they do" (Boyce and Haney 1997). Fossorial mammals, such as the Mazama pocket gopher, are good indicators of soil and vegetation health of the prairie environment. They are beneficial in soil aeration and plant distribution.

Inventorying and monitoring the south Puget Sound prairie species is essential to ensure their survival, as well as survival of the prairie habitat itself. Inventorying species populations helps to assess their abundance and determine how their distribution responds to changes in habitat and management practices. Inventorying of the Mazama pocket gopher is the focus of this thesis and will be discussed in detail. To monitor a target species, however, one must first learn of other similar species that may inhabit the area.

Fossorial and Burrowing Mammals of the South Puget Sound, Western Washington

Fossorial mammals are those mammals that dig and live most of their life underground in a burrow system. This underground lifestyle is not just to nest, but is maintained year-round; thus these mammals are not observed as often as other small mammals. The main taxonomic orders containing fossorial mammals include the order Insectivora and the order Rodentia. Many other burrowing animals may also use the runways of true fossorial mammals. Small mammals which may live in the same area as the Mazama pocket gopher will be discussed.

The order Insectivora is the insect eaters. In this order is the family Soricidae, which contains the shrews. Shrews nest in brush and other debris above ground, but may occasionally use runways of fossorial mammals. Also in this order is the family Talpidae, which contains moles. These are true fossorial mammals, living most of their life underground. Their presence can be detected by their above ground conical (volcano-like) mounds, which are usually arranged linearly. The moles have typical fossorial characteristics. The moles of the south Puget Sound prairie include the Townsend mole (*Scapanus townsendi*) and the Coast (Pacific) mole (*Scapanus orarius*). The Townsend mole has short black, velvet-like pelage, a streamlined body, heavy shoulders, and the external appendages are muscular, short, and close to the body. This mole has a long snout, short neck, and essentially naked tail; and the front feet are shovel-like, as wide as they are long, with large heavy claws. Head and body length is approximately 15 cm – 20 cm (6 – 8 inches) (Carraway et al. 1993). The Coast (Pacific) mole has a robust, depressed body, a conoidal and depressed head, small eyes and auditory meatus concealed in the fur, and pelage that is easily moved in any direction. The head and body length is approximately 12.7 cm (5 inches) (Hartman and Yates 1985.). [8]The order Rodentia contains many families. It is important to differentiate the mammals in this order because they are often confused with each other. The family Sciuridae contains ground squirrels, squirrels, and chipmunks, as well as woodchucks (also called groundhogs or marmots), other marmots (also called rockchucks), and prairie dogs. Except for tree and flying squirrels, which nest in trees, the other mammals in the squirrel family mostly nest above ground or in brush and debris; some may live in

[8] All references regarding the specific mammals are from the Peterson Field Guide of Mammals (1980), the Burke Museum (2004), and the National Wildlife Federation website: www.enature.com.

burrows in the ground. Most mammals of this family have a habit of sitting up on their haunches to see over low vegetation. If they do use burrow systems, they frequently come above ground and may have more than one opening and lookout post. The family Aplodontiidae includes the mountain beaver, also residing in western Washington. These mammals make extensive tunnels, runways, and burrows beneath dense streamside vegetation. Burrows are large, about 15.2 cm – 25.4 cm (6 – 10 inches) in diameter. The family Cricetidae contains mice, rats, lemmings and voles. Members of this family may live above or below ground. The south Puget Sound prairie, like most of the United States, is home to the deer mouse (*Peromyscus maniculatus*), which nests in burrows mostly above ground. Also in the family Cricetidae are the voles. The creeping (Oregon) vole (*Microtus oregoni*) is a species of the south Puget Sound prairie. This small mammal burrows through the duff on the forest floor or among the grass roots and seldom comes aboveground. [9]The family Zapodidae contains jumping mice. They have no external cheek pouches and have extremely long tails and large hind feet. The Pacific jumping mouse (*Zapus trinotatus*) is found in the south Puget Sound prairie. These small mammals can nest under grasses or beneath the surface. The family Geomyidae contains the Mazama pocket gopher, the subject of this thesis.

Pocket Gopher Distribution

Pocket gophers are distributed from Canada to Panama, including most of the United States, and across much of Mexico (Chase et al. 1982; Hafner and Hafner 1982). The three genera of pocket gophers found in North America include the Midwestern

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[9]All references regarding the specific mammals are from the Peterson Field Guide of Mammals (1980), the Burke Museum (2004), and the National Wildlife Federal website: www.enature.com.

pocket gopher (*Geomys* species), the Mexican pocket gopher (*Pappogeomys* species) (Hall 1981), and the Western [Northern and Mazama species] pocket gopher (*Thomomys* species).

The northern pocket gopher (*Thomomys talpoides*) is found on the crest of the Cascade mountains and very southwestern Washington, as well as across much of eastern Washington. The Mazama pocket gopher (*Thomomys mazama*) is found in western Washington, around the south Puget Sound, and also in western Oregon and California (Hall, 1981).

The Mazama pocket gopher's generic name Thomomys was derived from the Greek "thomos" meaning "a heap" (probably in reference to mounds of earth produced in tunneling) and the Greek "mys" meaning "mouse" (probably in reference to the somewhat mouse like body shape) (Jaeger 1955).

T. mazama is listed as a federal and state "candidate species[10]" because of their population decline due to habitat loss. The pocket gopher's historic range includes prairie habitat in Pierce, Thurston, Mason, Wahkiakum, Clallam (Hall 1981), and possibly other areas in Washington. However, urban sprawl, vegetation succession with the elimination of fire, and other prairie habitat losses have led to significant decline in this pocket gopher's population and possible change in range. Witmer et al. (1996) speculate that extensive deforestation in the south Puget Sound area has altered the distribution of *T. mazama;* populations are now more widespread.

[10] A candidate species is defined in Washington Department of Fish and Wildlife Policy M-6001 to include fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive.

Pocket Gopher Biology

Pocket gophers are members of the rodent family Geomyidae. Their common name is derived from the external, fur-lined cheek pouches possessed by all geomyids. These pouches are used to transport plant material to and from caches, which are used for food storage when fresh vegetation is not readily available. All pocket gophers are fossorial herbivores that are active year round (Huntley and Inouye 1988). These mammals are solitary and will vigorously defend their territories. However, burrows are occupied by more than one animal during a breeding season (Hansen and Miller 1959). Pocket gophers are made for their fossorial lifestyle with a body that tapers from a muscular head to narrow hips. The forefeet have a long tapering claw on each of the ten toes, which are used for digging, while the five toes in the rear have shorter claws (Bailey 1915). Pocket gophers have small eyes and ears, and their lips close behind their large rootless, ever-growing incisors to burrow without getting soil in their mouth (Chase et al. 1982; Verts and Carraway 1998 and 2000). Pocket gophers live approximately one year but can live up to five years (Chase et al. 1982).

The color of the Mazama pocket gopher depends on the subspecies, but ranges from black to different shades of red, yellow, and brown (Baily 1915; Dalquest and Scheffer 1942a; Taylor 1919). The nose and face are usually darker, while the chin, feet and tip of tail are lighter gray, and the chest usually contains white splotches (Bailey 1915). The tip of the tail may be naked or nearly so (Dalquest and Scheffer 1942a). This tail is highly sensitive, thought to assist in navigation of their burrow systems (Howard and Childs 1959). Witmer et al. (1996) found that in Washington, body mass, length of tail, and length of ear differed between females and males. Total body length ranges from 94 - 214 (7.6 – 8.4 inches) (Verts and Carraway 1998). The young are approximately 152 mm (6 inches). On the average, gophers are 50 cm (2 inches) in diameter.

Mating in pocket gophers occurs sometime during February through May. Witmer et al. (1996) states, “During March, while live trapping animals…we caught two adults in each of several burrow systems, indicating the mating season was underway, as has been noted by others [including: Marsh and Steel 1992; Teipner et al. 1983]. Johnson and Benson describe the breeding season to be April and May. Litter sizes reported in the literature average about 5, but range from 2 – 8 (Chase et al. 1982; Ingles 1965).

Pocket gophers are herbivorous rodents that consume both below and above ground vegetation. They do not hibernate, like other rodents, but are active year round (Johnson and Cassidy 1997; Williams et al. 1986; Chase et al. 1982; Andersen and MacMahon 1981). Pocket gophers forage above ground near burrow openings for vegetation, or pull the vegetation down from inside their burrows, consuming roots or entire plants (Howard and Childs 1959; Miller 1957). An example of above ground feeding is given by Maser et al. (1981) in his discussion of the Mazama pocket gopher: “While aboveground, *T. mazama* stays close to its opening to the burrow, cuts vegetation, loads its cheek pouches, and quickly disappears below ground. It commonly reappears later and repeats the process”. Burton and Black’s (1978) study of *T. mazama* feeding habits in south-central Oregon during 1973 and 1974 showed stomachs from 110 Mazama pocket gophers contained 31 species of plants. Grasses contributed most of the diet in the winter (60.5% in January) and least in summer (16.5 to 17.4% in July) whereas forbs contributed most in summer (41.7 – 60.4% in July) and least in winter (4.1% in March, 7.1% in December). Woody plants contributed the most in the winter (6.2% in January) and least in the summer (trace – 1.6% in July and September). Roots comprised

11.2 – 44.2 % consumed with the greatest amount in the fall and spring. Overall, use of various species of plants as food corresponded closely with their phenology and abundance. In July, when all types of vegetation were available, *T. mazama* consumed forbs (Burton and Black 1978). Food caches of burrow systems excavated in an orchard in western Washington from February through April 1992 and in April 1995 contained root cuttings of either thistle or scotch broom (Witmer et al. 1996).

Witmer et al. (1996) tracked home ranges of adult Mazama pocket gophers between February and April 1992 and April 1995 in Lacey, Washington, using radio telemetry. Areas ranged from 73 to 143 square meters (an average of 108 square meters) for males and from 47 to 151 square meters (an average of 97 square meters) for females. From examining burrow systems, population density was estimated to be 10 gophers/hectare (Witmer et al. 1996). Home ranges are generally smaller in better quality habitat (Chase et al. 1982; Marsh and Steele 1992). More studies are needed on the home range of gophers.

Benefits of the Pocket Gopher

Pocket gophers may play important roles in soil aeration, soil mixing, and soil drainage (Chase et al. 1982). They may also help increase primary plant production and soil nutrients (1980; Grant and McBrayer 1981). In a Cedar Creek Natural History Area (Minnesota) study of the plains pocket gopher (*Geomys bursarius*), overall plant diversity (species richness) was significantly higher on or near gopher mounds; the average increase per 1 x 0.5 meter plots ranged from 4.7% to 47.8% more plant species (Huntley and Inouye 1988). Pocket gopher mounds may retard evaporation, thus enhancing plant growth by improving plant water balance. Although there isn't significant data regarding soil moisture of the vegetation buried under mounds, Williams et al. (1986) observed that the mounds tend to form a mat which, in combination with the added layer of soil, may reduce evaporation of water from the soil under the mounds.

Pocket Gopher Mounds and Burrow Systems

In constructing tunnels, pocket gophers move soil to the ground surface and deposit it in piles called mounds (Huntley and Inouye 1988). The typically crescent-shaped mounds are produced when excavated earth is pushed from the tunnel opening onto the surface. Pocket gophers, unlike other rodents, aggressively maintain sealed entrances to their burrows. This plugged entry can usually be found in the concavity of the crescent-shaped mound, close to the edge of the mounded soil (Dalquest 1948; Walker 1949). Pocket gophers tend to produce more mounds during early spring and late summer to autumn (Cox and Hunt 1992). Mounds production also depends on the amount of space (habitat) each gopher has to construct its tunnel systems. Scale needs to be taken into account when looking at pocket gopher populations and spacing of their mounds (Anderson 1987b; Brett 1991; Heth 1992).

Pocket gopher mounds can be distinguished from those of other fossorial mammals, such as mole mounds. The mound structure difference is shown in Figure 1. Moles push soil up from vertical shafts, creating volcano-like mounds. In comparison, the pocket gopher mound is usually a fan-like shape made of processed dirt. The mound of the pocket gopher is a dump of excavated earth, brought to the surface for disposal, with a considerable diversity of pattern (Scheffer 1948). It is a pile of soil pushed to the surface of the ground as the gophers feed and develop or extend their underground burrow systems (Reid et al. 1966). Pocket gophers push loosened earth with their head and shoulders through the tunnel and out the short lateral exit. At the exit, the pocket gopher may only flip the dirt out or, as the dump grows, it must venture forth and dispose of it as the immediate situation requires (Scheffer 1948). However, Scheffer also states, “In low, wet lands, as observed in some parts of the Willamette Valley in springtime, these [pocket gopher] mounds are heaped in form somewhat like a rounded, truncated cone, with an open crater at the top, instead of the usual earth plug. It may be surmised that this arrangement is both for aeration and exclusion of surface water.” Another difference between pocket gopher and mole mounds is the mound distribution. Mole mounds are spaced along the burrow allowing for the tracing of burrows by surface observation. In contrast, gopher mounds are irregularly spaced and the course of the burrow cannot be traced simply by observing the arrangement of the mounds (Dalquest 1948).

Pocket gophers dig and maintain discrete underground burrow systems, in which they spend most of their lives (Howard and Childs 1959), or a gopher may take over a burrow system of a neighbor that has moved or died. Burrow systems serve as a foraging base, food storage, nest, and waste deposit (Reichman et al. 1982). The burrows also serve as protective residences (Howard and Childs 1959). Each burrow system is an exclusive area that varies with the size of the individual, soil type and the available plants (Davis 1938). The horizontal feeding tunnels usually lie within a few inches of the ground and lead to lateral tunnels which terminate at the surface in typical excavation mounds (Miller 1957).

Walker (1949) describes burrows as approximately 3.8 – 4.4 cm in diameter and 10 – 15 cm beneath the surface, with a vertical tunnel to deeper burrows that include the nest. Witmer et al.’s (1996) study of the Mazama pocket gopher found that many burrow systems were located in the top 25 cm of soil, but deep burrows averaged 141 cm in depth. These deep burrows may provide important refuge during inclement weather and may help drain the burrow system during periods of heavy or prolonged rainfall (Teipner et al. 1983). Witmer et al.'s study also showed nests were, on average, 88.5 cm deep, 25 cm in diameter, 15 cm high, and lined with dry grass and often a few pieces of plastic and root cuttings. The food cache was typically found about 30 - 60 cm from the nest, and was 52.8 cm deep, 23 cm in diameter, 18 cm in height, and usually full of single type of root cuttings. Feces were deposited in nearby chambers (Witmer et al. 1996).

The Research Question

As mentioned above, the Mazama pocket gopher inhabits, and is beneficial to, the south Puget Sound prairie environment. Yet it is speculated that this small fossorial mammal is declining in abundance due to prairie habitat loss. "Little is known about the Mazama pocket gopher of western Washington and Oregon despite their economic importance and uncertain population and taxonomic status. The original work of Dalquest and Scheffer (1944b) still serves as the basic source of information on the species. It is apparent that more research is needed to determine the distribution and status of subspecies of western pocket gophers in the Puget Sound area" (Witmer et al. 1996).

To learn more about the Mazama pocket gopher, the first step is to verify its presence in an area. Biologists would like a simple way to do this. Current pocket gopher detection is done by trapping. This method, whether kill trapping or live trapping, is labor intensive, time consuming, costly, and may be lethal. And only a small percentage of animals are actually trapped. In trapping gophers, one is more likely to find a trap "plugged", a term used when the gopher fills in their burrow system or an opening with dirt. It is suggested that another detection of pocket gopher presence is by mound observations. This technique could provide a simple way to determine if the gopher is still in the prairie habitat it once occupied; however, this area is also often inhabited by moles and, as mentioned above, the mounds of these two fossorial mammals may look similar, especially in a wet climate.

It would be advantageous to use another method of determining pocket gopher presence in an area, with possible lower risk to the animal and more accurate. One procedure focuses on hair collection and identification. This method is discussed throughout the literature. Gurnell et al.'s (2001) paper, "Practical Techniques for Surveying and Monitoring Squirrels" shows that hair collection and species hair identification is possible with squirrels, and Gurnell and Pepper's (1994) paper, "Developing a Mammal Monitoring Programme for the UK", illustrates that hair collection and identification is used for many other mammals, including mice and shrews. Gurnell et al. used a PVC pipe device holding tape to collect hair when the mammal runs through the tube. They refer to this technique as an "indirect monitoring method" called "hair tube surveys" and state that while they are "not so accurate in assessing population densities, they [indirect methods] can be sufficiently accurate for monitoring purposes (Gurnell et al. 2001). The goal of this study was to develop a method of hair collection to verify Mazama pocket gopher presence in the south Puget Sound. A device and technique was developed to collect guard hair directly from a fossorial mammal passing through its burrow system. The hair collected could be identified under a microscope to aid in verifying the presence of *T. mazama* or determine if another fossorial or burrowing mammal is present instead. If the right techniques are employed, the collection of guard hair could specifically determine if either the Mazama pocket gopher or moles are on a site. Verifying the presence of *T. mazama* in an area could lead to further studies of this species, as well as possible prairie habitat conservation. A literature search shows hair collection techniques for small mammals, such as squirrels, but no method for the collection of fossorial mammal hair was found.

Collecting Mammal Hair for Identification

The collection of mammal hair for identification is appearing more often in current literature. One technique used to identify mammals includes examining their guard hair under a microscope and identifying to genus and species. This is done by observing the hair's color, length, and scales, as well as cutting the hair lengthwise and looking at the cortex and medullary configuration (Moore et al. 1974). This technique is used in forensic laboratories for identification of wildlife evidence, in identifying the composition of avian pellets to examine their diet, and to compare similar mammals, such as lynx and bobcats. Milnus (2003) describes hair snagging techniques for bear used through the 1990s by Taberlet, McLellan, Paetkau, and Proctor.

Among the literature throughout the years, describing the above technique of microscopic identification of mammal hair, is Hausman's (1920) paper, "Structural Characteristics of the Hair of Mammals"; William's (1938) paper on "Aids to the Identification of Mole and Shrew Hair with General Comments on Hair Structure and Hair Determination;" and Mathiak's (1938) paper, "Key to Hairs of the Mammal of Southern Michigan." Many state wildlife agencies also use microscopic hair identification, such as the Wyoming Game and Fish Department (Moore et al. 1974), whose identification key, "Identification of the Dorsal Guard Hairs of Some Mammals of

Wyoming," is still used today. Dagnall et al. (1995) also describes techniques for preparing hair samples for microscopic examination.

Why collect fossorial mammal hair, especially Mazama pocket gopher hair?

Developing a technique to collect hair from fossorial mammals may verify presence before initiating other studies. Specifically for the Mazama pocket gopher, collecting their hair and positively identifying presence may lead to south Puget Sound prairie species and habitat conservation and protection.

MATERIALS AND METHODS

STUDY AREA

The Mazama pocket gopher live trapping and field experiments were conducted at the Olympia Regional Airport, Olympia, Washington and surrounding lands. Controlled experiments were conducted at the USDA Wildlife Services (NWRC) facility and farm, just south of the airport.

The Olympia airport is located in Thurston County at T17N, R2W, and Section 14 (Figure 4). The airport has been owned by the Port of Olympia since 1963. Local commercial aviation goes back to the 1920s. It is home to aircraft service operations, hangars, corporate offices, and a modern public terminal. The airport consists of two runways. The primary runway is 45.72 meters (150 feet) wide, by 1651.1 meters (5,419 feet) long and the secondary runway is 45.72 meters wide by 1267.05 meters (4,157 feet) long. The airfield elevation is 62.8 meters (206 feet) mean sea level (The Olympia Regional airport/Port of Olympia). The overall acreage of the airport is 835 acres, with 486 acres available for development. The airport contains mainly grasses.

Olympia is in a Western Hemlock (*Tsuga heterophylla*) vegetation zone (Franklin and Dyrness 1973). However, Douglas fir (*Pseudotsuga menziesii*) is dominant. The elevation is approximately 50 m above mean sea level and receives approximately 90 cm (20 – 60 inches per year) of precipitation annually. The soil at the airport is of a Tumwater gravelly-sandy loam, derived from glacial outwash.

Experiments were conducted to test hair collection materials, to test a device to hold the material, and to establish a technique to collect guard hair from fossorial mammals while in their burrow system. All small mammals in the experiment were handled and/or detained in accordance with the USDA Wildlife Service approved standard optional procedures and proper care.

<u>Experiment 1: Initial Materials Suitability Screen</u>

To complete the hair collection materials experiment, live pocket gophers were trapped in a modified Sherman box trap with a mesh bottom and one mesh end. The traps were set at the Olympia airport July through October 2004. Areas of the airport that were readily accessible for trapping were focused on; these included eastern, southern, and western outskirt airport locations (Figure 4). At each site, traps were set underground beside "fresh" pocket gopher mounds, as determined by very dark, newly disturbed soil. Two traps were placed end to end in each burrow system to trap gophers coming from either direction. Black plastic was placed on top of the trap. The trap and plastic were then completely covered with soil.

When a gopher was found in a trap, the site location was recorded by GPS, gopher length was recorded, and the gopher's hind feet/nails were marked with red fingernail polish. This marking lasted about a week to indicate if the trapped gopher had already been captured that week or not. No recaptures were detected. The gopher was sent through the test runway to see if the hair collection material collected hair. If the small mammal went through the test and no hair was collected, a different test material was interchanged and the gopher was run through again. If hair was collected, the animal was placed back into the burrow system it was trapped from. In addition, if the animal was stressed or wouldn't run through the tubes, it was also placed back in its burrow system.

The test runway consisted of an entry point box; a clear PVC tube 44.5 cm (17.5 inches) in length and 5 cm (2 inches) in diameter; a second clear PVC tube, 15.2 cm (6 inches) in length and 5 cm diameter, with the rectangular hole cut out on top; a third clear PVC tube 44.5 cm in length and 5 cm in diameter; and an exit goal box. All PVC tubes and the goal boxes were attached with tube couplings (Figure 7).

Each test hair collection material was affixed to a 3.8 cm x 5 cm (1.5 inch x 2 inch), 1.9 cm (0.75 inch), thick wooden block affixed to a larger rectangle of 6.4 cm x 7.6 cm (2.5 inches x 3 inch), 0.6 cm (0.25 inch) thick plywood (Figure 7). The wooden block was sanded smooth and then pushed into the runway's middle PVC pipe with an appropriate 6.4 cm x 3.8 cm square hole cut for the block. The square hole in the pipe allowed for quick interchange of blocks with different test hair collection materials.

A) Mazama pocket gophers from the Olympia airport were used in the pre-test of the hair collection materials. The eleven pre-test hair collection materials included Scotch double-sided exterior mounting tape, Evercare Pet Hair Pic-Up adhesive roller, self warming eye brow hair waxing tape strips, Scotch permanent double-sided tape safe for photo, Enoz Fly Traps, metal pet hair brush, toothbrush, Velcro extreme, Stanley Surform replacement small metal blade for removing paint, Brillo pad, and Swiffer static cloth. Five pre-tests were conducted for each material on Mazama pocket gophers (Figure 5).

B) Mazama pocket gophers from the Olympia airport were used to test the successful hair collection materials in the pre-test experiment. This final test was performed 3 times on each hair collection material. Quantitative information regarding the number of hairs obtained on the material were recorded and kept for microscopic hair identification. Qualitative information that was recorded included how easily the hair was seen on the hair collection material, how easily the hair was removed from the hair collection material, and how easily the hair collection material was used in the field (Figure 5).

Experiment 2: Control Testing of the PVC Hair Collection Device

The most effective hair collection material on the block, per Experiment 1, was inserted into a black PVC pipe a length of 7.62 cm (3 inch) with a 7.62 cm diameter and an appropriate 6.35 cm x 3.81 cm rectangular hole cut in the top for the hair collection material and block. The bottom of the PVC pipe was cut out to expose a natural soil bottom when placed in an underground burrow system (Figure 7).

A) The hair collection device was tested in a glass walled soil enclosure (a large ceiling-to-floor "ant farm"). The chamber is approximately 2.5 meters deep x 18 cm wide x 4 meters long. The top 0.5 meter of the chamber is constructed from slick metal to prevent escapes. The surface is exposed to natural light, supplemented by grow lights for the planted grass and carrots, which serve as food sources for the gopher. The bottom 2 m of the chamber is made of glass to permit observation of burrows and animal activities. The bottom of the chamber is enclosed within a sealed room illuminated by red light. The red light enables an observer to study the animals with minimal disturbance. Carrots and grass were planted in the chamber before the pocket gopher was introduced. The pocket gopher was given one week to establish itself and create burrows in the fossorial observation chambers.

After one week, the PVC hair collection device with the block/plywood and the best hair collecting material was installed in a top horizontal burrow system created by a pocket gopher in the chamber. The PVC device was covered by black plastic and dirt. A red spotlight lit the hair collection device enabling better observation. Six video cameras monitored pocket gopher responses to the hair collection device. Each camera monitored a different area of the chamber. Taped videos were viewed, and gopher response to the device was recorded, specifically whether the gopher went through the PVC device and if the device collected hair. Three trials of the PVC device experiment were completed.

B) Pocket gopher responses were further assessed in four small outdoor open pens (2.5 m x 5-m). Approximately 0.5-m of soil covered the pen bottom, enabling pocket gophers to create their own burrow system. Soil in each open pen was sowed, raked, and watered; each pen was then planted with grass. Other vegetation added to each pen included two small planted pine trees, cuttings of hairy cat's ear (*Hypochaeris radicata L.*) and/or branches. After one month, one pocket gopher (four total) was introduced into each of the four separate pens. Pocket gophers were given one week to establish themselves and construct burrows before initiating testing of the hair collection device. One hair collection device was placed in each pen in a burrow system and covered with black plastic and dirt. The device was checked after a couple of days to determine if the PVC device collected hair.

Experiment 3: Field Testing of the Final Hair Collection Devices

A) The PVC hair collection device from Experiment 2 was placed in the burrow systems of seven pocket gophers at the Olympia, Washington airport. Again, the PVC device was placed inside each burrow system. Pieces of carrot or apple were placed under the device to attract the pocket gopher. The top of the collection tube was covered with black plastic to prevent light from entering and soil and vegetation cropped from nearby was placed on top of the plastic. Each PVC device was checked to see if the gopher ran through the device and if hair was collected.

B) The block/plywood piece (Figure 7) from the previous experiments was tested alone without the PVC device. The block/plywood piece was then modified with screws on all sides and was placed in dug out burrow systems with the screws shoved into the top layer of dirt of the burrow to secure it. This device was tested to see if it would collect hair but be less intrusive than the PVC device. This hair collection block was tested in five different pocket gopher burrows in the field.

C) The block/plywood device used throughout the experiment was attached to a 7.6 cm x 7.6 cm (3 inches) square piece of hardware cloth to test as another possible hair collection device. The piece of hardware cloth was 1.3 cm (½ inch), galvanized 19 gauge mesh with the measurements of 7.5 x 8 inches; 16 squares x 15 squares. The block was fastened in the middle of the piece of hardware cloth by one 1.9 cm (¾ inch) galvanized poultry net staple. The block hung down into the dug out underground burrow system and was suspended from the square piece of hardware cloth which rested flat above ground, and was covered with black plastic, and then covered with soil. Each hardware cloth device was checked to see if the device collected hair.

Hair Collection and Hair Slide Observations

Hair was collected from Experiment 1, as well as from known mammal [11]specimens. The entire hair collection material (clear tape) was put directly on a slide and the whole hair was examined under a 400X microscope. Known hair samples were placed on a slide and looked at, as well. The slides were stained with a mixture of 1 part

[11] Hair samples from old Burke Museum specimens.

food color to 3 parts water to help enhance the image of the elongated hair. The whole hair was examined. The different mammal species' hair from the field and the known hair samples, were compared with those from the literature. A visual identification key of the mammal hairs was made (Figures 10 and 11).

RESULTS AND DISCUSSION

Small Fossorial and Burrowing Mammals of the South Puget Sound

A literature review identified the prairie fossorial mammals of the south Puget Sound as the Mazama pocket gopher, the Coast (Pacific) mole (*Scapanus orarius*), and the Townsend mole (*Scapanus townsendii*). Small prairie burrowing mammals that would most likely use the burrow systems of these fossorial mammals include the creeping vole (*Microtus oregoni*), the deer mouse (*Peromyscus maniculatus*), the Pacific jumping mouse (*Zapus trinotatus*), and the Townsend chipmunk (*Eutamias townsendii*). In addition, the short tailed weasel (*Mustela erminea*) might hunt for prey in the burrow systems. Any other small rodent could use the burrow system, but were less likely to do so than those mentioned above.

Experiment 1: Initial Materials Suitability Screen

The hair collection material pre-test showed double-sided exterior tape and pet tape collected hair in three out of five trials, and Scotch clear double-sided tape collected hair in five out of five trials. Velcro collected hair in one out of five trials. All other materials did not collect hair in any of the trials (Table 1.1). The final hair collection material quantitative test of three trials each showed the double-sided exterior tape collected one, two, and ten pocket gopher hairs; pet hair tape collected greater than twenty-five, five, and ten hairs; and clear double-sided Scotch tape collected greater than twenty-five, greater than twenty-five, and two hairs. Velcro failed to collect hair (Table 1.1). The final hair collection material qualitative tests showed the double-sided exterior tape collected hair, but the hairs were difficult to see on the gray tape. This tape was somewhat easy to remove hair from and was easy to use in the field. The pet tape collected hair and the hair was easy to see on the white tape. Hair was somewhat easy to remove from this tape, but it was difficult to use in the field. The clear double-side Scotch tape collected hair, and the hair was easy to see on the clear tape. Hair was easily removed from this tape, and it was the easiest to use in the field. The Velcro had the ability to collect hair, but it was difficult to see the hair on gray Velcro. This material was easy to remove hair from and was easy to use in the field (Table 1.1).

Experiment 2: Control Testing of the PVC Hair Collection Device

The PVC hair collection device failed to collect hair in the glass walled soil enclosure, as well as the four outdoor pens. The gophers' response for all trials was to "plug" the device.

Experiment 3: Field Testing of the Final Hair Collection Devices

All three hair collection devices did not collect hair. The response of the gopher was to "plug" the PVC hair collection device and the block/plywood hair collection device in all trials. During the trials of the hardware cloth/block hair collection device, the device was plugged four out of seven times.

Hair Collection and Hair Slide Observations

The microscopic hair identification was possible with a 400X microscope. Hairs were identified by looking at the elongated hair's medulla, the cells comprising the inner core of the hair. The hair of the Mazama pocket gopher, Coast (Pacific) mole, and Townsend mole were compared, along with the deer mouse and the creeping vole.

Discussion on each experiment:

<u>Experiment 1: Initial Materials Suitability Screen</u>

Eleven materials were tested to determine the best material to collect hair. Suggestions for these materials were derived from input given by members of the biological community, as well as the literature. The experiments using the proposed hair collection materials of fly paper and eyebrow waxing tape were stopped after the first trial because the materials were too adhesive and posed a risk to the animals.

The color of the hair collection material was important, as it was difficult to see the brown/gray gopher hair on a gray surface such as the double-sided exterior tape and Velcro. The hair collection materials that were double-sided were easier to use in the field than those materials that had to be affixed to the block by another adhesive substance.

The clear double-sided Scotch tape was obviously the optimum hair collecting material and is similar to the material used in the literature for collecting squirrel hair in hair tube surveys of Gurnell et al. 2001. The typical Scotch tape on a roll rips off easily, making it easy to use in the field. Also, the whole piece of clear tape can be placed on a slide to observe the hair under the microscope without having to remove the hair from the tape, saving time.

<u>Experiment 2: Control Testing of the PVC Hair Collection Device</u>

Black PVC was used as a less obtrusive color, and the bottom of the pipe was cut off to allow a more natural dirt bottom. A PVC pipe diameter of 7.6 cm (3 inches) was used to allow enough room for the hair collection block and material to hang down and for the device to be pushed into the bottom of the burrow system, with 5 cm (2 inches) of room for the gopher or mole to squeeze through and leave hair samples. The glass walled soil enclosure experiment showed the device not collecting hair and also showed the gopher's response of "plugging" the device. The open pen experiments confirmed this in an outside controlled environment.

Experiment 3: Field Testing of the Final Hair Collection Devices

The PVC device in the field showed the same results as in the controlled environment, leading to the construction of another device to collect hair from inside the burrow system.

A hair collection device solely using the block/plywood piece was tested. This block would often fall into the burrow, depending on the above ground hole one dug out into the burrow system. The block device was modified to include screws protruding from all four sides to push into the dirt and hold the device better. This also proved to be unstable and was too intrusive for the gopher, in that this device was always "plugged".

The final hair collection device with the block/plywood piece attached to a square piece of hardware cloth was easy to construct, easy to use, and less intrusive. This device was still "plugged" often; before being discounted, however, this device deserves more study.

The hair collection device was also thought to possibly collect other hair from small mammals of the south Puget Sound, such as the deer mouse and the creeping (Oregon) vole. However, it was determined that these burrowing mammals, which may use pocket gopher or mole burrows, are too small to collect hair from with the same size device used for the fossorial mammals.

Hair Collection and Hair Slide Observations

Land mammals typically have three types of body hair: guard hair which gives the mammals' characteristic appearance, a fine undercoat for insulation, and giant hairs which resemble guard hair but are few and larger. The samples collected are guard hairs and can be identified under a microscope to species as belonging to species shown in the literature. First observation of the hair by the naked eye should include texture and color. Pocket gopher guard hair is readily collected from the rear, and has a downy sort of texture. The Mazama pocket gopher can range in color from shades of black, brown, red, and gray. Mole hair is harder to collect, in that it is coarse and does not pull out of a mole's body as easily as a pocket gopher. This is especially true with the Townsend mole. Mole hair is a gray to jet black. The hair of other small mammals, such as the vole and deer mouse, seems to be easily collected and also comes in different colors.

[12]When examining hair under a microscope, one should look at the hair length, hair color bands, hair shape, and the different hair structures including the different medulla configurations, shield shapes and shield medulla, and scale patterns (Figure 8). The medulla is the central portion of the hair composed of a series of discrete cells or a spongy mass and is the main portion examined (Figure 8). The medulla can be seen in a piece of whole hair under a 400X microscope on a slide. Cross sectioning of the hair

[12] Taken from "Identification of the Dorsal Guard Hairs of Some Mammals of Wyoming" Moore et al.1974.

offers a more extensive examination and helps determine the different species; however, this examination takes skill in dissecting the hair correctly.

Looking at the whole hair, the medulla configuration (whether fragmented, uniserial vs. multiserial ladder, broken vs. unbroken configurations, etc.) and the medulla width are used in comparing hair samples (Figure 8). All the hair sample slides (Figures 10 and 11) show a basal medulla with a uniserial ladder configuration. The basal medulla is not an easy indicator when comparing gophers, other rodents, or moles for the inexperienced eye.

One should also look at the shield shape and shield medulla. Mole hairs are distinguished by having a spatula shaped shield, but the medulla within the shield is usually absent (Figure 8). Pocket gophers usually have the same spatula shaped shield, but the medulla is present within the shield. This presence or absence of the shield medulla is an obvious key to comparing gopher and mole hair under a microscope.

Still one should look at the scale patterns when comparing species' hair. Pocket gopher (Geomyidae) hairs are hard to separate from other rodents, such as deer mice (Figure 11). To identify gopher hair to species, one should look at the irregular-waved mosaic and double chevron cuticular scale patterns (Figure 8) in the basal region.

<u>**Gopher Live Trapping, Mounds, and Burrow Observations**</u>

To perform the hair collection material experiments, pocket gophers were live trapped. With this came many observations on trapping and on gopher mounds and burrow systems.

Gopher mounds, in general, are known by their "low to the ground" mound with a plug (dirt covering the exit hole) on the mound's margin (Figure 2). This plug is sometimes very obvious and is round like a baby food jar lid, yet other plugs are more difficult to observe. Gopher mounds are different than mole mounds in that mole mounds are almost completely round and conical in shape, peaking like a volcano (Figure 2). Mole mounds have a plug at the very peak of the mound and when the mound is probed the burrow system runs right under the mound.

The literature describes gopher mounds as having a crescent or "C" shape. Although this is true, crescent shaped mounds were not the most abundant mound observed at the Olympia airport. Most of these mounds were cloud shaped (Figure 3). Usually there were several mounds in a group and one tended to be a perfect crescent mound, while the others were the cloud shaped (not completely circular and peaked like a mole mound, however). Again, the crescent shaped mound had a plug on the mound's margin. The cloud shaped mounds either had a plug on the mound's margin, or more frequently, the plug wasn't as obvious. In the indentations of the crescent mound and cloud shaped mound, a burrow system was found to the side. There were more indentations in the cloud shaped mound, and therefore more possibilities to look for an underground burrow system. The gopher burrow was found by probing the earth to the side of the mound with a rod until the rod went easily into the ground and then abruptly stopped. The burrow system was dug out. In many cases, especially with the crescent shaped mound, there was a "T" from the mound out to a burrow runway consisting of a runway passage along side of the mound (Figure 2). Two traps were set end to end in the runway, capturing the pocket gopher coming from either side. Sometimes there seemed to be more than one runway, but one of these either stopped or led to a dead-end (cache for food, feces, dirt etc.). It was also observed at times that there was a runway which seemed to continue one direction, but had a dead-end in the opposite direction; in this case, one trap was set. This was less frequent. The trap(s) were placed in the dug out underground burrow system and black plastic covered the trap. The black plastic was then completely covered with dirt to keep the trap cool, as the black plastic will heat the trap if left exposed, causing mortality of gophers. The covering of the trap with black plastic to block the light and above ground air flow was instrumental in capturing gophers (technique suggested by Dr. Nolte UDSA/APHIS/WS). The traps were checked every three to four hours. This was especially important during the very hot days in July and August.

The trap was often packed with dirt by the gopher. “Plugging” is the action of a fossorial mammal to fill an above ground opening, such as the plug at their mound (Figure 2), or at a disturbed site inside their burrow system when a foreign object is inserted, such as a trap. It was observed that gophers will plug a disturbance/object in their burrow system completely and construct a new runway under or around it. If there is an active gopher at the site, it was observed that it usually took two to four hours for the plugging to occur.

Mound identification was easiest in the dry summer months. It was also easier at this time to identify a fresh gopher mound by fresh, dark soil on the surface. However, when precipitation started in September, it was more difficult to locate fresh gopher mounds, as all of the mounds were dark from dampness and rain destroyed the shape of the mounds. A noted difference between gopher and mole mounds is their arrangement.

Mole mounds are usually arranged linearly, whereas gopher mounds are usually irregularly spaced. More studies are needed on mound and burrow observations, as well as on trapping.

More studies are also needed on the pocket gopher's home range. It was observed that two different gophers were trapped under two different mounds within 16 feet of each other (9/10/04, 2:00pm, Olympia airport office, UTM 10T: 0507835, 5202437 and 0507845, 5202437), yet other gophers were trapped far apart. The literature is vague on gopher home range size. This observation also poses more questions on the inter-connectiveness of burrow systems and the sociability of gophers, as they will fight each other to death if they meet. Disturbance and gopher response is still another aspect that needs more research. As previously mentioned, new mounds appear with the disturbance of trapping and also with the disturbance of mowing, building, tractors, and cows. Mounds seem to be constructed within a few hours after these disturbances. This observation might be advantageous to research concerning the destruction of Mazama pocket gopher habitat. Also, the seasonality, date, and time of the highest production rate of mound building could be studied more closely.

Hair Collection Device Observations

The experiments showed that the square piece of hardware cloth resting above ground fastened to the block/plywood piece with Scotch double-sided clear tape hanging down into the burrow system was the best hair collection device constructed. However, since no hair was collected with this device during the field trials, it is not concluded that the hair collection device is successful in collecting hair. Also, one cannot conclude that the device is better in detecting the presence of a pocket gopher than trapping.

A carrot was placed as bait under each device, and when the device was checked and there was still a carrot, it was assumed that there was no gopher activity at the site. Almost all hardware cloth/block device trials that weren't "plugged" with dirt had bait left behind, leading to the assumption that it wasn't that the device didn't collect hair, but rather that no gopher was at the site.

The problem with the devices tested is that they were too intrusive for the gophers in their burrow system. This was evident with the PVC device trials, as the device was "plugged" for all control and field trials. The PVC device was first tried and thought to work because it is shown in the literature to work for other small mammals. However, the use of this device also resulted in the "plugging" of the burrow system where it was placed. The other two devices hanging down from above ground into the burrow system were less intrusive, yet they were still "plugged". Another problem with the hanging hair collection devices is the different burrow diameters. Burrow systems near the surface averaged 12.7 cm (5 inches) in diameter. When burrow systems were greater in diameter or when the burrow system dramatically dropped deeper underground, the block did not hang down deep enough to scrape across the animal's back to collect hair. On average, in a burrow system with a depth of 12.7 cm or less, the 2.5 cm (1 inch) block was sufficient to collect hair from the gopher. The main advantage of all of the devices, besides being less intrusive than trapping to detect the presence of the gopher, was that the devices could be left in place for longer periods of time than a trap. However, it was found that it is advantageous to check the device after a day, in that if there was an active gopher present, the response to "plug" the device came approximately two to four hours after it was set.

What Is Next? Future Studies

More studies are needed to determine if using the hardware cloth/block hair collection device is more efficient than live trapping and if it is an effective tool in detection of fossorial mammal presence. A larger sample size and more replications are needed to determine if the device works to collect hair. Also, more studies are needed on "plugging". "Plugging" seems to be a gopher characteristic, even though moles may also fill burrows with soil. The time frame ("plugging" after a couple of hours) and the compact nature of the "plugging" suggests gopher activity more than moles and should be considered, as well.

Recommendations

Mound observations may still be the best detection of Mazama pocket gopher presence. In the south Puget Sound, this is best done in the dry summer months. When trying to differentiate between mole and gopher mounds, one must study the characteristics of each type of mound, as well as realize that gopher and mole mounds may be close to each other, if not next to each other. Another option in detection of the Mazama pocket gopher is to combine all detection methods to completely verify presence. Mound observation, hair collection, and then live trapping may all be in order.

A skilled observer with limited time and resources can study how to differentiate pocket gopher and mole mounds. This should be done with care to only base conclusions on freshly created mounds and consider all the different mound characteristics. In instances where uncertainty remains, live trapping is still an option to consider.

The Mazama Pocket Gopher Status and Policy

Two centuries ago, prairies and oak woodlands covered much of the south Puget Sound in Washington State. Today, approximately three percent of native prairie is left. Most of the prairie has been lost to farms and urban development, and the remaining prairie is being consumed by invasive species. Loss of the south Puget Sound prairie habitat has resulted in a decline in prairie species, including the Mazama pocket gopher.

As with many south Puget Sound prairie species, the *T. mazama* is considered a "species of concern" by the Washington State Department of Fish and Wildlife (WDFW), the agency responsible for monitoring Washington's fish, wildlife, and habitat. A "species of concern" includes those species listed under the status categories of state endangered, state threatened, state sensitive, or state candidate. The Mazama pocket gopher is both a state and federal candidate species, which will be reviewed for possible listing as state endangered, threatened, or sensitive.

The Olympia, Washington Airport

The importance of prairie conservation of the south Puget Sound is evident in the species that need to be protected, including the Mazama pocket gopher. Much prairie habitat is being paved over by roads and buildings. Habitat that is actually available to preserve is located on military bases and airports. This is due to limited access to people. The Olympia airport is one such airport with prairie habitat.

It is recommended that the Olympia airport focus on future studies of its prairie community. A balance between the management of prairie vegetation and prairie species and commitment to the airport's goals and its future development is possible. Ongoing study of the different prairie species at the airport is recommended to determine possible strategies to address this balance.

The Mazama pocket gopher has a significant population at the Olympia airport. Further studies of gopher presence and distribution are needed. This could be accomplished by doing mound surveys during the active mound building months in late summer and early fall months. Hair collection may aid in concluding gopher presence. In addition, live trapping and marking gophers with pit tags could aid in an estimation of population numbers. The Olympia Regional Airport/Port of Olympia is open minded to a "win-win" situation between the management of the prairie and the airport. It is the positive and progressive attitude of businesses like this that allow our society to be able to enjoy both the environment and technology.

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