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Track Tube Construction and Field Protocol for Small Mammal Surveys with Emphasis on the Endangered Pacific Pocket Mouse (*Perognathus longimembris pacificus*)

Chapter 15 of
Section A, Biological Science
Book 2, Collection of Environmental Data

Techniques and Methods 2-A15

U.S. Department of the Interior
U.S. Geological Survey

Cover: Drawing depicting a Pacific pocket mouse inside of a track tube. Original cover illustration by Tristan Edgarian, U.S. Geological Survey.

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Area	
acre	4,047	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
ounce, fluid (fl. oz)	0.02957	liter (L)
quart (qt)	0.9464	liter (L)
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
	Area	
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
	Volume	
liter (L)	33.81402	ounce, fluid (fl. oz)
liter (L)	2.113	pint (pt)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)

Supplemental Information

Note to USGS users: Use of hectare (ha) as an alternative name for square hectometer (hm^2) is restricted to the measurement of small land or water areas. Use of liter (L) as a special name for cubic decimeter (dm^3) is restricted to the measurement of liquids and gases. No prefix other than milli should be used with liter.

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Track Tube Construction and Field Protocol for Small Mammal Surveys with Emphasis on the Endangered Pacific Pocket Mouse (*Perognathus longimembris pacificus*)

By Cheryl S. Brehme, Tritia A. Matsuda, Devin T. Adsit-Morris, Denise R. Clark, Jeremy B. Sebes, Melanie Anne T. Burlaza, and Robert N. Fisher

Abstract

Track tubes are used to identify small animals by their tracks. Animals that are small enough to fit into the tubes walk over ink pads and onto cardstock paper to obtain bait within the tube, leaving their footprints. The tracking tubes described in this document are designed to be set on the ground with free access and exit at either end with additional design components for stability, durability, and efficiency. They are also designed to prevent dirt from getting onto the ink pads and to decrease the ability of birds and other mammals to pull out track cards or bait.

We describe detailed methods for constructing, setting and checking track tubes, as well as measuring and identifying small mammal prints for a small mammal study. The protocols described are for monitoring the Pacific pocket mouse (PPM); however, this method can be applied to many small mammal species that have uniquely identifiable tracks in relation to co-occurring species.

We have deployed track tubes for over 5 years on Marine Corps Base Camp Pendleton for PPM discovery efforts and to monitor the three extant PPM populations on Base. We have shown that nightly detection probability is similar to that of live-trapping, but the track tubes can be checked weekly or bi-monthly. We use this passive and economical method to assess timing of annual emergence and torpor, seasonal activity, and localized colonization and extinction events. Using this method, we can model occupancy dynamics in relation to habitat and disturbance covariates that directly inform management and support a monitoring and management feedback loop for this species.

Introduction

Sampling for small mammals has largely relied on live trapping for many years to accomplish a wide range of research objectives including abundance estimation, occupancy estimation, reproductive and health assessments, and genetic analyses (for example, Kelt, 1996; Wilson and others, 1996; Schulte-Hostedde and others, 2001; Kaufman and Kaufman, 2015). Live-trapping can be costly, often requiring several visits for each “trap night” to open and bait traps, to check traps at night, and to check and close traps each morning (Sikes and Gannon, 2011). In areas with federally and state listed threatened and endangered species, live-trapping also requires specialized permits. However, this method may not be practical for sampling large areas or many populations of species, particularly when capture probabilities are low (Thompson, 2013). Some applications, such as initial discovery efforts, species presence, as well as density and abundance, may only require the positive identification of species (for example, MacKenzie, 2002; Stanley and Royle, 2005; Wiewal and others, 2007; Mackenzie and others, 2017; Evans and Rittenhouse, 2018). For instance, occupancy monitoring has been increasingly used as a more useful metric to monitor patchily distributed species with high fecundity, short generation times, and high dispersal ability while accounting for less than perfect detection probabilities. By increasing sample effort across the landscape and collecting habitat, environmental, and co-occurring species covariate data, these and other spatial models can also help us to better understand habitat suitability, meta-population dynamics, interspecies dynamics, and responses to ecological processes and management actions (for example, MacKenzie, 2006; Kalies and others, 2012; Miller and others, 2012; Fauteux and others, 2013).

In 2007, the U.S. Geological Survey (USGS), representatives from Marine Corps Base Camp Pendleton (MCBCP), U.S. Fish and Wildlife Service (USFWS), and a scientific review panel agreed that the live-trapping sampling methodology used for monitoring the endangered Pacific pocket mouse (PPM) (*Perognathus longimembris pacificus*) was time intensive, destructive to habitat, with a low probability of capture. This method also limited the amount of area that could be effectively surveyed in any given year, thus reducing the robustness of any spatial long-term trend indices. Because of this, we conducted a study to determine if an alternate accurate sampling tool or method could be developed that would increase probability of detection and cost effectiveness, as well as decrease negative effects to the species and its habitat. As a result, USGS designed track tubes as a cost effective and less invasive method for long-term monitoring of PPM (Brehme and others, 2010, 2011).

Track tubes are used to identify small animals by their tracks. Animals small enough to fit into the tubes walk over ink pads and onto cardstock paper to obtain bait seed, leaving their footprints. USGS track tubes are a modified version of those described by Mabee (1998), Glennon and others (2002), and Loggins and others (2010). They are designed to be set on the ground with free access and exit at either end with additional design components for stability, durability, and efficiency, to reduce the ability for dirt and water to get inside and onto the ink pads and to decrease the ability of large birds, squirrels, and rabbits to pull track cards out of the tubes.

We determined that checking and re-inking every 1–2 weeks results in a high probability of detecting PPM without the ink pads drying. As a cost comparison, 5–10 weeks of tracking tube surveys are equivalent in effort to approximately 2 nights of live-trapping (both requiring 6 visits). By monitoring over a longer period, the cumulative probability of detecting PPM at a site is significantly greater (Brehme and others, 2010, 2014, 2016). Close to perfect detection can be achieved over 2–5 weeks of sampling depending upon the number of track tubes deployed (Brehme and others, 2014, fig. 9). For PPM, we recommend placing at least one tube every 0.016 ha (12.5 × 12.5 m) which is commensurate with the core-use area of a single individual (Shier, 2008).

We have deployed track tubes for 5 years on MCBCP for both PPM occupancy monitoring and discovery efforts (Brehme and others, 2017). The cost savings in labor has allowed us to deploy and run thousands of tubes throughout the PPM active season across multiple populations. By monitoring continuously throughout the season, the track tubes can be used to assess annual emergence and torpor, seasonal activity associated with reproduction, recruitment, and localized colonization and extinction events. Using a large number of track tubes across the landscape also has enabled us to model PPM population dynamics in relation to habitat and disturbance covariates. The modeling results have directly informed habitat management and support a monitoring and management feedback loop for this species (Brehme and others, 2017). Track tubes do not allow for collection of demographic, reproductive, or health information; therefore, periodic live-trapping is performed in a small subset of core plots within each population site to obtain seasonal information on reproductive phenology.

Although the track tubes and protocols described in this report are designed specifically for PPM, this method can be applied to many small mammal species that have uniquely identifiable tracks in relation to co-occurring species. The track tube diameter should be selected to allow passage of target species and exclude larger species.

This protocol provides detailed instructions on constructing track tubes, setting and checking track tubes, and measuring and identifying small mammal prints for a small mammal study.

Track Tube Components

The track tubes described in this document are made of PVC pipe fitted with wood stabilizers. The track tubes contain track card bases with ink pads, removable track cards, and bait seed all secured by magnets or binder clips (figs. 1 and 2). The track tubes are made of standard 1 in. (2.5 cm) and 1-1/2 in. (3.8 cm) diameter schedule 40 PVC pipe cut to a length of 15 in. (38.1 cm). However, other diameters can be used depending upon the size of the target species. Diameters should be chosen to accommodate target species while excluding larger non-target species. For example, for monitoring PPM, a very small 6 g mouse, we use both 1 in. (2.5 cm) and 1-1/2 in. (3.8 cm) tubes. The 1 in. (2.5 cm) tube excludes most other medium and large rodents from the tube; however, PPM detection probability is slightly higher in the 1-1/2 in. (3.8 cm) tubes (Brehme and others, 2010). Use of both sizes ensures maximum detectability within any sampling area.

The PVC pipes are fitted with wooden stabilizers, which are routed, and glued to fit the contour of the edges of the tube. Stabilizers help to prevent the tubes from rolling, prevent most water, dirt and debris from getting in the track tube and ink pads, and lessen accessibility of the track cards to larger animals. Without the stabilizers, ink pads easily get clogged from dirt and debris which cause ink pads to prematurely dry and quickly become ineffective.

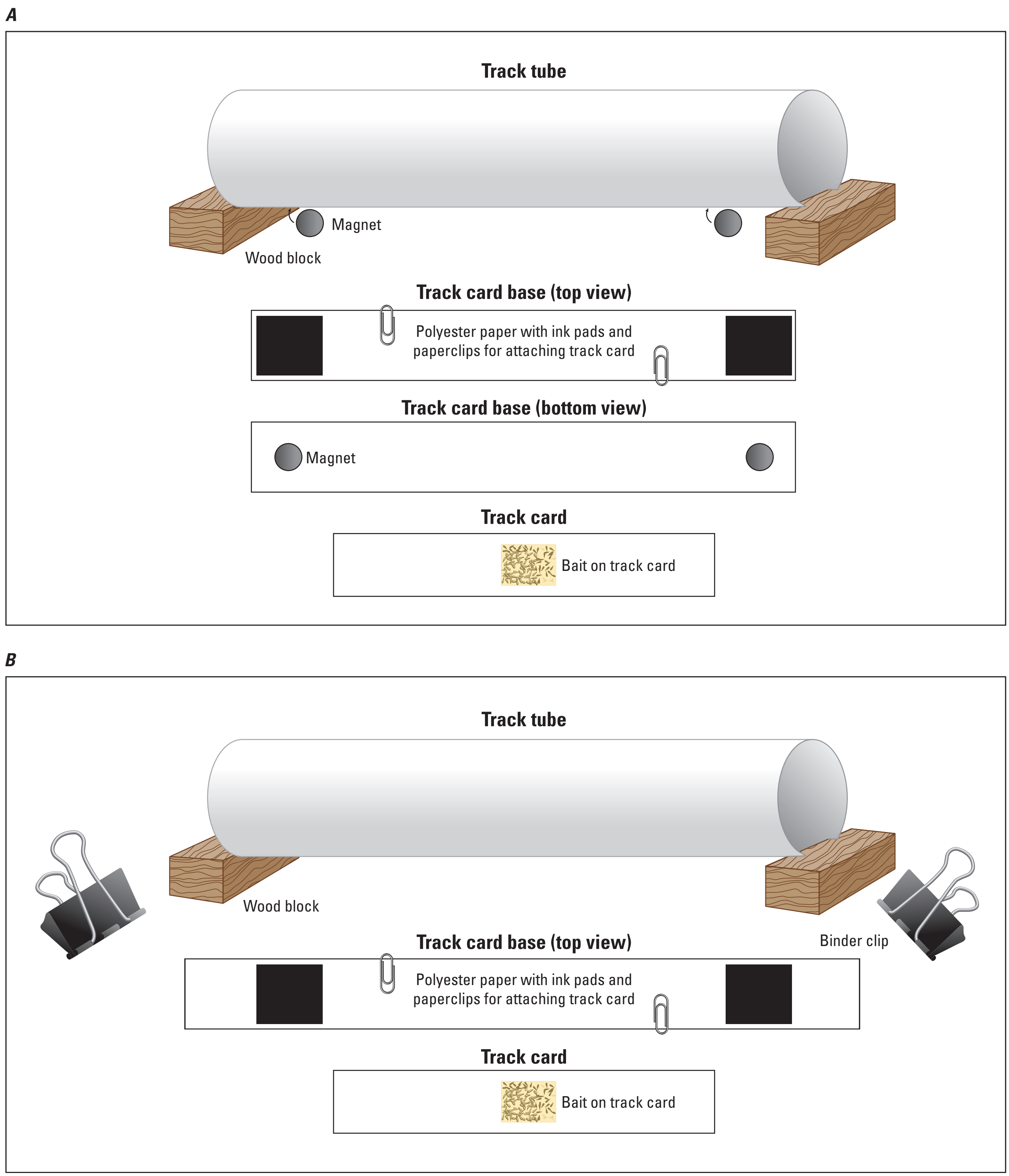

Figure 1. Track tube and components with (*A*) magnet (*B*) binder clip end treatments and components with magnet and binder clip end treatments.

Figure 2. Track tube and components with (*A*) magnet and (*B*) binder clip end treatments with magnet and binder clip end treatments.

In 5 years of using track tubes in the field, we found that ground foraging birds, woodrats, squirrels, and rabbits pull the track card bases and track cards out of the tubes to get to the bait seed, which reduces the probability of detecting target species. Initially, the track card bases were loose within the PVC tube and the addition of tube stabilizers reduced, but did not eliminate, the problem. As a result, we used strong Neodynium magnets attached to the track card base and outside of the tube to secure the track card inside (figs. 1*A* and 2*A*). This addition greatly reduced the frequency of cards being pulled out by other species. We have also had success using binder clips to secure modified cards to the track tube without affecting detection probability of PPM. We present this as an alternate and potentially less expensive method of securing the base cards (figs. 1*B* and 2*B*). However, the long-term durability of the binder clips in different environmental conditions has not been tested, and once set, the removal and re-attachment of the clips in the field is more time consuming than the magnets.

The inside components are similar to those described by Loggins and others (2010). Modifications include the use of durable waterproof paper as a base card to attach ink pads. Tracking cards are then placed on top and secured with paper clips. This allows us to use a single base card for an entire season and to simply re-ink the pads and replace the tracking card and bait during each check.

Track Tube Construction

Construction of the track tubes requires cutting PVC pipe to create tubes of proper lengths, making wood stabilizers with grooves to attach to the ends of the PVC tube, and gluing two wood stabilizers to each tube. We present several options that depend upon experience and the tools and materials available to the constructer. Wood stabilizers can be made from wood dowels or furring strips cut in half lengthwise and the grooves can be made using a drill press with nested saw bits or made freehand using a router. We highly recommend using personal protective equipment and reviewing and implementing safety procedures of the specific tools and machinery used, as described in OSHA Guidelines 3157 (1999, also available online at https://www.osha.gov/Publications/osha3157.pdf).

The materials and equipment needed for construction of track tubes are presented in table 1. Step by step instructions are provided for both 1 in. (2.5 cm) and 1-1/2 in. (3.8 cm) diameter track tubes, but the instructions can be applied to any sized tube to meet study design needs.

Cut Track Tubes

PVC pipes are generally available in 10 ft. (3.1 m) sections. PVC can be cut using a miter saw, hack saw or pipe cutters. If using a miter saw, tubes will be 14-7/8 in. (37.8 cm) in length because of the material lost with blade cut. If using a pipe cutter or hacksaw the loss in material with each cut may be negligible and tube length will be about 15 in. (38.1 cm). Cut eight 15 in. (38.1 cm) tubes from each 10 ft. (3.1 m) section.

Construct Tube Stabilizers

A completed, proper stabilizer should look like the example shown in figure 3*B*. Tube stabilizers can be made from 3/4 × 3/4 in. (1.9 × 1.9 cm) square dowels or a wood furring strip (table 1). Square dowels are available in 6 ft. (1.8 m) or greater lengths. Alternatively, 1 × 2 in. (2.5 × 5.0 cm) furring strips can be used and cut in half lengthwise. Furring strips are typically available in 8 ft. (2 m) or greater lengths.

1. If using furring strips, cut in half lengthwise using a table saw.
2. Along dowel or pre-cut furring strip, mark divider lines for stabilizer sections every 2-1/2 in. (6.4 cm) along the entire length of wood.
3. Trace minor arc within each 2-1/2 in. section using the outside of the PVC tube so that the upper arc is 1/4 in. (0.6 cm) from the edge of the wood (fig. 3*A*).
4. Cut out grooves to a depth of approximately 5/16 in. (0.8 cm) to 3/8 in. (1.0 cm) into the wood along the arc lines as described in sections, Drill Press Method or Router Method. We recommend to practice drilling a few holes in scrap wood before attempting to cut the stabilizer grooves.

Table 1. Materials and tools needed for construction of 1- and 1-1/2-inch track tubes.

[**Abbreviations:** PVC, polyvinyl chloride pipe; ft, foot; in., inch; –, not applicable]

Materials			
Item		**Purpose**	**Notes**
PVC pipe	10 ft × 1-1/2 in. (or 1 in.) schedule 40 PVC or appropriate diameter	1-1/2 in. tube body (or 1 in. tube body)	Cut into eight 15 in. sections
Wood stabilizer (using dowels or furring strips)	6 ft × 3/4 in.× 3/4 in. square dowels	For wood stabilizers that attach to body of tube	–
	8 ft × 1 in. × 2 in. wood/furring strip	For wood stabilizers that attach to body of tube	–
Glue	Liquid Nails® (polyurethane glue)	Gluing wood blocks to PVC body	–
Storage Bin	18 gallon storage bin	Storage of tubes	–
Tools			
Item		**Purpose**	**Notes**
Hack saw or pipe cutter or miter saw		Cutting PVC pipe	–
Miter saw or handsaw		Cutting PVC pipe and wood blocks	Material loss with each cut may be negligible and tube length will be about 15 in.
Table saw (for furring strips only)		Cutting 1 × 2 in. wood/furring strips lengthwise into two 1 × 1 in. strips	Tubes will be 14-7/8 in. long because of material loss from blade
Drill press, router, or Rotozip® spiral saw (only one needed)		Cutting groove into wood blocks	–
Drill press method only: 1-1/4 in. and 1-3/8 in.		Cutting grooves for the 1 in. tubes	Two saw bits are nested for proper width.
Hole saw bits with matching arbor: 1-7/8 in. and 2 in.		Cutting grooves for the 1-1/2 in. tubes	Two saw bits are nested for proper width
Caulking gun		For dispensing polyurethane glue	–

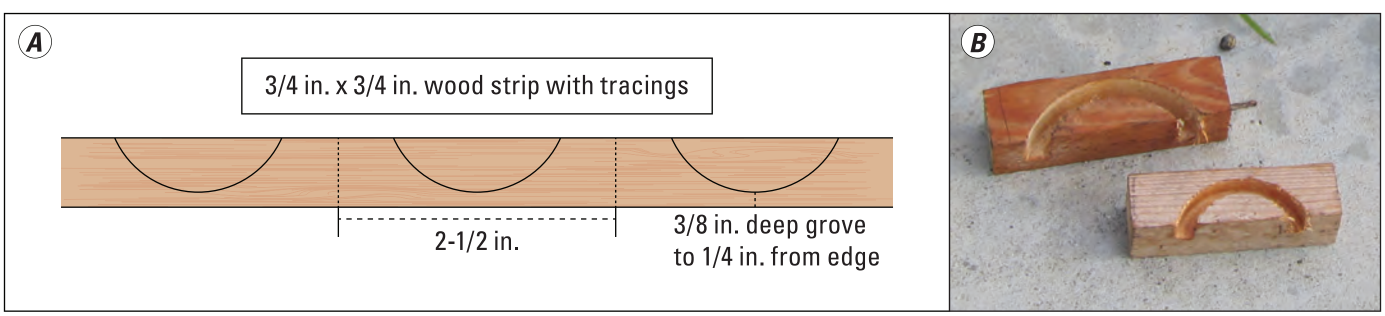

Figure 3. Diagram (*A)* and photograph (*B*) showing showing tube stabilizer construction.

Drill Press Method

If using a drill press, nest two hole saw bits so that grooves are thick enough to fit the PVC pipe end.

1. For the 1-1/2 in. (3.8 cm) tubes, nest 1-7/8 in. (4.8 cm) and 2 in. (5.1 cm) hole saws onto the arbor to create 1-1/4 in. to 2-1/2 in. (3.2–6.4 cm) size holes.
2. For the 1 in. tubes, nest 1-1/4 in. (3.2 cm) and 1-3/8 in. (3.5 cm) hole saws onto the arbor to create 3/4-in. (1.9 cm) and 1-1/8 in. (2.9 cm) size holes.
3. A jig will accurately and safely hold your work so you can make consistent, repeatable cuts quickly. We recommend constructing a jig that will secure the dowel or pre-cut furring strip and guide the drill bits when drilling out grooves (fig. 4).
4. To make the jig, take a section of 2 × 4 in. wood and cut a dado (slot) into the wood. The depth and width should be cut to fit the dowel or pre-cut furring strip, which will slide along the dado cut.
5. Set marked dowel or pre-cut furring strip in dado and line up hole saw bits with first marked arc line.
6. Securely clamp down jig under drill press.
7. Using the drill press with the nested hole saw bits, bore a hole to approximately one-half the depth of the square dowel or pre-cut furring strip (3/8 [1.0 cm]).
8. Slide dowel or furring strip along dado and continue to cut the hole grooves every 2-1/2 in. (6.4 cm) along marked arc lines.
9. Run square dowels through jig and drill out grooves.
10. After completing all the grooves along the wood strip and ensuring the tube ends fit within the grooves, cut the wood strip into multiple wood stabilizers at each of the divider lines using a miter saw, handsaw, or table saw.

Router Method

If using router:

1. Clamp down the square dowel or pre-cut furring strip to a stable surface.
2. Cut out grooves to approximately one-half the depth of the wood strip (5/16 in. [0.8 cm] to 3/8 in. [1.0 cm]) following the traced arc patterns.
3. Check regularly to make sure the PVC pipe fits into the cut grooves.

After completing all the grooves along the wood strip and ensuring the tube ends fit within the grooves, cut the wood strip into multiple wood stabilizers at each of the divider lines using a miter saw, handsaw, or table saw.

Attach PVC Pipe to Stabilizers

Attach stabilizers to cut PVC tube using caulking gun and polyurethane glue (Liquid Nails® recommended). To ensure a stable track tube, place the newly glued tube on a flat surface to confirm wood bases are level with each other before or while drying (fig. 5).

Track Cards and Track Card Base Construction

All materials for track cards and track card bases are presented in table 2 including specific brands found effective after extensive testing.

Track Cards

Track cards are constructed of 110 lb cardstock paper. After an animal steps onto the ink pad and moves into the tube, the tracks are registered onto this track card paper. The track card paper is then removed, replaced, and interpreted during each track tube check. Track cards can be cut on a paper cutter, or bulk paper reams can be cut to specifications in a print shop. Make enough track cards to replace used track cards throughout the survey period.

1. Cut the cardstock paper into 11 in. (27.9 cm) strips (or preferably have a ream of paper cut to size at local print shop).
    a. For the 1-1/2 in. (3.8 cm) tubes, cut cardstock to 1-1/4 in. (3.2 cm) widths.
    b. For the 1 in. (2.5 cm) tubes, cut cardstock to into 7/8-in. (2.2 cm) widths.

Track Card Bases

Track card bases are situated inside the track tube and will typically last for an entire season or year of continuous use. The bases are made of a sturdy 14-mil digital polyester paper. This paper is durable, waterproof, and greaseproof, and does not change shape in high temperature or high moisture environments. Sizes can be ordered and cut to specifications at a local print shop. If polyester paper is unavailable, track card bases can be made by cutting strips out of legal-size file folders and wrapping in clear contact paper (Loggins and others, 2010).

Ink pads are cut and glued to each end of the track card base. Track cards are then set between the ink pads and secured with paper clips to facilitate easy replacement between checks (figs. 1 and 2). Track card bases are slightly different depending on the end treatment (Option 1: Track Card Base for Magnet End Treatment or Option 2: Option 2: Binder Clip End Treatment) and are described separately.

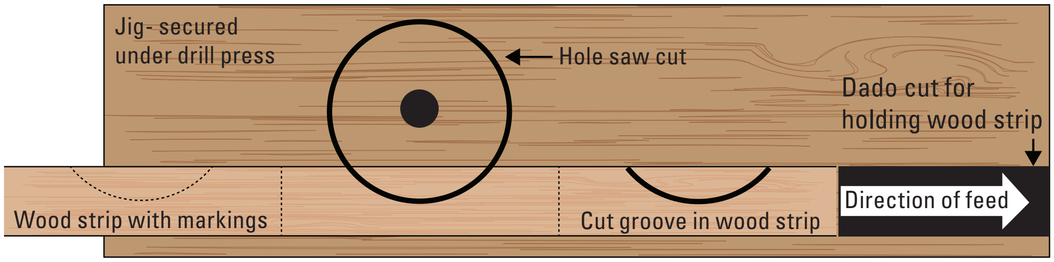

Figure 4. Drill press method jig for making tube stabilizer grooves with wood strip feed.

Figure 5. Wood stabilizer connected to track tube.

Table 2. Materials and tools needed for track cards, track card bases, and ink solution.

[**Abbreviations:** in., inch; L, liter; lb, pound; fl. oz, fluid ounce]

Item	1-1/2 in. tubes	1-in. tubes
Tracking Base Cards		
High quality felt	Cut into 1-1/8 in. squares	Cut into 7/8 in. wide × 1-1/8 in. tall squares
Glue (Liquid Fusion® - clear urethane adhesive)		
Scissors or rotary cutter with cutting mat		
Tracking Base Cards: Magnet End Treatment (Option 1)		
12 × 18 in. 14-mil weatherproof polyester paper (Thermanent®, digital Thermanent®, or Xerox® NeverTear)	Cut into 1-1/8 in. width × 14 in. length strips	Cut into 7/8 in. width × 14 in. length strips
Neodymium magnets (4 per track tube)	Strength: N50 or N52 Size: 1/2 in. diameter × 1/8 in. depth	Strength: N50 or N52 Size: 3/8 in. diameter × 1/8 in. depth
Glue (Liquid Fusion® Clear Urethane Adhesive)		
Tracking Base Cards: Binder Clip End Treatment (Option 2)		
12 × 18 in. 14-mil weatherproof polyester paper (Thermanent® digital Thermanent® or Xerox® NeverTear)	Cut into 1-1/8 in. width × 16 in. length strips	Cut into 7/8 in. width × 16 in. length strips
1 in. binder clips (2 per track tube)		
Tracking Paper inserts		
8-1/2 × 11 in. heavy cardstock (110 lb Wausau® Paper)	Cut into 1-1/8 in. width × 11 in. length strips	Cut into 7/8 in. width × 11 in. length strips
Standard paper clip		
Ink Solution		
Food grade mineral oil	2-1/2 parts	
Carbon lampblack powder	1 part	
Plastic funnel and large plastic container with lid	1 L plastic soda bottle or similar	
Small applicator bottles	Used in field kit (8 fl. oz, twist top bottle; for example, hair dye dispenser bottles work well)	

Cut Ink Pads

Felt pads are used as ink pads at each end of the track card base. High quality felt is recommended as it will last longer and hold more ink.

1. Cut felt into squares using scissors or a cutting mat and rotary cutter set.
    a. For the 1-1/2 in. (3.8 cm) tubes, cut felt into 1-1/8 in. (2.9 cm) squares.
    b. For the 1 in. (2.5 cm) tubes, cut felt pads 7/8 in. wide × 1-1/8 in. tall (2.2 × 2.9 cm).

Option 1: Track Card Base For Magnet End Treatment

The final length and width of the track card base should be such that the strips sit inside the tube at a height just below the top of the wood stabilizers (fig. 5). It is very important that the cards do not extend onto the stabilizers as it makes it easy for animals to pull the tracking card out of the tube.

1. Cut the 14-mil polyester paper into 14 in. (35.6 cm) strips (or preferably have a ream of paper cut to size at local print shop).
    a. For 1-1/2 in. (3.8 cm) tubes, cut into 1-1/8 in. (3.2 cm) widths.
    b. For the 1 in. (2.5 cm) tubes, cut into 7/8 in. (2.2 cm) widths.
2. Attach a track card to the middle of the track card base using paperclips as a guide.
3. Place felt within the outline of the track card base and at least 1/4 in. (0.6 cm) from each end of the tracking card (fig. 6*A*).
4. Glue felt pads to each end of the track card base. Make sure to evenly spread the glue (Liquid Fusion® Clear Urethane Adhesive) before setting felt.

Leaving a small space between the felt pad and track card is important because if the ink pads contact the track card in the field, the card will absorb the oil from the ink pad resulting in an oily track card and a dry ink pad.

5. Attach Neodynium magnets to the underside of the track card base on each end with glue (Liquid Fusion® Clear Urethane; fig. 6*B*).
6. Wait 24 hours for the glue to completely cure before attempting field use.

Option 2: Binder Clip End Treatment

When using binder clips, the final length and width of the track card base should be such that the strips extend to the length of wood stabilizer ends.

1. Cut the 14-mil polyester paper into 16 in. (40.6 cm) strips (or, preferably, have a ream of paper cut to size at local print shop).
    a. For 1-1/2 in. (3.8 cm) tubes, cut into 1-1/8 in. (3.18 cm) widths.
    b. For the 1 in. (2.5 cm) tubes, cut into 7/8 in. (2.2 cm) widths.
2. Attach a track card to the middle of the track card base using paperclips as a guide.
3. Place felt within at least 1/4 in. (0.6 cm) from each end of the tracking card leaving the longer end section free (figs. 1*B* and 2*B*).
4. Glue felt pads to each end of the track card base. Make sure to evenly spread the glue (Liquid Fusion® Clear Urethane Adhesive) before setting felt.

Leaving a small space between the felt pads and track card is important because if the ink pads contact the track card in the field, the paper will absorb the oil from the ink pad resulting in an oily track card and a dry ink pad.

Ink Solution

The ink solution is composed of 2-1/2 parts (by volume) of food-grade mineral oil to 1 part carbon lampblack powder as described by Loggins and others (2010).

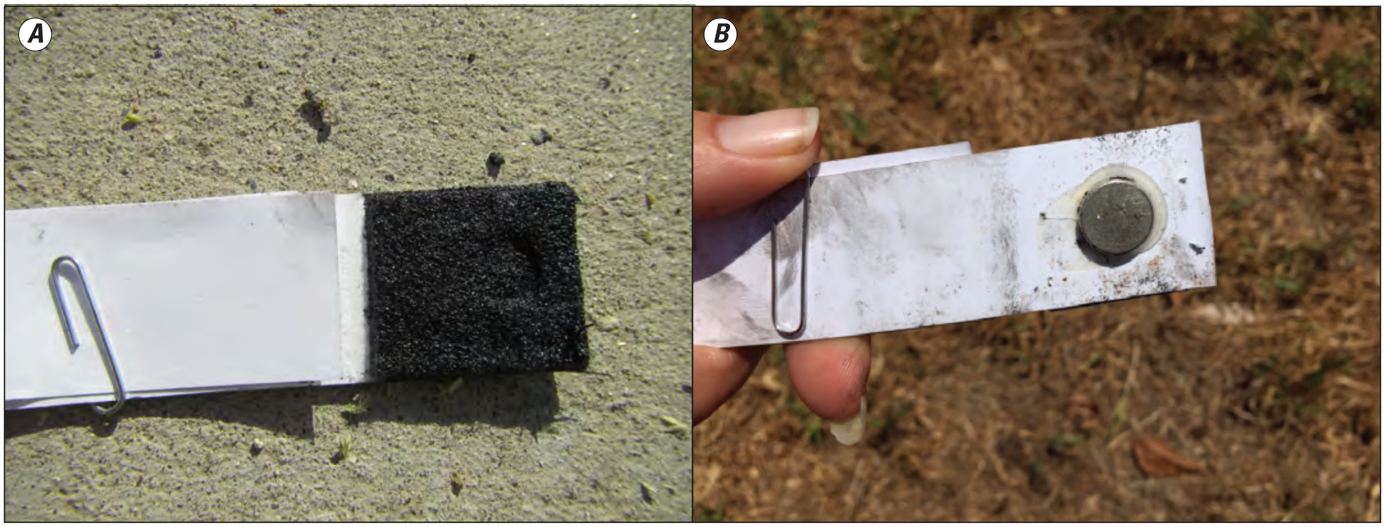

Figure 6. Track card with magnet end treatment. (Top of track card shows felt pad *[A]* and bottom *[B]* shows magnet)

SAFETY PRECAUTIONS:

Be sure to read the Material Safety Data Sheet for the Carbon Lampblack powder. The ink solution should be prepared under a fume hood or outside, optionally with a dust mask, to prevent inhalation of carbon lampblack powder. In powder form, the lampblack is a respiratory carcinogen if inhaled in large quantities or over long periods. Do not use near an open flame. It can irritate skin and eyes so gloves and eye protection are recommended. It is not dangerous as part of a liquid solution. However, the ink solution is messy and can stain clothing, surrounding materials and skin. The use of gloves anytime while handling ink solution is recommended.

To make 2-1/2 cups (2.5 l) of the ink solution:

1. Measure 2-1/2 cups (2.5 l) of mineral oil into a suitable container (we use a 1 qt or 1 l wide-mouthed plastic soda bottle).
2. Add 1 cup (0.25 dry l) of lampblack powder to the mineral oil using a plastic funnel (we use 1-pint (0.5 l) type used for adding engine oil). For lampblack powder, we add in four 1/4 cup scoops that allows us to directly scoop the powder out of the Lampblack container.
3. Secure the ink container cap and shake well to mix.
4. Pour the ink solution into one or more field applicator bottles (we use 8 oz. hair color applicator bottles). If the solution sits for a while, shake the container well before pouring ink solution into an applicator bottle for the field kit to ensure the mixture is evenly distributed and the carbon lampblack has not settled on the bottom of the container.

Field Preparation

Assemble a field kit with required equipment and materials for setting and checking track tubes in the field (table 3, fig. 7). Field kits should always be stocked sufficiently.

Field Protocol

Once all the equipment and materials are prepared for the field, follow instructions for setting and checking track tubes in the field.

Table 3. Required field kit materials and optional supplies.

Field Kit	Purpose
Tool bag	Large enough to hold all kit items.
Carry bag for track tubes (for example, heavy-duty stake bag; Forestry Suppliers 38520)	Needed for initial set up and removal only.
Track Tubes[1]	
Track card bases[1] (pre-assembled with glued on felt pads and magnets—if magnet end treatment)	One for each track tube.
Track cards	At least one for each track tube. For setting and replacing track cards during checks.
Standard paper clips[1]	To attach track cards to base.
Bag containing bait (bird seed, millet seed)	Microwave for 3 minutes to inactivate. Kept in chalk bag in field kit.
Ink solution in 8 oz. dispensing bottle	To ink or re-ink felt squares on track card bases.
Natural glue sticks (Pritt or Elmer's®)	For gluing bait seed to track card base.
N50+ Neodynium disk magnets[1]	Magnet end treatment (Option 1): two per track tube.
Binder clips (1 in.)[1]	Binder clip end treatment (Option 2): two per track tube.
Garden staples1 and small mallet (optional)	For securing track tubes to the ground, two per tube (if squirrels or other animals disturb/turn over tubes).
Flagging tape and pin flags[1]	For marking survey points and pathways.
Industrial marker (Sharpie®)	For labelling tubes and flags.
Disposable gloves	Protection from ink (small, medium, and large).
Paper towels or wet wipes	To clean ink off equipment.
Pen, pencil or ultrafine sharpie	For labeling track cards for data collection.
Rubber bands	For grouping track cards together.
Scissors	Trim track cards if too long (if needed). Handles may also be used to easily pry magnets apart in field.
Gypsum powder (optional)	Used to make chalk lines to mark paths in sensitive PPM habitat.
Coin envelope (optional)	For collection of scat (DNA analysis).

[1] Once tubes are set first time, only a few extra are needed for replacement during repeat checks, if necessary.

Figure 7. Complete field kit for checking and resetting track tubes. (Shown unpacked *[A]* and packed into tool bag *[B]*)

Flagging Movement Paths And Placing Track Tubes

Light, repeated foot traffic has been negatively associated with PPM occupancy (Brehme and others, 2014), particularly in sand dominated soils; therefore, it is extremely important to minimize any disturbance to well defined pathways.

1. To minimize habitat disturbance in sensitive areas, use pin-flags, whisker flags, flagging tape, and (or) white chalk to mark walking pathways to the study site and in between tubes.

2. Navigate to survey point location (for example, preset survey points and points along transects).

3. At the location, find the optimal place to set the tube within the designated subplot or in the nearby microhabitat.

Placement should be based on the target species. For PPM, tubes are optimally placed within 5 m of the center point of the subplot on open ground next to forb or shrub species known to be dietary seed resources for PPM. Make sure the location is level (so seed does not slide onto one of the ink pads. If the location is on an incline, place the tube perpendicular to the incline.

1. Gently clear a flat open space on the ground with your boot that is long enough to create a small pathway leading to the tube on both ends.

2. Before placing the track tube, rinse the inside of the tube with local substrate (a handful of sand or dirt right around where the tube is placed). Rinsing the tube with local substrate increases the detectability of PPM (Brehme and others, 2012), likely because it reduces the foreign smell of the tube.

3. Place tube on ground.

4. Label track tube and mark location with pin flag or flagging tape.

5. Record GPS coordinates. For our purposes, each tube is labeled with a preset site name, grid number, and subplot number.

Preparing Track Card Base

1. Add 1–4 track cards to the track card base using two paperclips (fig. 2).

2. Shake ink bottle frequently to ensure it is properly mixed. If not properly mixed, it will greatly reduce effectiveness of the track tube.

3. Gently add mixed ink to each felt pad using an 8 fl. oz (0.25 l) dispenser bottle. Make sure all white areas of the felt pad are covered in ink and are appropriately saturated (fig. 8*A*). If too much ink is applied, scrape the surface lightly with a folded track card to remove excess ink (fig. 9).

Note: The freshly inked pad should have a light smooth sheen or slight shine (fig. 8*A*). DO NOT over-ink the pad; An over-inked pad will have pooled ink or a shiny bubbly surface (fig. 8*B*). If the ink is pooled, animals are hesitant to enter the tube and are more likely to ingest the ink solution, and, the prints will be smeared and messy. An under-inked pad is shown in (fig. 8*C*). Under-inked pads will dry out quickly and not provide enough ink to obtain a clear track, particularly of very small rodents like PPM. If the ink pad is properly saturated, it will stay wet and functional for approximately two weeks (depending on usage and temperature).

1. Apply a thin film of non-toxic plant based glue with natural glue stick to the center of the track card (about 1 in. (2.5 cm) diameter). The glue attaches the first layer of bait to the track card surface allowing the tube to remain an effective attractant for a longer period, even if other mice or ants remove the loose seeds on top.
2. Gently crease the center of the track card (lengthwise) into a cup shape “well” (fig. 10).
3. Add about a tablespoon (4 ml) of bait into “well” (less for the 1 in. (2.5 cm) tube; fig. 10). **Note:** cook millet seed (*Panicum* spp.) bait for PPM in microwave oven for 3 minutes to ensure seeds are inactivated before use.
4. Carefully insert the baited track card base into the track tube being careful not to let the seed slide on the ink pad or outside of the tube.
5. If using magnets, secure the track card base to the tube by placing two Neodymium magnets on the outside bottom of the tube (fig. 2*A*).
6. If using binder clips, place clips on ends of track tubes.
   a. Fold the bottom handles of the clips under the wood stabilizers, and remove top handles by pressing together. Save handles for re-use when checking the tubes.
   b. Use the glue stick to coat the top sides of the clip, then add local substrate and tap off excess (fig. 2*B*).
7. If larger animals, such as ravens, squirrels and rabbits are a problem (they may overturn the tubes) at the site, place one or two garden staples over the tube and secured into the ground with a hand mallet (fig. 11). The tubes can also be wedged between large rocks if available nearby.

Checking and Resetting Track Tubes

1. Remove garden staple (if using) and magnets or binder clips from the outside of the track tube. To avoid misplacing magnets, it is recommended that magnets are placed in the open or attached to something metal (garden staple/pin flag).
2. Remove track card base from the tube and check for tracks. Remove the track card if it contains any tracks (or if dirty).
3. On all track cards with prints, use a pencil or pen to label the back of card with the site, grid number, tube number, and date.
   a. If a tube was disturbed (turned over) during the survey period, label back of track card with a “T” to indicate “tossed”.

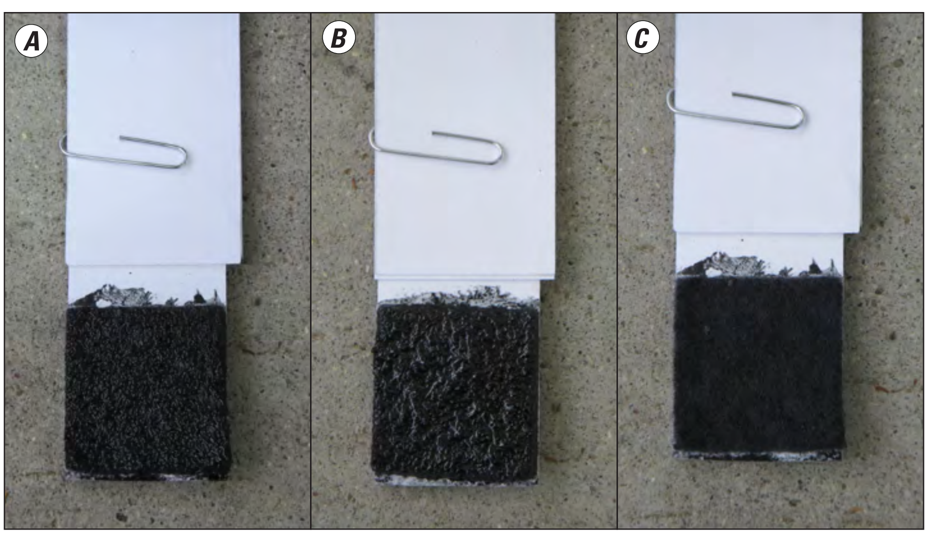

Figure 8. Inked pads with (*A*) correct amount of ink, (*B*) over inked, and (*C*) under inked.

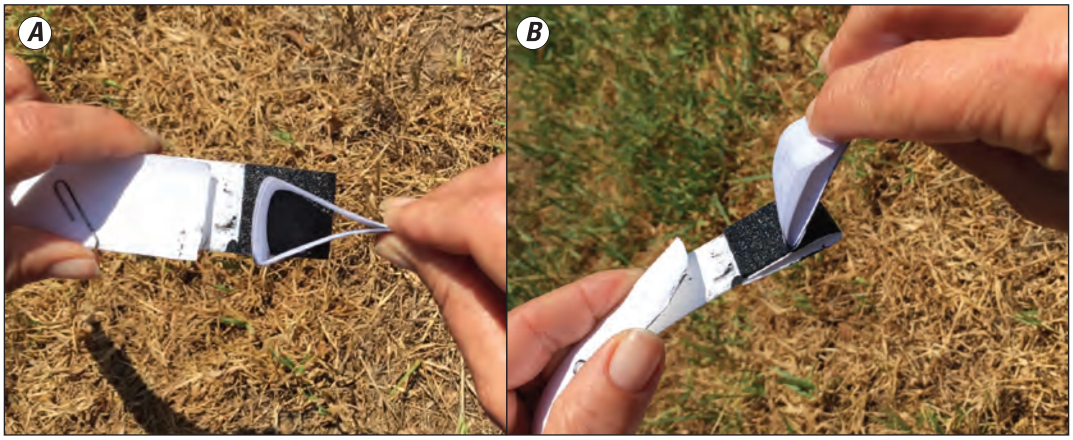

Figure 9. Use of a folded track card to (*A*) scrape ink pads and to (*B*) smooth or remove excess ink.

   b. If the track base card was pulled out of the tube, indicate that it was by writing a “PO” on the track card.

   These data are important to include for analysis of detection probability. Tracks can be interpreted on site or the cards can be secured (using rubber bands) and taken back to an office for track interpretation and data entry.

4. Place one to three new tracking cards on the track card base (as needed) and secure with paper clips.
5. Scrape off any dirt and debris from the ink pad. A double folded track card works well for this (fig. 9*A*). Check ink (sheen and [or] lightly touch with finger or stick) and add more ink if necessary. If too much ink is added, use the folded side of an empty track card to smooth and remove excess ink (fig. 9*B*).
6. Add film of natural glue to the center of the card and rebait with seed.
7. Carefully place the inked and baited track card base with track cards in to the track tube.
8. Secure the track card base to the tube with magnets or binder clips and garden staple (if needed) as previously described.

Track Interpretation

Reference Track Guide

Development of a track reference guide is important to properly interpret tracks. For this, we recommend creating a local reference collection of all small mammal species tracks. A reference guide created for PPM surveys on MCB Camp Pendleton is provided in appendix 1.

To create a reference collection, footprints should be collected during live trapping. To get the range of sizes and patterns within a species, we recommend obtaining at least 10 individuals of each post-weaned age class (juvenile, subadult, adult) of each species. It may be difficult to initially achieve this number, especially for rarer species and younger age classes. Protocols for live-trapping are available elsewhere (Powell and Proulx, 2003, Hoffmann and others, 2010, Sikes and Gannon, 2011). When an animal is captured, it should be identified to species, weighed, measured, and photographed. To obtain prints:

1. After scruffing an individual, place each forefoot and hindfoot on an ink pad and then release on a sketch pad in a box. Allow time for individual to move around pad.
2. Or, after scruffing an individual, move animal to entry point of a well inked track tube. Allow individual to move into the tube, cap end with hand, and then allow sufficient time for individual to exit other end of tube.
3. Measure length and width of forefeet and hindfeet tracks for all individuals. Calculate the means and the 95 or 99 percent confidence intervals. For some species, a width to length ratio may also be helpful.
4. Carefully analyze the toe, pad, and gait patterns for each species. The toe and pad configurations are unique for most species, although some species in the same genus may be similar.
5. Determine which species can be distinguished (or cannot be distinguished) by attributes of size and toe, pad, and gait patterns.
6. Scan the best track examples for each species for the reference guide.

Figure 10. Cupping or folding track card to create well for bait seed.

Figure 11. Track tube secured to ground with garden staples.

Measuring Footprints

Forefoot and hindfoot prints can be measured for length and width. For PPM monitoring, we measure width of the forefoot only and use this measurement, along with forefoot toe and pad patterns to identify rodents to species or genus (fig. 12). Measurements can be made using a ruler or caliper. Hindfoot toe patterns and gait patterns can also be helpful in verification of species and groups. We typically require either two forefoot prints or a forefoot print in addition to a full or partial hindfoot for verification. Otherwise, a pattern can appear to the eye but may have been formed by chance from multiple overlapping toe prints. Although it can take some time to become adept at interpreting track cards, you will gradually obtain a search image which will allow you to quickly scan and identify tracks of species and groups based upon their toe and pad patterns and size.

1. Look over the entire card and circle with pencil at least one forefoot track per species (if PPM, circle at least two tracks).
2. Measure the forefoot track width between the outer toe prints using a ruler or caliper (fig. 12). Forefoot width is measured to the nearest 0.1 mm from the center point of each outer toe print.
3. Record the species (or genus as appropriate) and width measurement(s) on the back of the track card.
4. Enter information into a spreadsheet or database (for example, USGS PPM Database). The track cards should be saved or scanned.

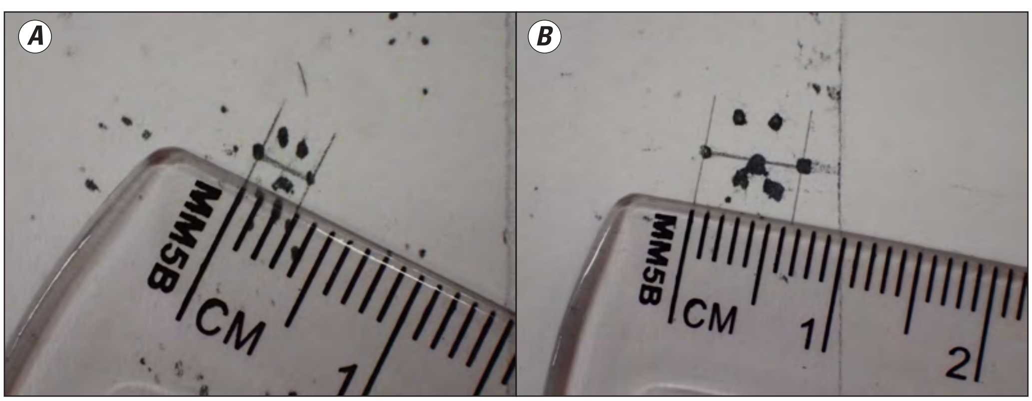

Figure 12. Points of width measurement for forefoot prints of a (*A*) Pacific pocket mouse (*Perognathus longimembris pacificus*) and (*B*) deer mouse (*Peromyscus maniculatus*).

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Appendix 1. Guide To The Identification Of Pacific Pocket Mouse Tracks And Other Common Mice In Marine Corps Base, Camp Pendleton, North Coast San Diego County, California

Tritia A. Matsuda and Cheryl S. Brehme

Summary

In 2008 and 2009, USGS conducted pilot studies to analyze the potential use of tracking tubes to survey for presence of *Perognathus longimembris pacificus* (Pacific Pocket Mouse, PPM). A reference collection was created to aid in the identification of tracking tube prints, particularly to distinguish PPM prints from those of other common mice in Marine Corps Base Camp Pendleton (MCBCP), within northern coastal San Diego (Matsuda and others, 2010).

To create a reference collection, footprints were collected while conducting live trapping for PPM in 2008 and 2009 (Brehme and Fisher, 2009; Brehme and others, 2010; Loggins and others, 2010). In 2008, live trapped individuals were placed on an ink pad and then released on a sketch pad to capture footprints. In 2009, live trapped individuals were run through a 1.5-inch diameter tracking tube (see Brehme and others, 2010). Optimal prints were used for the scaled figures of footprints and movement patterns. Drawings of ideal footprints were created from a composite of footprints for each species. We measured forefeet and hind feet tracks from the center points of the outer toes for width and center points of the highest (leading) toe to the lowest pad for length (fig. 1.1). We took two measurements for hindfoot length, complete and partial, because complete prints were not common. Most often a partial hindfoot print was captured with the upper pads and toes only. Both lengths are presented to provide a contrast of total foot length among species. Data are presented showing sizes of footprints by age class for each species (mean, standard error) along with photocopies and sketches of toe and pad patterns.

PPM can be easily identified from their toe pattern and the width of forefoot prints. Length is helpful but not necessary for PPM identification. PPM prints are smaller than all other species (table 1.1). PPM and other heteromyids (*Chaetodipus californicus* and *C. fallax* table 1.2 and fig. 1.2) have a distinct leading toe and their forefoot prints are substantially longer than wide (an 'oval shaped' pattern). All other species (figs. 1.3–1.9 and tables 1.3–1.7; *Reithrodontomys megalotis* and *Peromyscus* species) have no leading toe, a more 'circular splayed' pattern, and their forefoot prints are almost as long as they are wide. The closest species in body size to PPM is *Reithrodontys megalotis*. Although closer in body size, the forefoot print of *R. megalotis* is larger with a distinct toe and pad pattern similar to *Peromyscus*, often with an offset 'lazy' pinky toe. While data for different *Peromyscus* prints are presented, it is difficult to distinguish between *P. maniculatus* and *P. eremicus* (also known as *P. fraterculus*; Riddle and others, 2000) prints; *Peromyscus californicus* prints would be distinguishable by the larger size. *Neotoma* spp. are included for comparison, but would be excluded from actual capture due to the large body size.

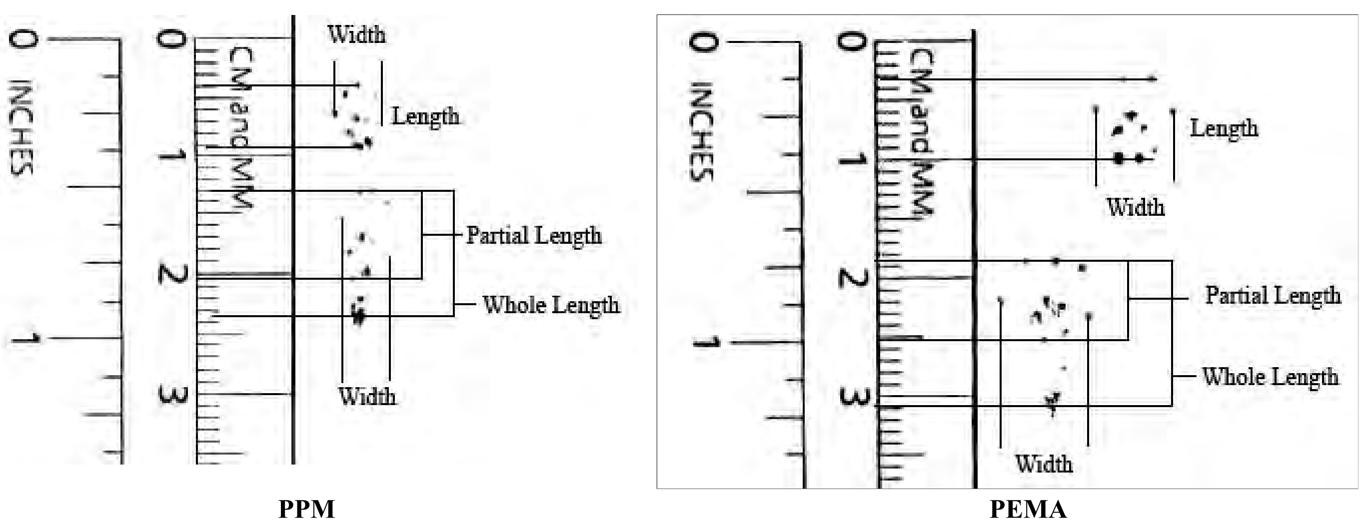


Figure 1.1. Points of measurement for forefoot and hindfoot prints for the Pacific pocket mouse (PPM, *Perognathus longimembris pacificus*) and deer mouse (PEMA, *Peromyscus maniculatus*).

Table 1.1. Species comparison of track measurements.

[Track measurements are in millimeters. **Abbreviations:** FF, forefoot; HF, hindfoot; Std, standard; Species abbreviations: PPM, *Perognathus longimembris pacificus*; REME, *Reithrodontomys megalotis*; CHFA, *Chaetodipus fallax*; CHCA, *C. californicus*; PEMA, *Peromyscus maniculatus*; PEER, *P. eremicus*; PECA, *P. californicus*; NEsp, *Neotoma* species; N/A, not applicable]

Species	FF Width			FF Height			HF Width			HF Height			HF Ht w/ heel		
	Mean	Std Error	Confidence Level (95.0%)	Mean	Std Error	Confidence Level (95.0%)	Mean	Std Error	Confidence Level (95.0%)	Mean	Std Error	Confidence Level (95.0%)	Mean	Std Error	Confidence Level (95.0%)
PPM	3.31	0.04	+/-0.09	5.00	0.04	+/-0.07	4.970	0.15	+/-0.32	7.530	0.17	+/-0.37	11.85	0.22	+/-0.51
CHFA	4.63	0.19	+/-0.11	6.25	0.07	+/-0.15	6.900	0.10	+/-0.28	10.50	0.29	+/-1.24	16.17	0.17	+/-0.72
REME	5.74	0.08	+/-0.16	6.00	0.00	+/-0.00	6.860	0.18	+/-0.4	8.210	0.30	+/-0.66	15.70	0.20	+/-0.56
CHCA	5.83	0.25	+/-0.58	7.15	0.08	+/-0.17	8.500	0.21	+/-0.46	12.08	0.23	+/-0.51	19.07	0.44	+/-1.08
PEMA	6.43	0.14	+/-0.3	6.98	0.17	+/-0.35	7.530	0.28	+/-0.61	7.670	0.41	+/-0.87	12.67	0.67	+/-2.87
PEER	5.90	0.20	+/-0.43	6.27	0.23	+/-0.50	7.230	0.24	+/-0.53	7.450	0.25	+/-0.55	13.50	0.50	+/-1.59
PECA	7.08	0.24	+/-0.61	8.50	0.37	+/-0.94	9.330	0.33	+/-0.86	11.92	1.17	+/-3.01	21.00	0.00	0.00
NEsp	7.33	0.33	+/-1.43	10.0	0.00	0.00	10.33	0.93	+/-3.99	14.00	1.00	+/-4.30	N/A	N/A	N/A

Pacific Pocket Mouse (PPM), *Perognathus longimembris pacificus*

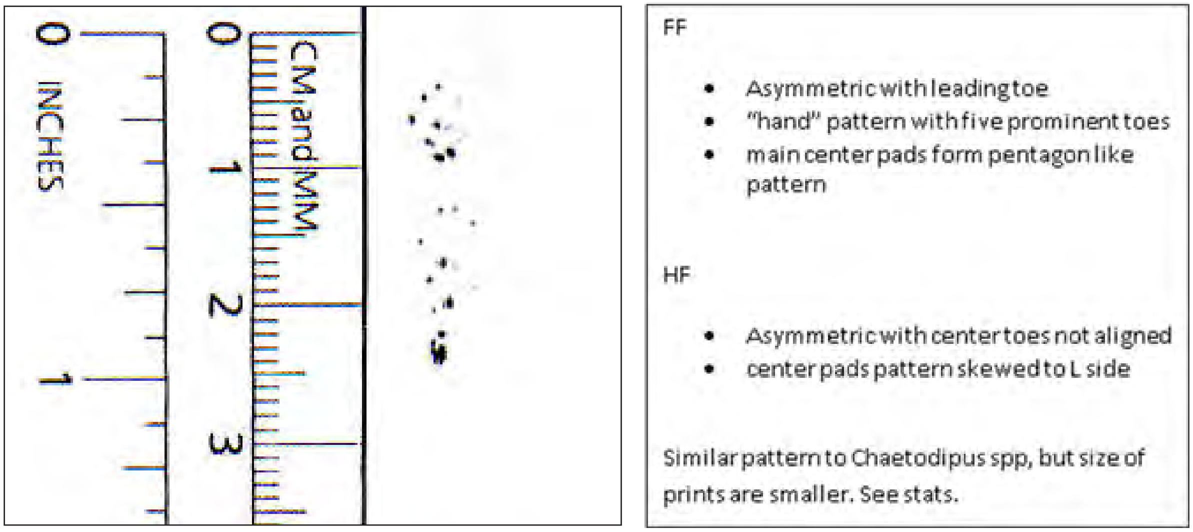


Figure 1.2. Forefoot and hindfoot prints and details for the Pacific pocket mouse, *Perognathus longimembris pacificus* (PPM).

Table 1.2. Track measurement details of the Pacific pocket mouse, *Perognathus longimembris pacificus* (PPM).

[Track measurements in millimeters. Abbreviations: FF, forefoot; HF, hindfoot; PPM, Pacific pocket mouse; se, standard error]

	N=52 FF Width		N=52 FF Length		N=15 HF Width		N=15 HF Length		N=10 HF Length w/ heel	
Species	mean	se	mean	se	mean	se	mean	se	mean	se
PPM	3.31	0.04	5.00	0.04	4.97	0.15	7.53	0.17	11.85	0.22

		N=35 FF Width		N=35 FF Length		N=11 HF Width		N=12 HF Length		N=6 HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PPM	**A**	3.34	0.05	5.06	0.04	4.95	0.21	7.63	0.21	12.17	0.21

		N=17 FF Width		N=17 FF Length		N=4 HF Width		N=3 HF Length		N=4 HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PPM	**SA**	3.24	0.08	4.88	0.07	5.00	0.00	7.17	0.17	11.38	0.38

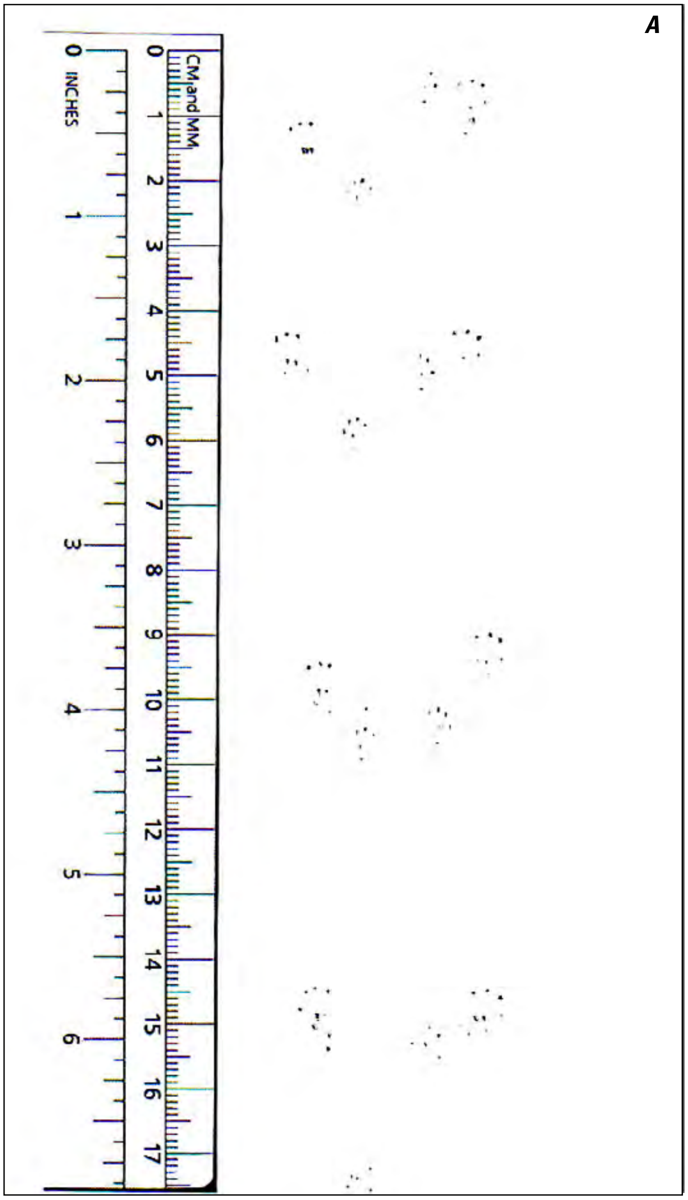
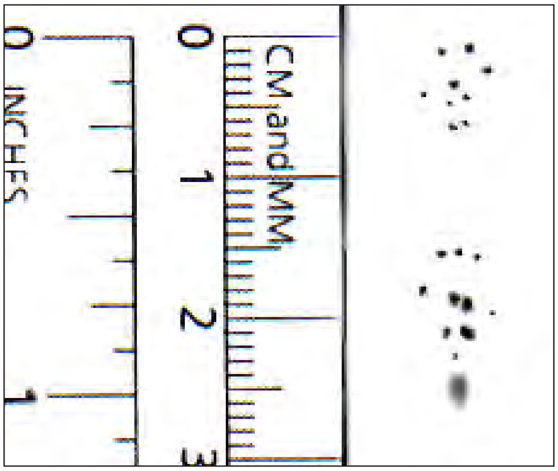


Figure 1.3. Forefoot and hindfoot prints (*A*) for the Pacific pocket mouse showing (*B*) enlarged view.

Western Harvest Mouse, *Reithrodontomys megalotis* (REME)



FF
- Symmetric with no leading toe
- Only four prominent toes in print
- Main center pads form square with center pad over square

HF
- Symmetric foot pattern along center toe
- Center toes in "line" with each other
- Center pads are in square pattern with one pad below square

Similar to PEMA and PEER. Smaller size prints. Differing pattern of center pads.

Figure 1.4. Forefoot and hindfoot prints and details for the western harvest mouse, *Reithrodontomys megalotis* (REME).

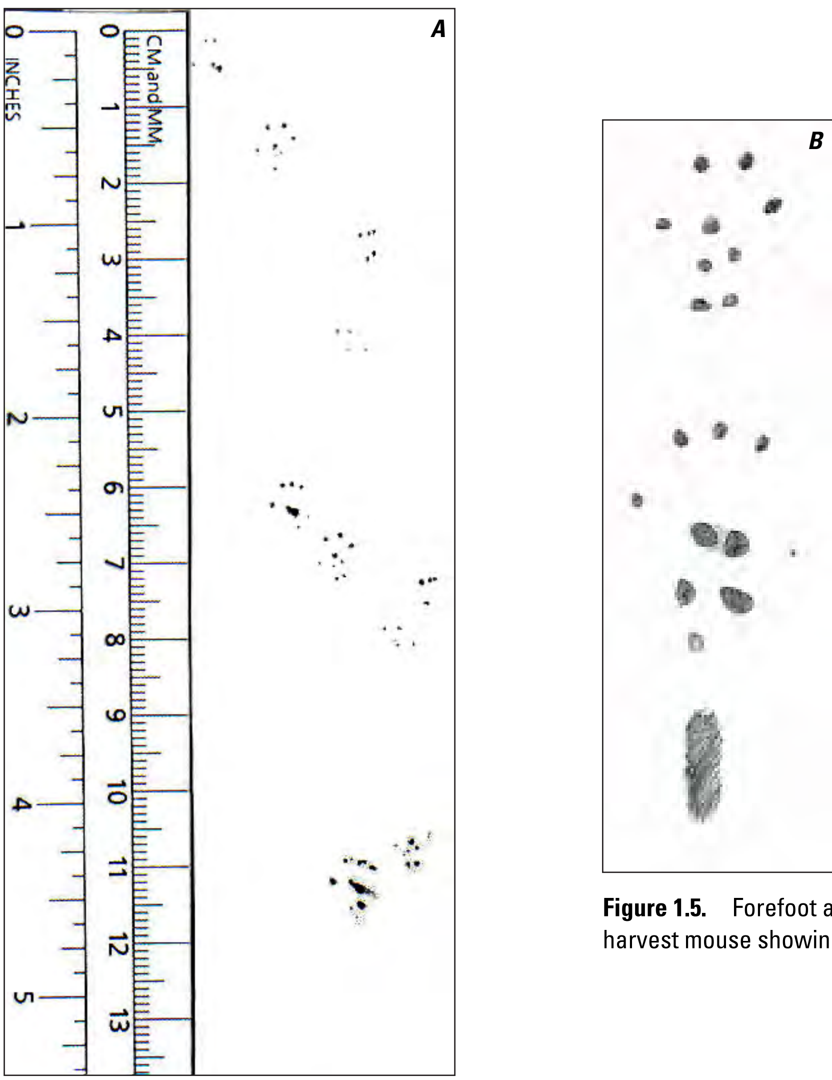


Figure 1.5. Forefoot and hindfoot prints (*A*) for the western harvest mouse showing (*B*) enlarged view.

Table 1.3. Track measurement details of the western harvest mouse.

[Track measurements in millimeters. **Abbreviations:** FF, forefoot; HF, hindfoot; REME, *Reithrodontomys megalotis*, se, standard error]

	N=17		N=16		N=14		N=14		N=5	
	FF Width		**FF Length**		**HF Width**		**HF Length**		**HF Length w/ heel**	
Species	mean	se	mean	se	mean	se	mean	se	mean	se
REME	5.74	0.08	6.00	0.00	6.86	0.18	8.21	0.30	15.70	0.20

		N=15		N=14		N=11		N=11		N=3	
		FF Width		**FF Length**		**HF Width**		**HF Length**		**HF Length w/ heel**	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
REME	**A**	5.73	0.08	6.00	0.00	6.95	0.14	8.27	0.31	15.67	0.33

		N=1		N=1		N=2		N=2		N=1	
		FF Width		**FF Length**		**HF Width**		**HF Length**		**HF Length w/ heel**	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
REME	**SA**	6.00	0.00	6.00	0.00	6.00	1.00	7.50	1.50	16.00	0.00

		N=1		N=1		N=1		N=1		N=1	
		FF Width		**FF Length**		**HF Width**		**HF Length**		**HF Length w/ heel**	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
REME	**J**	5.50	0.00	6.00	0.00	7.50	0.00	9.00	0.00	15.50	0.00

Pocket Mice, *Chaetodipus californicus* (CHCA) and *C. fallax* (CHFA)

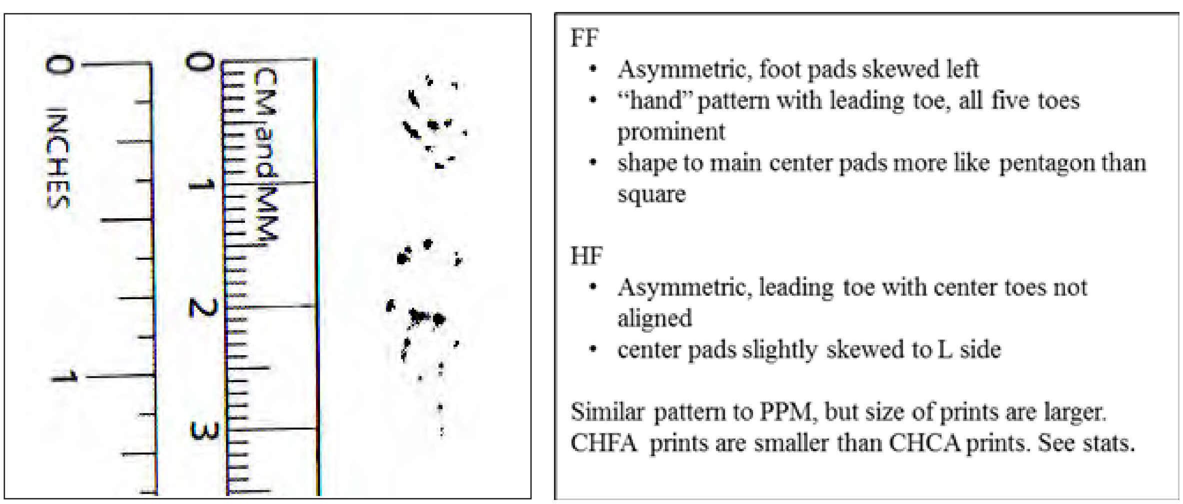


Figure 1.6. Forefoot and hindfoot prints and details for the pocket mouse, *Chaetodipus californicus* (CHCA).

Table 1.4. Track measurement details of the pocket mice, *Chaetodipus californicus* and *C. fallax*.

[Track measurements are in millimeters. Abbreviations: FF, forefoot; HF, hindfoot; CHCA, *Chaetodipus californicus*; CHFA, *C. fallax*; se, standard error]

	N=9		N=10		N=13		N=13		N=7	
	FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	mean	se	mean	se	mean	se	mean	se	mean	se
CHCA	5.83	0.25	7.15	0.08	8.50	0.21	12.08	0.23	19.07	0.44

		N=6		N=7		N=9		N=9		N=4	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
CHCA	**A**	5.83	0.28	7.14	0.09	8.44	0.29	12.00	0.28	18.75	0.25

		N=2		N=2		N=3		N=3		N=2	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
CHCA	**SA**	6.00	1.00	7.25	0.25	8.50	0.29	12.33	0.67	18.75	1.25

		N=1		N=1		N=1		N=1		N=1	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
CHCA	**J**	5.50	0.00	7.00	0.00	9.00	0.00	12.00	0.00	21.00	0.00

	N=14		N=14		N=5		N=5		N=3	
	FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	mean	se	mean	se	mean	se	mean	se	mean	se
CHFA	4.68	0.07	6.25	0.07	6.90	0.10	10.50	0.29	16.17	0.17

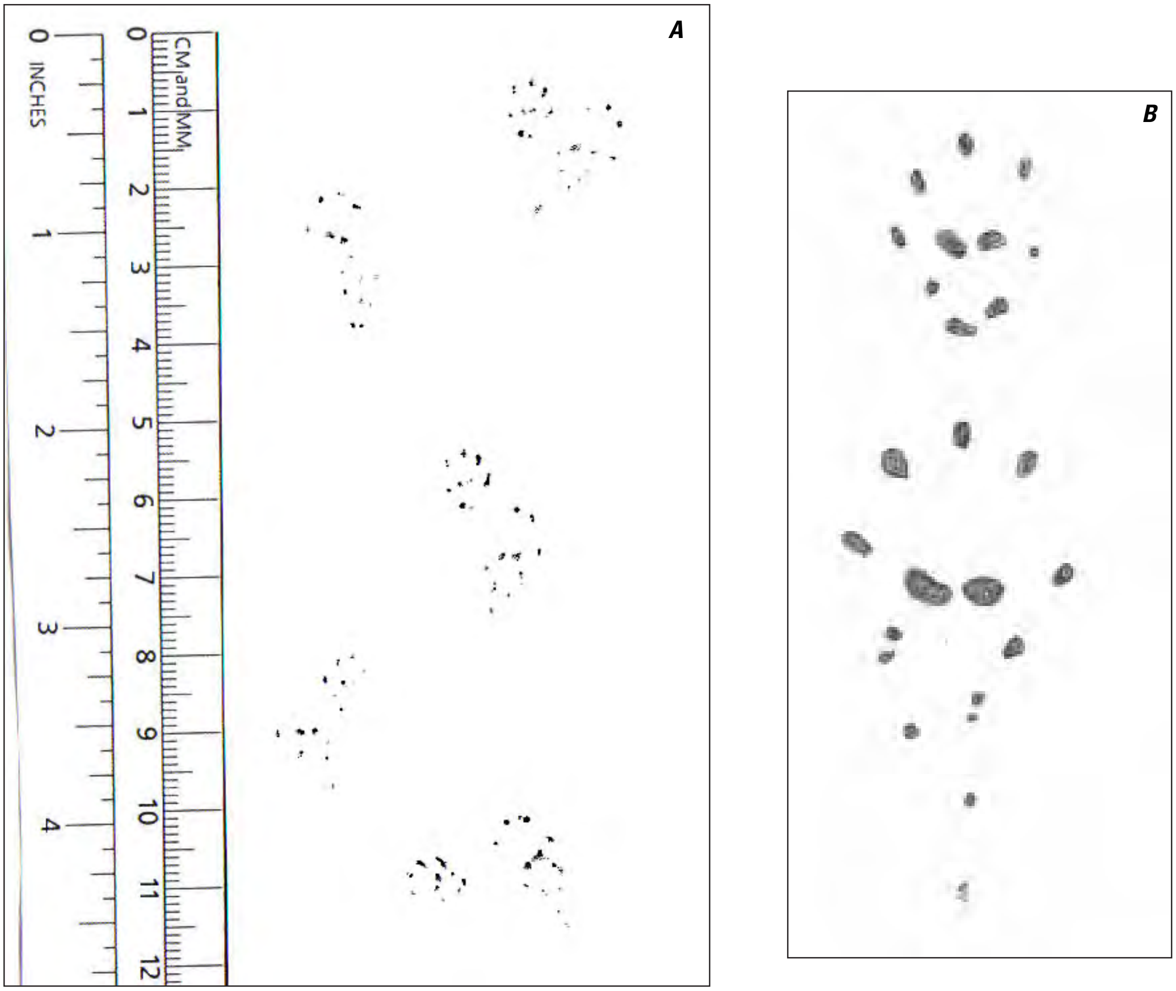
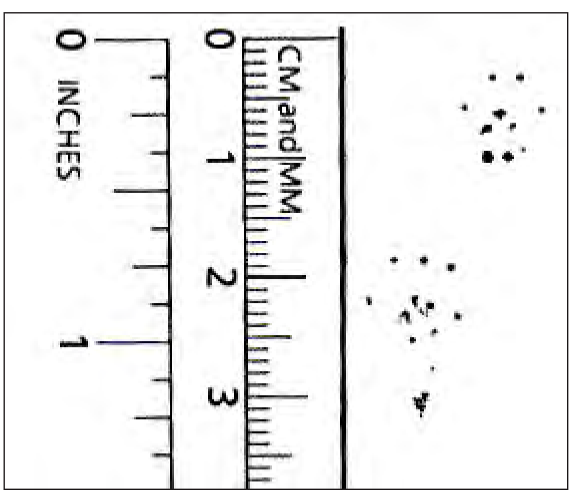


Figure 1.7. Movement pattern prints (*A*) from *Chaetodipus californicus* and generalized drawing (*B*) for *Chaetodipus* spp.

Deer mice, *Peromyscus maniculatus* (PEMA) and P. *eremicus* (PEER)



FF

- Symmetric with no leading toe
- Four prominent toes in print
- Main center pads form square with large center pad over square and minor pad on lower corner of square, depending on whether its left or right FF

HF

- Symmetric foot pattern along center toe
- Center toes in "line" with each other
- Center pads are in square with another pad above square

Similar to REME. PECA prints are much larger than PEMA/PEER prints.

Figure 1.8. Forefoot and hindfoot prints and details for deer mice, *Peromyscus maniculatus* (PEMA) and *P. eremicus* (PEER).

Table 1.5. Track measurement details of the deer mice, *Peromyscus maniculatus* and *P. eremicus*.

[Track measurements are in millimeters. Abbreviations: FF, forefoot; HF, hindfoot; PEMA, *Peromyscus maniculatus*; PEER, *P. eremicus*; se, standard error]

	N=20		N=20		N=15		N=15		N=3	
	FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	mean	se	mean	se	mean	se	mean	se	mean	se
PEMA	6.43	0.14	6.98	0.17	7.53	0.28	7.67	0.41	12.67	0.67

		N=14		N=14		N=12		N=12		N=2	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PEMA	**A**	6.67	0.11	7.04	0.10	7.83	0.23	8.00	0.46	13.00	1.00

		N=1		N=1		N=0		N=0		N=0	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PEMA	**SA**	6.00	0.00	7.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A

		N=5		N=5		N=3		N=3		N=1	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PEMA	**J**	5.80	0.34	6.80	0.66	6.33	0.83	6.33	0.33	12.00	0.00

	N=15		N=15		N=11		N=11		N=4	
	FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	mean	se	mean	se	mean	se	mean	se	mean	se
PEER	6.23	0.19	6.64	0.22	7.44	0.27	7.25	0.25	13.00	1.00

		N=11		N=11		N=8		N=8		N=2	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PEER	**A**	6.67	0.11	7.04	0.10	7.83	0.23	8.00	0.46	13.00	1.00

		N=2		N=2		N=1		N=1		N=0	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PEER	**SA**	5.00	0.00	5.50	0.00	7.00	0.00	7.00	0.00	N/A	N/A

		N=2		N=2		N=2		N=2		N=2	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PEER	**J**	5.00	0.00	5.00	0.00	6.50	0.50	8.50	0.50	14.00	0.00

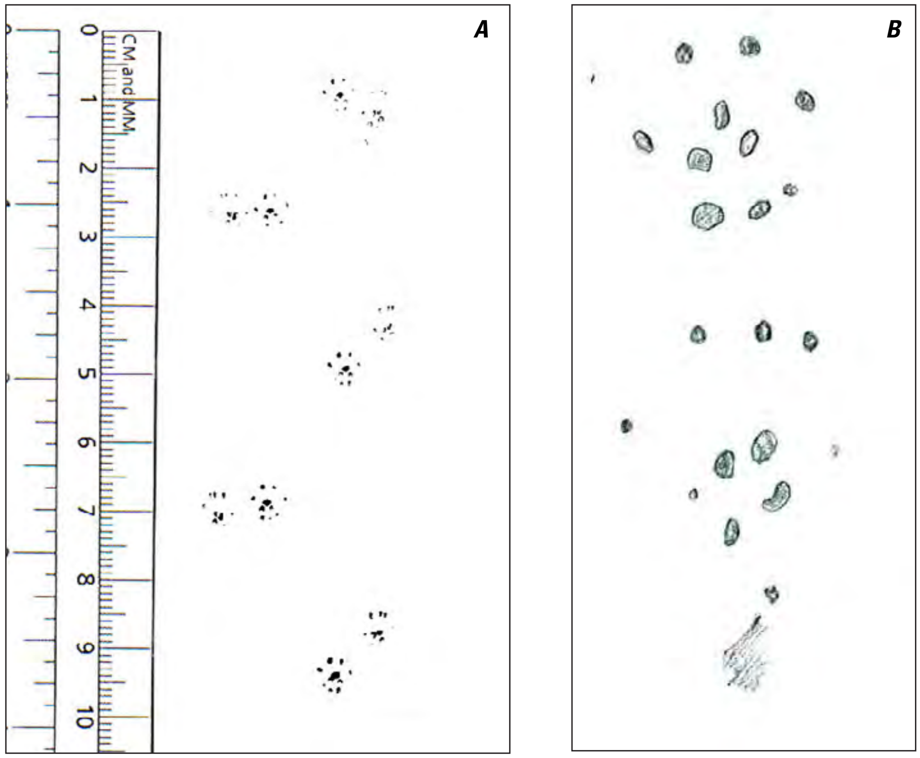
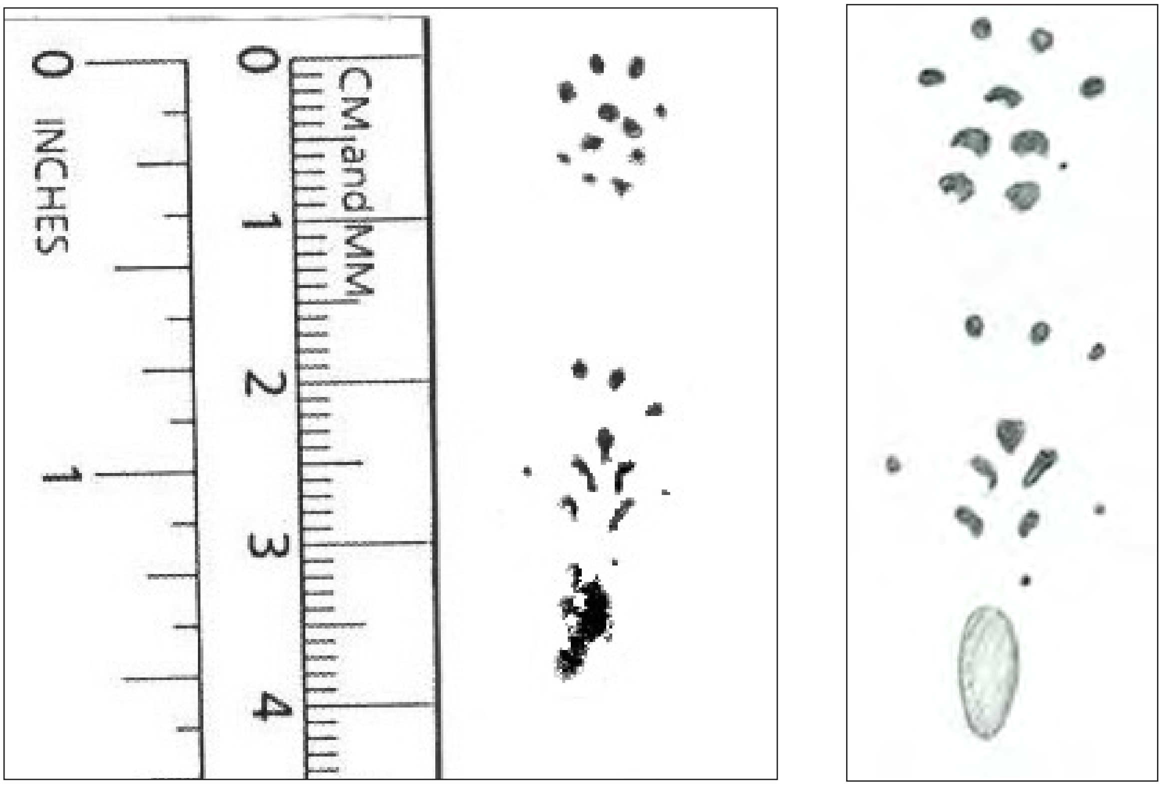


Figure 1.9. Movement pattern prints (*A*) from *Peromyscus eremicus* and generalized print (*B*) for *Peromyscus* spp.

California Mouse, *Peromyscus californicus* (PECA)



FF
- Symmetric with no leading toe
- Four prominent toes
- Main center pads form rectangle with and minor pad right of lower right corner of rectangle

HF
- Symmetric foot pattern
- Center pads are in square with another pad above square, pads in square angled outward

Similar to other "Peromyscine" but much larger size prints differentiate PECA from other Peromyscus species. Adult PECA similar in size to subadult or juvenile NEsp.

Figure 1.10. Forefoot and hindfoot print details for the California mouse, *Peromyscus californicus,* (PECA).

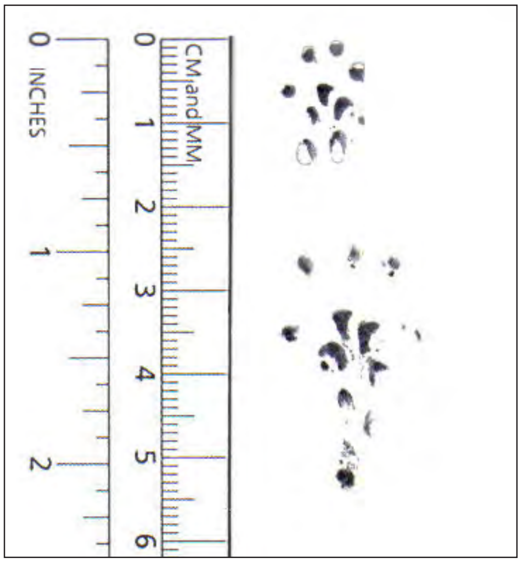
Table 1.6. Track measurement details of the Caliifornia mouse, *Peromyscus californicus.*

[Track measurements are in millimeters. Abbreviations: FF, forefoot; HF, hindfoot; PECA, *Peromyscus californicus*; se, standard error]

		N=6		N=6		N=6		N=6		N=2	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age class**	mean	se	mean	se	mean	se	mean	se	mean	se
PECA	**A**	7.08	0.24	8.50	0.37	9.33	0.33	11.92	1.170	21.00	0.00

Woodrat, *Neotoma* spp. (NEsp)

Neotoma spp. prints would not be collected under normal tracking tube deployment conditions. The maximum 1.5 in. tube diameter excludes very large species such as woodrats. Prints are included for comparison of size and pattern to other species presented in this guide. *Neotoma* spp. prints have been collected when entire track setups are disturbed and/or removed by woodrats attempting to collect either seed or the setup itself.



FF
- Symmetric with no leading toe
- Only four prominent toes in print
- Main center pads form square with center pad over square and minor pad right of upper right corner of square

HF
- Symmetric foot pattern along center toe
- Center toes in "line" with each other
- Center pads are in pentagon shape

Similar to "Peromyscine" mice, but has largest prints. Subadult and juvenile NEsp are similar in size to adult PECA. NEsp have longer prints and a wider HF. Print size separates from all other species.

Figure 1.11. Forefoot and hindfoot print details for the woodrat, *Neotoma* spp. (NEsp).

Table 1.7. Track measurement details of the woodrat, *Neotoma* spp.

[Track measurements are in millimeters. Abbreviations: FF, forefoot; HF, hindfoot; NEsp, *Neotoma* spp.; se, standard error]

		N=3		N=2		N=3		N=3		N=0	
		FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age Class**	mean	se	mean	se	mean	se	mean	se	mean	se
NEsp	**SA**	7.33	0.33	10.00	0.00	10.33	0.93	14.00	1.00	N/A	N/A

	N=1	FF Width		FF Length		HF Width		HF Length		HF Length w/ heel	
Species	**Age Class**	mean	se	mean	se	mean	se	mean	se	mean	se
NEsp	**A**	8.0	0.0	13	0.0	15	0.0	17	0.0	27	0.0

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