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clarification of permit requirements for NMMJM non-invasive survey techniques

1 message

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All,

At the beginning of the optional discussion session on the second afternoon of the recent NMMJM Science Update meeting in Durango, CO, the group asked if a Federal permit was required to conduct non-invasive survey techniques for the jumping mouse, such as track-plating and camera stations. We reached out to biologists and permit coordinators in other FWS regions where similar methods are used for other listed small mammal species, and the consensus was that permits were not required for non-invasive survey techniques.

Although we are currently not requiring a permit to conduct track-plating or camera trap techniques for the NMMJM, we would like to ensure consistency as much as possible in applying these methods. Therefore, we ask that if you plan to implement these survey techniques, you: 1) notify the appropriate lead biologist in the state where the activities will take place prior to implementing surveys (NM: jodie_smithem@fws.gov; CO: alison_michael@fws.gov; AZ: david_r_smith@fws.gov), and 2) you either follow the guidelines in the attached draft manuscript from Harrow et al. (*please note this is still draft so please do not distribute outside of this e-mail group*) or contact us to discuss other possible non-invasive survey methods prior to implementing surveys. I also attached a protocol from Florida where they use track tubes to survey for threatened and endangered beach mice that might be of interest to some of you. Please note they do not utilize two exit strategies in that method though, which is discussed in our biological opinion as being a needed conservation measure for the jumping mouse; therefore, it is not a supported survey design at this time.

We also ask that you please share any results with us from using non-invasive survey techniques at the end of this field season so we can evaluate whether these methods had any unintended consequences for the mouse. If evidence indicates impacts to jumping mice are occurring beyond what other regions of the FWS experience with their listed small mammal species, we will notify this group by the end of the year that permits will be required due to this new information. Otherwise, the determination that permits are not required for these non-invasive survey techniques will stand.

Thank you for your dedication to jumping mouse conservation. Please let me know if you have any questions about the above information.

Jodie Smithem

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2 attachments

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Wildlife Society Bulletin

Track plates detect the endangered New Mexico meadow jumping mouse

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Abstract:	The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*), an endangered subspecies found in the southwestern United States, inhabits riparian areas with tall, dense herbaceous vegetation as habitat. To detect the presence of this species for use in defining life history and habitat use, we developed and tested a non-invasive track plate method. New Mexico meadow jumping mice have unique feet and toes that are readily distinguishable from other small mammals within their geographic range. We created a reference guide for rodent tracks that confirmed the unique footprints of the jumping mouse and tested this method against detection with live traps. When comparing trapping with the track plate method, in only 1 of 16 comparisons did results differ (Spearman's rho = 0.88, P < 0.0001). At 6 sites, jumping mice were not detected using either method, at 9 sites jumping mice were detected by both methods, and at 1 site we captured jumping mice in live traps but did not detect them with track plates. Based on our success with this approach, we developed a 14-minute instructional video (https://www.youtube.com/watch?v=i2x0Ydc1XVM) on assembly, deployment, and interpretation of track plates. Although trapping provided specific information (e.g., demographics, genetic material), track plates detected jumping mice, minimized risk of injury or mortality to animals, and lowered costs of operation.

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RH: Harrow *et al*. • Detecting jumping mice with track plates

Track plates detect the endangered New Mexico meadow jumping mouse

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ABSTRACT The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*), an endangered subspecies found in the southwestern United States, inhabits riparian areas with tall, dense herbaceous vegetation as habitat. To detect the presence of this species for use in defining life history and habitat use, we developed and tested a non-invasive track plate method. New Mexico meadow jumping mice have unique feet and toes that are readily distinguishable from other small mammals within their geographic range. We created a reference guide for rodent tracks that confirmed the unique footprints of the jumping mouse and tested this method against detection with live traps. When comparing trapping with the track plate method, in only 1 of 16 comparisons did results differ (Spearman's rho = 0.88, $P < 0.0001$). At 6 sites, jumping mice

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were not detected using either method, at 9 sites jumping mice were detected by both methods, and at 1 site we captured jumping mice in live traps but did not detect them with track plates. Based on our success with this approach, we developed a 14-minute instructional video (https://www.youtube.com/watch?v=i2x0Ydc1XVM) on assembly, deployment, and interpretation of track plates. Although trapping provided specific information (e.g., demographics, genetic material), track plates detected jumping mice, minimized risk of injury or mortality to animals, and lowered costs of operation.

KEY WORDS Arizona, detection, endangered species, New Mexico, noninvasive methods, survey methodology, track plate, *Zapus hudsonius luteus*

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*; hereafter jumping mouse) is a genetically and morphologically distinct subspecies found in the southwestern United States (Miller 1911, Hafner et al. 1981, King et al. 2006, Frey and Malaney 2009). Jumping mice have an unusual life history because they are active for only 3 to 5 months during summer, hibernating the remaining months of the year (Quimby 1951, Morrison 1990, Frey 2015). The species is considered a riparian obligate that uses tall (≥61 cm), dense herbaceous vegetation along perennial flowing water such as streams, ditches, and wet meadows (Morrison 1990, Frey 2006, Frey and Malaney 2009, Frey and Wright 2011, Frey and Wright 2012). Jumping mice also use adjacent dry upland areas beyond floodplains to nest, raise young, and overwinter (Morrison 1990).

Populations of jumping mice declined or disappeared throughout their range in the southwestern United States; this led to their listing as endangered in 2014 under the Endangered Species Act (ESA; 50 CFR Part 17 2014, USFWS 2014). Loss of habitat is attributed to livestock and water management, development, recreation (impacts from fishing, camping, off-road vehicles, human social trails), and stochastic events such as wildfires and drought (Morrison 1990, Allen et al. 2009, Frey and Malaney 2009, U.S. Fish and Wildlife Service 2014).

Limited information regarding distribution and habitat requirements for the jumping mouse make study of the species important for recovery efforts. Previous survey methods used trapping (e.g., Morrison 1992, Wright and Frey 2015) but risks to animals included stress, injury, and mortality (Sikes et al. 2016). Track plates successfully distinguished species, communities, or activity of small mammals (Carey and Witt 1991, Glennon et al. 2002, Connors et al. 2005). Detecting this species from their tracks as an alternative method of detection could increase survey efficiency.

The range of the Pacific jumping mouse (*Z. princeps*) overlapped the range of the New Mexico meadow jumping mouse in parts of northern New Mexico and southern Colorado (Cassola 2016). No other subspecies of meadow jumping mouse (*Zapus hudsonius*) occurred within the range of the New Mexico meadow jumping mouse species in the southwestern United States (Ramey et al. 2005). Other sympatric species captured with jumping mice included those with different footprints such as deer mice (*Peromyscus* spp.), voles (*Microtus* spp.), and harvest mice (*Reithrodontomys* spp.; e.g., Reid 2006). The feet of other abundant species such as chipmunks (*Neotamias* spp.) and woodrats (*Neotoma* spp.), appeared substantially larger than those of *Zapus*. Because of this, we hypothesized that we could distinguish between tracks of jumping mice and non-target species.

We devised an alternative detection method to assist survey efforts for this species. Our 3 objectives were to assess the ability to differentiate tracks of jumping mice from sympatric species and create a track guide for field use, develop and test a design to collect tracks, and compare the effectiveness of track plating to standard live capture methods. Because our target species was the jumping mouse, we did not attempt to identify to species or genus other species detected on track plates.

STUDY AREA

We conducted work on the Apache-Sitgreaves National Forests in Arizona and the Santa Fe National Forest in New Mexico. The Apache-Sitgreaves National Forests encompassed 1.05 million ha along the Mogollon Rim and the White Mountains in east-central Arizona. The Santa Fe National Forest covers >600,000 ha in northern New Mexico. Annual precipitation averaged 57 cm with annual maximum and minimum temperatures of 14 and -2 ºC, respectively (Western Regional Climate Center 2017).

At both sites, we surveyed along perennial and intermittent streams in meadows between 2000 and 3000 m elevation within the range of the jumping mouse (Morrison 1990, U.S. Fish and Wildlife Service 2014). Meadows frequently occurred along a gradient that included aquatic vegetation near the stream, mesic meadows, dry meadows, ponderosa pine (*Pinus ponderosa*) and mixed conifer forest. These vegetation gradients were closely associated with differences in flooding, depth to water table, and soil characteristics (Judd 1972, Dwire et al. 2006). Ponderosa pine with Gambel oak (*Quercus gambelii*), alligator juniper (*Juniperus deppeana*), and New Mexico locust (*Robinia neomexicana*) dominated at elevations closer to 2000 m. Higher-elevation areas included white fir (*Abies concolor*) and Douglas-fir (*Pseudotsuga menziesii*) with scattered spruce (*Picea* spp.).

For our study, we selected meadows adjacent to riparian areas considered potential habitat for the New Mexico meadow jumping mouse. These riparian meadows were typically dominated by sedges (*Carex* spp.), rushes (*Juncus* spp.), grasses (*Poa* spp.), and forbs (Patton and Judd 1970).

METHODS

Track Comparison and Guide

During a concurrent live-trapping project (Jun to Aug 2015), we obtained tracks of jumping mice for comparison to those of sympatric species and to create a guide comparing footprints of commonly occurring species. We placed individuals in a covered plastic storage box (16.5 x 28.3 x 43.2 cm) partially lined with a track plate that consisted of a 15 x 28 cm piece of self-adhesive paper (e.g., clear matte Con-Tact Brand Clear Covering Self-Adhesive Privacy Film and Liner, Con-Tact, Pomona, CA, USA) placed sticky side up. We centered 1 felt inkpad (5 x 15 cm; 100% polyester) on the self-adhesive paper and attached the track plate to the inside bottom of the box with double-sided tape or adhesive putty placed on the nonstick side of the track plate (Fig. 1A). When an animal stepped on the inkpad, ink would temporarily adhere to its feet. As the animal moved away from the inkpad, its tracks printed on the self-adhesive paper. Bait (a mixture of steel-cut oats and peanuts), placed along the edge of the felt pad and the wall of the box, served as an attractant for the animal.

Holes drilled in the plastic storage box lid allowed airflow. Animals remained inside the box for ≤10 minutes before release at their point of capture (Fig. 1B). We next removed the inkpad and attached the self-adhesive paper with the collected tracks to white paper (22 x 28 cm) labeled with date and species. This paper was then stored in a plastic sleeve in a binder to preserve the tracks (Fig. 1C). Animals were captured and handled under guidelines of the American Society of Mammalogists (Sikes et al. 2016), with the approval of the Northern Arizona University Institutional Animal Care and Use Committee, and under a Fish and Wildlife Service Permit.

We compared tracks of sympatric species with those of jumping mice by measuring fore prints including length (from longest toe to heel), pad width and length (from the 2 points farthest apart), and toe lengths (from the 2 points farthest apart). We also measured hind print length (from longest toe to heel). We compared measurements of fore prints and toes using Kruskal-Wallis tests (Conover 1980). We selected tracks that contained examples of fore and hind prints where toes were clearly distinguishable for comparison of jumping mice to sympatric species in our track guide.

Development of the Track Plate for Field Use

To construct a track plate for field surveys we needed 4 parts: track plate, ink, enclosure (for shelter), and enclosure cover (to protect from inclement weather). The track plate consisted of self-adhesive paper sized to the enclosure, placed sticky side up, and secured to the enclosure with double-sided tape. We saturated the inkpad with the same solution that we selected for track comparison; the inkpad covered ~20% of the track plate. Initially we tested placing the inkpad at the entrances (versus center) of the track plate but we observed these track plates saturated in tracks or smeared ink, leaving them unreadable. We thus placed the inkpad in the middle of the enclosure.

We tested ink solutions created from water or mineral oil and a pigmented powder (carpenter's chalk [e.g., Drennan et al. 1998], carbon black (e.g., Wiewel et al. 2007), graphite powder [e.g., Connors et al. 2005], and charcoal) to determine the best for imprinting tracks. We discarded use of water (dried quickly and left powdery residue that failed to capture tracks), graphite powder and charcoal (these inks did not print well so tracks were difficult to see or did not print). Although carbon black produced sharp, dark prints equivalent to carpenter's chalk, carbon black proved more expensive and difficult to obtain and was listed as potentially carcinogenic. We thus saturated the inkpads with a 1:1 solution of carpenter's chalk (Dewalt, Baltimore, MD, USA) and mineral oil.

From Jun to Sep 2015, we tested 4 enclosure designs for accessibility, protection from weather, and efficiency of data collection. Both the jumping mouse and the technician needed to easily access or handle the enclosure. Wooden roofing or siding shingles (12 x 40 cm) or roofing felt (#30 smooth black asphalt felt 14.5-kg, cut to 30.5 x 48 cm) placed over the shelters blocked precipitation and provided shade and concealment. Enclosures included simple designs easily transported in the field: a folding extra-large 7.6 x 9.5 x 30.5 cm Sherman trap (H. B. Sherman, Tallahassee, FL, USA), a double U-style gutter tube (12.7 x 25.4 cm vinyl, e.g., Geneva Products, Sicklerville, NJ, USA; modified from Drennan et al. [1998]), a single K-style gutter with acrylic base plate (12.7 x 30.5 cm vinyl, e.g., Geneva Products, Sicklerville, NJ, USA), and a plastic, see-through 33.0 x 20.3 x 12.7 cm modified shoebox with snap-on lid (e.g., ULINE, Pleasant Prairie, WI, USA) All designs included 2 entry points to reduce trapping jumping mice or other animals inside (Fig. 2).

The folding Sherman trap required modification to secure its doors in an open position. We inserted a No. 2 pencil under the treadle and placed the enclosure upside down, so the original ceiling served as a smooth surface for the track plate. Two U-shaped pieces of fencing wire staked the enclosure in position and prevented it from folding. A wooden roofing shingle covered the Sherman trap.

We combined 2 U-style gutter pieces to form the double U-style gutter tube oval design. The track plate attached to the smooth floor of the tube and we covered the enclosure with a wooden roofing shingle.

The single K-style gutter with acrylic base plate was held together by 2 rubber bands. The track plate attached to the acrylic base and the enclosure was covered with a wooden roofing shingle.

For the plastic modified shoebox design, we placed the enclosure upside-down with the lid in contact with the ground and the track plate attached to the lid. Holes drilled in the lip of the lid allowed for water drainage when it rained. Two 5 x 5 cm entrances cut offset from one another on the short sides of the enclosure and through the lip allowed entry by animals but kept the locking snaps for the lid intact. Roofing felt covered the enclosure.

With each design, we prepared enclosures for track plating by cutting self-adhesive paper to fit and taping the paper to the flat surface of the box so it covered the entire surface. We mixed carpenter's chalk and mineral oil in a gallon-sized plastic zipper bag, double-bagged to prevent leakage. Thirty felt pads were placed in the ink mixture until saturated. This step was repeated until we prepared enough enclosures for testing.

In the field, we concurrently tested the 4 enclosure types at 3 sites, setting 20 track plates at each site for one week of track plating. We removed the backing of the paper to expose the self-adhesive side, placed an inkpad in center of the enclosure, added bait, and set the enclosure on the ground. We covered each enclosure to prevent rain from splashing inside and affecting the inkpad or tracks. Enclosures were checked every 24 hrs to avoid overprinting (visitation leaving tracks too dense to detect prints of jumping mice) for 3 to 5 days. If a track plate contained tracks, we removed the cover, opened the enclosure, shook out any bait and feces, and extracted the self-adhesive paper. We attached the paper sticky side down on a piece of 21.6 x 27.9 cm white paper, uniquely labeled with date and location. When attaching, we smoothed the self-adhesive paper along the long side to remove air pockets, taking care not to smear any of the inkpad residue over tracks. We then replaced the self-adhesive paper in the enclosure. We also replaced or re-soaked inkpads that appeared dry since they could not produce tracks. When track plates contained no tracks, we reset the enclosure without replacing the self-adhesive paper. Labeled track plates were reviewed for jumping mouse tracks, results recorded on a data sheet, then stored in plastic sleeves in a binder.

Did the Track Plate Method Reflect Relative Abundance from Live Trapping?

We used the modified shoebox design to test efficacy of track plating versus live capture. We sampled 16 sites on the Apache-Sitgreaves National Forests from Jun to Aug 2016 and 2 sites on the Santa Fe National Forest in Jun and Jul 2017. We established a transect at each site, placing flags at 80 points spaced 3- to 5-m apart along the riparian drainage. Flags for the first 2 points were placed upstream on the right side of the stream with the next 2 flags placed downstream on the opposite stream bank. We continued flagging points by alternating every 2 points working downstream along the transect to equally sample both sides of the stream. At each flag, we placed either a track plate enclosure or a Sherman live trap. We randomized which method we tested first (track plating or trapping), conducted comparison trials of the other method within 3 weeks, and used the same transect points for both trapping and track plating. For both methods, we walked in the stream to set and check traps to avoid trampling vegetation used by the jumping mouse. For trapping, we set large Sherman live traps (8 x 9 x 23 cm) at each point on the transect baited with a mixture of steel cut oats and peanuts. We placed polyester batting in traps to provide insulation and covered each trap with a wooden shingle to protect from rain and solar insulation. We set traps each evening ≤2 hrs before sunset and checked them ≤4 hrs after sunrise each morning for 3 concurrent days. Captured animals were identified to species before release. When jumping mice were captured at a site with <3 trap nights, we discontinued trapping if additional trapping might put the species at risk. Our purpose was to detect occupancy and this was achieved at a site with ≥1 capture of a jumping mouse.

We deployed track plate enclosures for 3 concurrent days, checking them daily. Track plates with tracks were collected, labeled, and attached to white paper and preserved in a binder for identification and permanent retention. We used our track guide to identify tracks of jumping mice. Three independent reviewers trained in identification of tracks reviewed each track plate for presence of jumping mouse tracks and recorded whether or not they detected tracks of jumping mice. Jumping mice were considered present at a point on the transect when 3 reviewers reported ≥1 track for the same track plate enclosure.

We compared detection of jumping mice between track plating and live trapping at the site level. We considered the species present if ≥1 jumping mouse was captured or ≥1 track was identified at a site. We compared detectability between track plating and live capture methods and capture rates with a Spearman correlation to test for strength and direction of association between the methods (Myers et al. 2010). In addition, we compared relative abundance of jumping mice (number of captures per 100 trap nights [TN] per site) with detection by track plating (number of track plate enclosures with jumping mouse tracks per 100 TN per site) to determine if higher track counts indicated higher relative abundance of jumping mice at a site. We used a Pearson correlation to compare capture rates between track plates and trapping (Myers et al. 2010). For all tests, we used a *P*-value of 0.05.

RESULTS

Track Comparison and Guide

We collected 1 to 13 tracks each from 21 individuals representing 6 species: New Mexico meadow jumping mice, long-tailed vole (*Microtus longicaudus*), Mogollon vole (*M.*

mogollonensis), montane vole (*M. montanus*), brush mice (*Peromyscus boylii*), and deer mice (*P. maniculatus*) (Table 1). The larger tracks of chipmunks and woodrats made them clearly distinguishable from tracks of jumping mice so we did not statistically compare them. Although we did not capture shrews (*Sorex* spp.) during our project, we did capture them in subsequent tests. Their tracks, smaller than those of mice and voles, were easily distinguishable from those of jumping mice.

Tracks for sympatric species (voles and deer mice) were readily distinguishable from those of jumping mice. We did not detect differences in forefoot pad width and length between jumping mice and sympatric species ($X^2 \leq 8.85$, $P \geq 0.12$); however, the toes on the forefoot of jumping mice were elongated compared to voles and deer mice ($X^2 \geq 13.49$, $P \leq 0.02$; Fig. 3, 4). Because hind prints of deer mice and voles lacked the heel and were thus incomplete, we did not statistically compare them. However, the elongated hind prints and toes of jumping mice (>20 mm; Fig. 4), made them easy to differentiate from those of sympatric species (<14 mm; Fig. 4), even when only partial tracks were recorded.

We selected the best tracks for jumping mice and sympatric species to create a track field guide (Fig. 4). Technicians and those reviewing track plates used the track field guide for identification of tracks during or after field trials of track plate enclosures and comparisons of track plate enclosures with live capture methods.

Development of the Track Plate for Field Use

After testing 4 track plate enclosures to determine which most efficiently recorded tracks of jumping mice, we selected the modified shoebox as our preferred trap plate design. The folding Sherman trap was stable after placement only if we removed or flattened vegetation, rocks, or other debris under the enclosure to prevent it from rolling or collapsing. We found that the U-style gutter tube also rolled easily making it difficult to place on steep slopes, rocky, or shrubby areas. Although the K-style gutter enclosure was stable, it remained assembled as one unit, so was bulky to transport in the field. The modified shoebox design provided a large surface area thus collecting more tracks and protecting the track plate from the environment better than the other 3 designs. It was stable, lightweight, did not compress vegetation, and could withstand heavy rainfall events and flooding.

Testing Effectiveness of Track Plate to Trapping Methods

We captured jumping mice at 10 of 16 sites and identified tracks of jumping mice at 9 of 16 sites (Table 2). Detection differed between the track plate method and trapping at only 1 site. At this site, we captured a jumping mouse but did not detect tracks. Thus both techniques detected jumping mice similarly, regardless of the technique we tested first (Spearman's rho = 0.88, $P <$ 0.0001). In addition, capture rates of jumping mice (number of animals captured per 100 TN) positively correlated with detection by track plating (number of track plate enclosures with tracks per 100 TN; Table 2), suggesting track plates could indicate relative abundance of jumping mice at a site (Pearson's rho = 0.50, $P = 0.047$, Table 2).

DISCUSSION

The short active period for New Mexico meadow jumping mice creates difficulty in surveying for this species with methods limited to a single approach: live trapping. Our track plate approach provided a new effective, non-invasive method for detecting jumping mice. Although tracks of many sympatric species (e.g., voles, deer mice) were indistinguishable using track plates, the unique, elongated hind foot and toes of the forefoot enabled us to easily detect the presence of the jumping mouse. The modified shoebox design provided a large surface area, collected more tracks, and protected the track plate from the environment better than our other designs. It was stable and lightweight, did not compress vegetation, and could withstand flooding.

Our track plate enclosure effectively detected presence of jumping mice and provided similar results to live trapping throughout the summer active period of the jumping mouse. In only 1 comparison did results differ between the 2 techniques when we failed to detect jumping mice with track plates but did capture them. At this site, capture rate was low (only 1 jumping mouse captured) which could have affected detectability. We also observed at least 1 failure of a jumping mouse to leave tracks on a track plate. On 2 occasions at other sites, technicians encountered jumping mice sitting inside track plate enclosures when they checked track plates. In 1 of these enclosures, the jumping mouse left no tracks, thus we were aware of a detection error at that track plate enclosure. Low densities of jumping mice or inadequate ink could therefore affect detectability.

The proportion of track plate enclosures at a site with jumping mouse tracks correlated positively with a measure of relative abundance from trapping. Brown et al. (1996), Drennan et al. (1998), Glennon et al. (2002), Wiewel et al. (2007), and Rytwinski and Fahrig (2011) also found that track plates provided good indices of abundance for other mammals. However, Wiewel et al. (2007) described their track plate index as only a "moderately adequate" predictor of small mammal population estimates because this relationship varied among years. Carey and Witt (1991) found that track plates did not effectively reflect abundance of Douglas' squirrels (*Tamiasciurus douglasii*) but did for flying squirrels (*Glaucomys sabrinus*). We caution interpreting relative abundance of jumping mice from a track plate index; however, we believe that our index provided a reasonable approximation.

We found no evidence that track plating resulted in injuries to animals. In addition to reliability, our track plates also reduced risk of stress, injury, hypo- and hyperthermia, and mortality to jumping mice. During rain events, animals could exit track plate enclosures before flooding and because enclosures floated, they could easily be recovered and reused. The 2 entrances of the enclosure prevented jumping mice from being trapped by predators (Table 3).

Survey sites for track plating could be more broadly dispersed than trapping since checking track plates was less time sensitive (e.g., with live trapping, animals must be removed from traps before temperatures rise and heat up the inside of traps; Table 3). In 2016, we successfully used track plating (66 sites), in combination with live trapping (19 sites), to survey 85 sites for jumping mice across the Apache National Forest (C. L. Chambers, Northern Arizona University, unpublished data). Surveying such a large area would not have been possible if using only live trapping because of the time required for trapping unless the number of technicians was substantially increased.

Our track plate enclosures were easy to use and inexpensive (Table 3). Materials (plastic shoeboxes with strong snap-on lids) were readily available in stores or online. We found that clear boxes worked well, as they did in another riparian study monitoring small and medium-sized mammals (Loukmas et al. 2003). Using 1 box type per project allowed stacking for easier transport. Technicians could quickly learn how to construct enclosures and set, interpret, and store track plates. Checking enclosures was less time sensitive than trapping, although track plates needed daily checks to avoid overprinting on track plates. Track plates required only 1 surveyor and 1 visit per day (although efficiency increased with more surveyors), and could be checked any time of the day (Table 3). Track plates also reduced risk of technicians to exposure of diseases (e.g., hantavirus; Drennan et al. 1998, Connors et al. 2005).

Despite their many advantages, track plates did not allow identification beyond genus, of individuals, or collection of demographic data in our study. If jumping mice did not contact inkpads or inkpads dried, no tracks imprinted. Track plates needed daily checking to avoid high densities of tracks that could obscure tracks of jumping mice. At 1 site, ≥1 raccoon (*Procyon lotor*) smeared ink across many track plates when retrieving bait, making track plates unreadable. Because multiple individuals and species may use a track plate, genetic analysis of samples (e.g., feces, hair) left by animals should be conducted with caution to make sure data are collected only for the target species (Table 3). In areas where other species or subspecies of jumping mice overlap, our track plate method should be used only when identifying to genus since we think it unlikely that tracks differentiate between species or subspecies of jumping mice (e.g., in parts of northern New Mexico or southern Colorado). We also found that setting and checking track plates offered no substantial time saving over live trapping.

Track plates improved our ability to detect and monitor jumping mice, estimate population size, and determine distribution and habitat use (e.g., Clevenger et al. 2001, Cain III et al. 2006, Ray and Zielinski 2008, Rytwinski and Fahrig 2011). They can also make regional survey and monitoring approaches more feasible (Zielinski and Truex 1995). Based on our success with this technique, we developed a 14-minute video (Martinez-Fonseca and Chambers 2016) that demonstrated how to assemble, deploy, interpret, and archive results of track plates. This video can help train researchers on use of this method to survey New Mexico meadow jumping mice. As with trapping, track plating requires a permit from Fish and Wildlife Service (ESA; Section 10a1A).

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Figure 1. Collecting tracks to create a track guide for distinguishing New Mexico meadow jumping mice (*Zapus hudsonius luteus*) from sympatric species. A. Set up of a track plate box to collect tracks from live-captured small mammals. B. Collecting tracks from Mogollon vole (*Microtus mogollonensis*) with release at point of capture. C. Archiving tracks of a known species.

Figure 2. Four box designs for collecting tracks of New Mexico meadow jumping mice on the Apache-Sitgreaves National Forests, Jun – Aug 2015. Designs included (L to R) a K-style gutter with acrylic base plate, a double U-style gutter tube, a folding, small Sherman trap, and a plastic modified shoebox. The modified shoebox was the most efficient and effective design.

Figure 3. Average length (mm) of individual fore print toes for 6 rodent species on the Apache-Sitgreaves National Forests, AZ, Jun – Aug 2015. Fore print toes (1 to 4) of New Mexico meadow jumping mice were longer than those of voles (Mogollon vole, long-tailed vole [*M. longicaudus*], montane vole [*M. montanus*]) and deer mice (deer mouse [*Peromyscus maniculatus*], brush mouse [*P. boylii*]).

Figure 4. Elongated hind print and length of the fore print toes of jumping mice distinguished their tracks from deer mice and voles. Rodent tracks were collected on the Apache-Sitgreaves National Forests (ASNF) Jun – Aug 2015.

Table 1. Mean number of tracks per individual measured for live-captured New Mexico meadow jumping mice and sympatric species with *SE* and range, Apache-Sitgreaves National Forests, Jun – Aug 2015; *n* represented the number of individuals per species.

Species	*n*	Mean # tracks per individual	*SE*	Range
New Mexico meadow jumping mouse	5	3.60	0.68	2 to 5
long-tailed vole	3	7.33	2.85	4 to 13
Mogollon vole	3	7.33	0.88	6 to 9
montane vole	5	4.40	1.44	1 to 9
brush mouse	2	9.00	0.00	9
deer mouse	3	7.33	1.76	4 to 10

Table 2. Comparison of live trapping and track plating methods used to detect New Mexico meadow jumping mice on the Apache-Sitgreaves (ASNF) and Santa Fe (SFNF) National Forests, Jun – Aug 2016 and Jun - Jul 2017. For Trap and Track plate, “no” indicated jumping mice were not detected by a method, “yes” indicated they were. First identified the method tested initially (i.e., if ‘trap’ then the site was trapped first, then track plated second); methods were not conducted simultaneously. Number of jumping mice captured per 100 trap nights (TN) (#animals per 100 TN) correlated with number of track plate enclosures with jumping mice tracks (#enclosures per 100 TN).

Site Number	Year	Location	Trap	Track plate	First	#animals per 100 TN	#enclosures per 100 TN
13	2016	ASNF	no	no	trap	0	0
15	2016	ASNF	no	no	trap	0	0
16	2016	ASNF	no	no	trap	0	0
38	2016	ASNF	no	no	trap	0	0
39	2016	ASNF	yes	yes	track plate	2	13
42	2016	ASNF	yes	yes	track plate	2	5
48	2016	ASNF	no	no	trap	0	0
52	2016	ASNF	yes	yes	track plate	1	8
60	2016	ASNF	yes	yes	trap	1	3
73	2016	ASNF	yes	yes	trap	2	19
77	2016	ASNF	no	no	trap	0	0
26	2016	ASNF	yes	yes	trap	5	20
63	2016	ASNF	yes	yes	track plate	3	8

66	2016	ASNF	yes	no	track plate	1	0
0	2017	SFNF	yes	yes	track plate	11	10
4	2017	SFNF	yes	yes	track plate	4	1

Table 3. Comparison of live trapping versus track plating methods to detect New Mexico meadow jumping mice in the southwestern United States.

	Trapping	Track plates
Identification	Very difficult to misidentify	Possible to misidentify or miss tracks although tracks are distinctive
	Can obtain demographic data, genetic samples	Only presence detected
Weather	Chance of mortality or injury during flooding, cold or hot temperatures	Unlikely to injure animal
Procedure	Checked daily to release animals	Checked daily to avoid overprinting
	Multiple sites must be in close proximity or use 1 qualified team/site	Multiple sites can be broadly dispersed
Trap	Must be moved outside of riparian area if flood events are likely	Can leave in riparian zone; track plates float so can be recovered
	Animal trapped inside until trap checked	2 entrances avoid trapping animals
Personnel	≥2 required to expeditiously check traps at dawn, must be reset at dusk	1 can check although >1 increases efficiency especially when setting >20 track plate enclosures
	Work must be at dawn and dusk; potential for surveyor fatigue given daily schedule	Work times flexible; lower potential for surveyor fatigue
	Risk of disease exposure (e.g., hantavirus)	Low to no risk of disease exposure
Trap materials	Must be ordered	Easy to obtain locally although if large numbers

		needed materials should be ordered
Cost of trap	~\$28 per trap	~\$5 per track plate enclosure
Regulatory	Chance of take	Little to no chance of take
	FWS permit required	FWS permit required

Figure 1. A.

558x842mm (72 x 72 DPI)

Figure 1. B.

838x558mm (72 x 72 DPI)

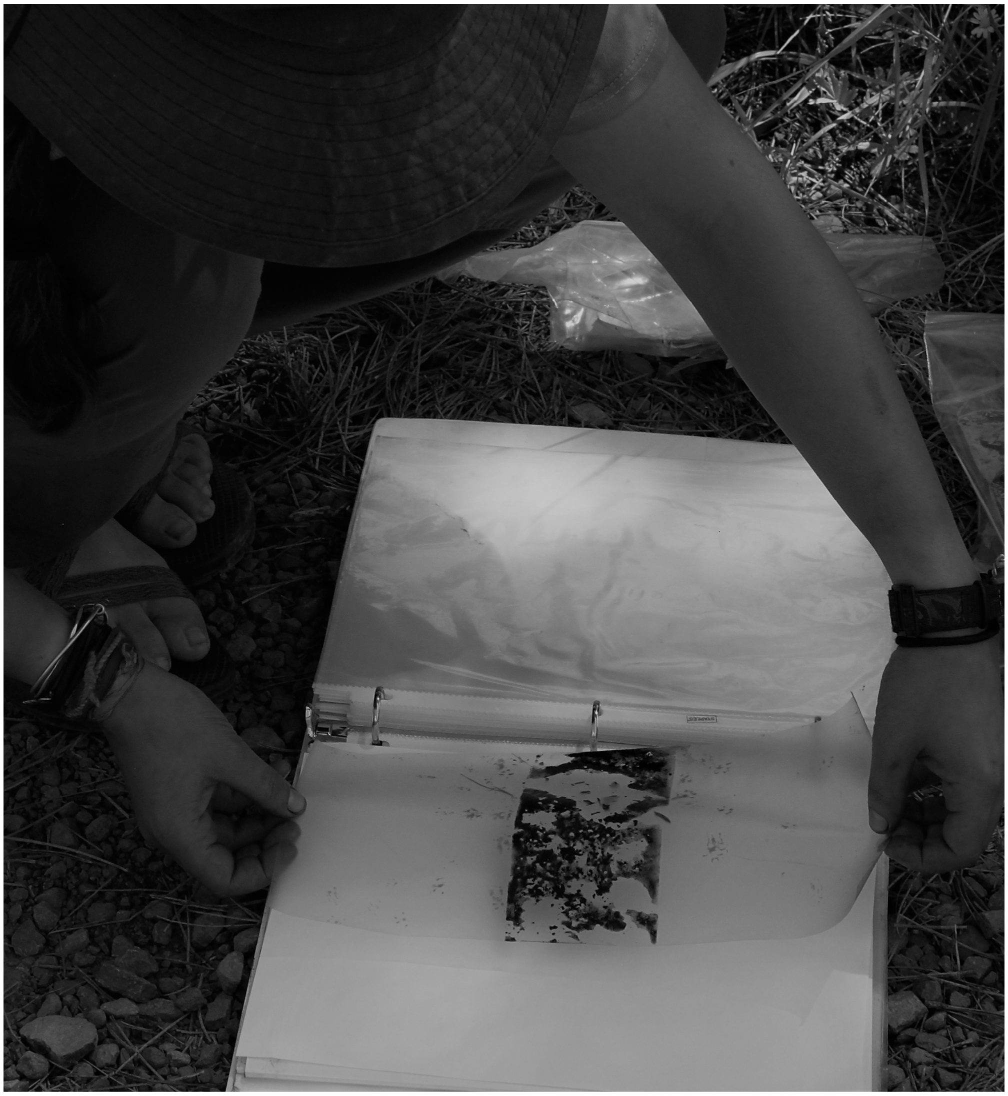


Figure 1. C.

1021x1111mm (72 x 72 DPI)

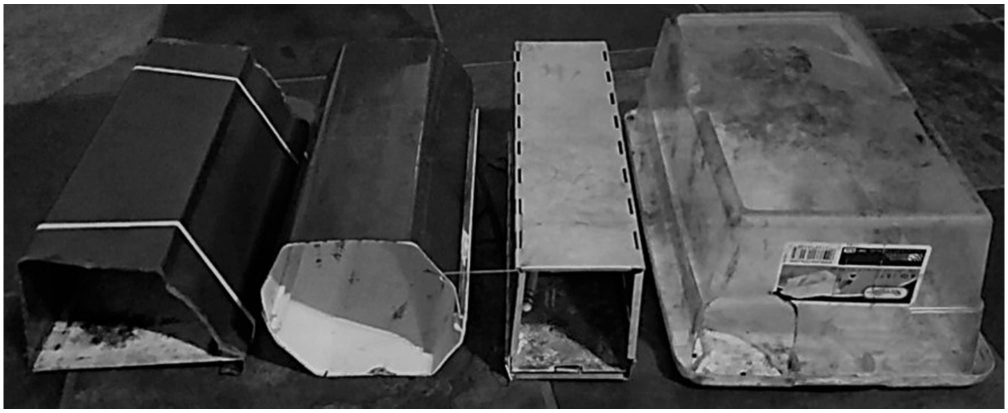
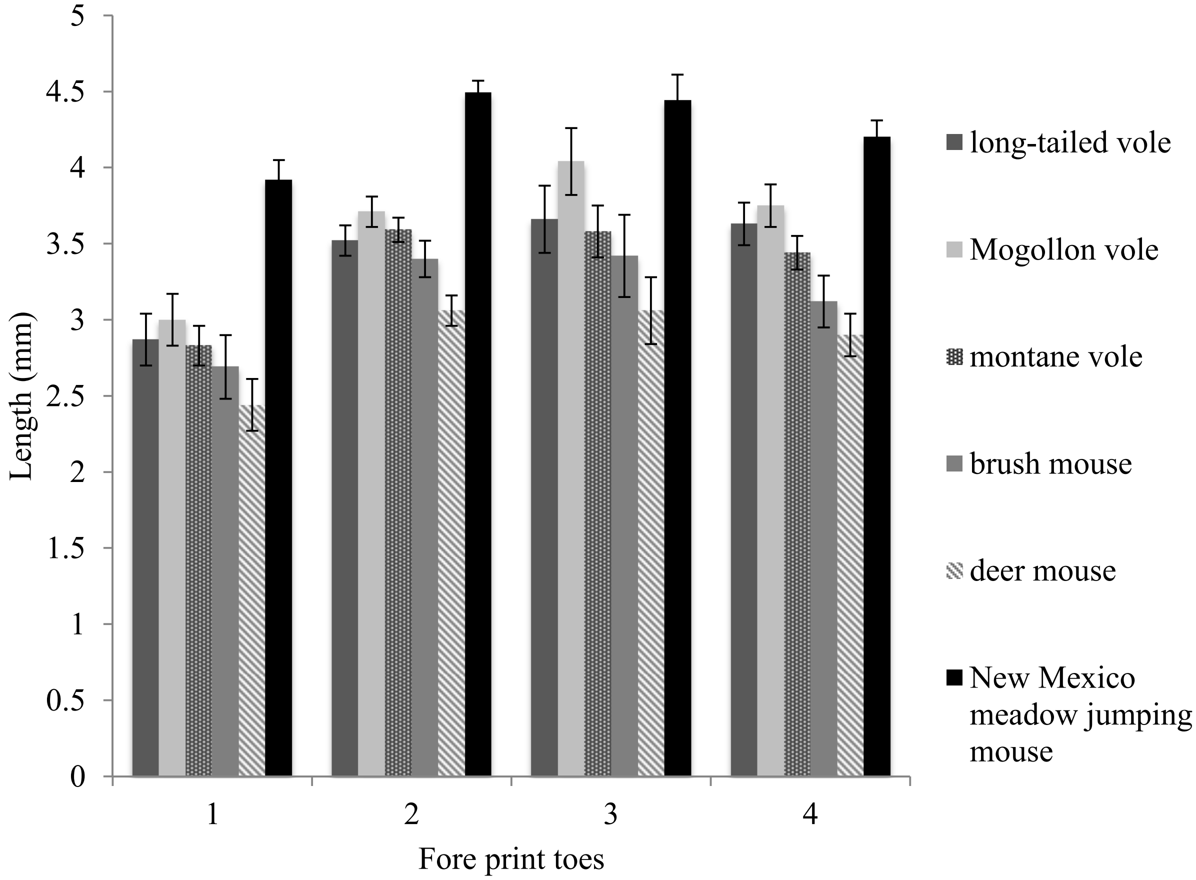
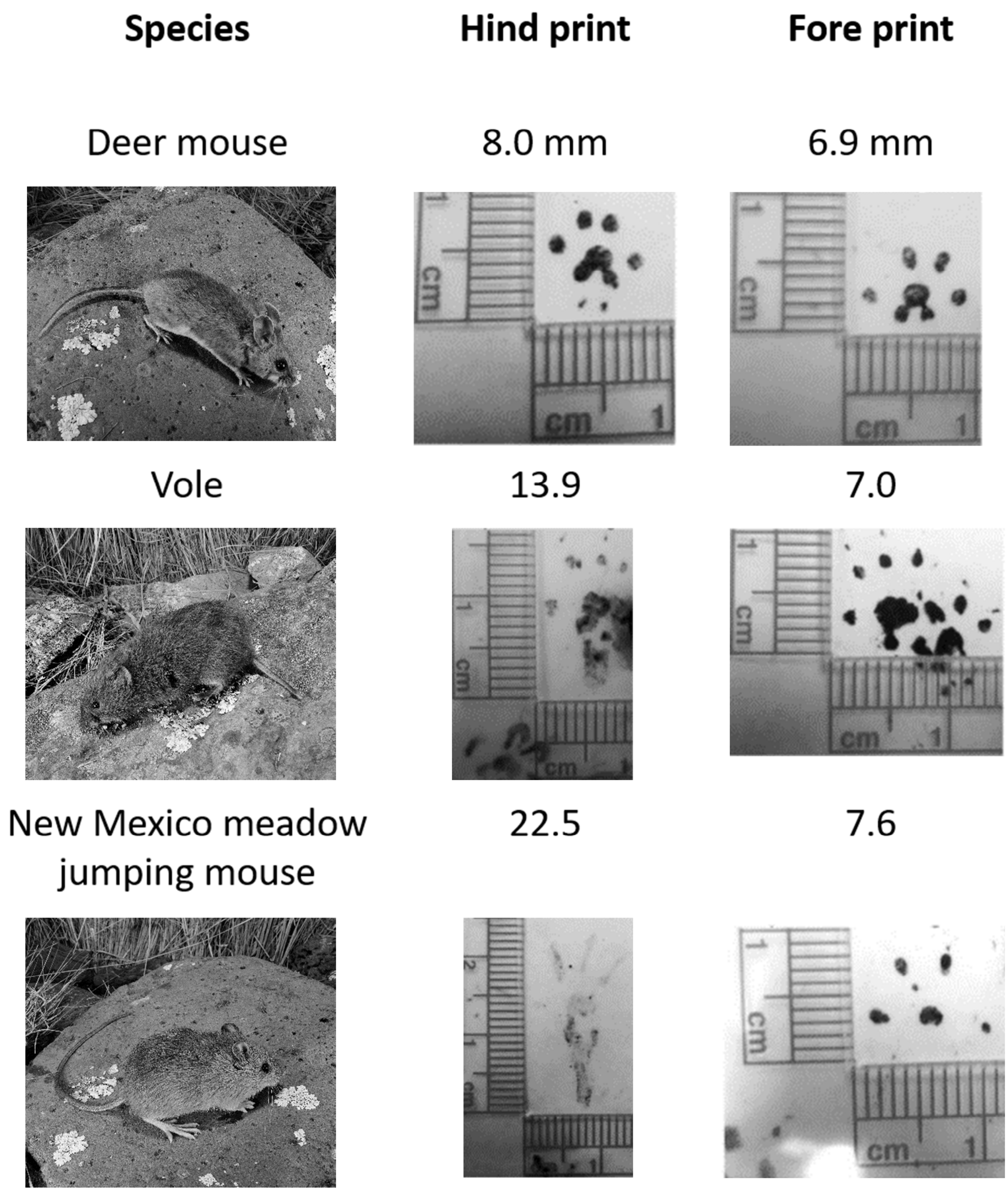


Figure 2.

234x94mm (96 x 96 DPI)


5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Length (mm)
1
2
3
4
Fore print toes
long-tailed vole
Mogollon vole
montane vole
brush mouse
deer mouse
New Mexico meadow jumping mouse


Species
Hind print
Fore print
Deer mouse
8.0 mm
6.9 mm
Vole
13.9
7.0
New Mexico meadow jumping mouse
22.5
7.6

Beach Mouse Tracking Tubes

Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
May 2006

Beach mice are often detected by live trapping surveys and visual tracking surveys. Although live trapping provides much valuable information about individual mice and the population in the area being trapped, it can become expensive, very time intensive, and can be stressful on the mice and thus is not feasible to perform live trapping surveys more often than on a quarterly basis. Visual tracking surveys are much less intensive, easier to perform, can be done frequently, and provide information about mice presence in an area. However, visual tracking surveys are extremely subjective and dependant on weather and sand conditions. Any rain event or high winds in the 24 hours prior to the visual tracking survey significantly alter results and often may result in no record of tracks even if mice are present. Even with good sand conditions, an inexperienced surveyor may have difficulty detecting or distinguishing tracks if they are not plentiful or clear, resulting in inconsistent surveys.

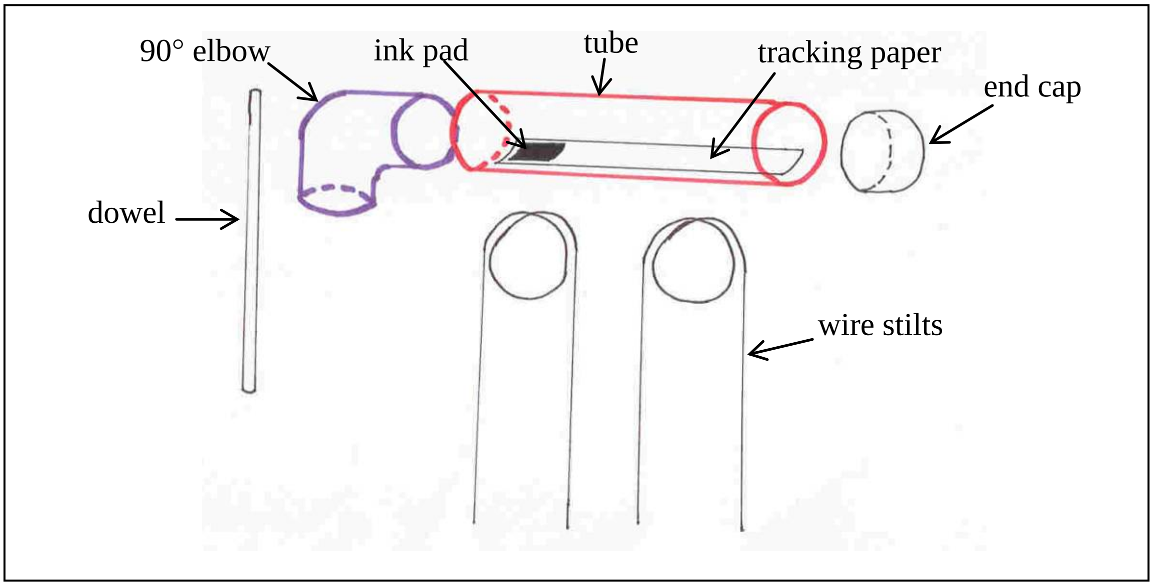
Tracking tube surveys have been developed to incorporate the ease and frequency of visual tracking surveys with the subjectivity of live trapping. Tracking tube surveys require relatively simple set up and can be run very easily on a monthly basis. A large area can be surveyed with a few persons at a low cost. The tube design excludes most critters except mice and is watertight, thus a rain event does not alter surveys results. Tracking tube surveys provide information about mouse presence/absence and distribution and should be done in conjunction with live trapping surveys, not in place of them. However, the frequency and intensity of live trapping surveys can be reduced when done with tracking tube surveys. Done this way, live trapping can confirm the species recorded from the tracking tube surveys.

Following is a description of all the components needed for a tracking tube survey along with directions for assembly. Tracking tube surveys for your area should be developed and overseen by a biologist but may be executed by anyone with sufficient training.

A. Materials needed for one tube

1 1ft section of 2” PVC pipe
1 2” PVC end cap
1 2” PVC 90° elbow
1 9” section of ⅜” dowel
2 9 gage wire stilts
1 tracking paper (see “Tracking Papers” section for paper assembly)
1 small pinch of bait (we recommend black oil sunflower seed – substitutes could be rolled oats, mixed seed, etc.)

Figure 1. Schematic diagram of a tracking tube and its components



B. Tube Assembly

- Slide each wire stilt onto the tube
- Secure the end cap and elbow onto each end with the elbow pointing downwards (Fig. 1).
- Place the dowel into the sand.
- With one hand on the top of each stilt, push the stilts into the sand so that the dowel is inserted into the elbow.
- There should be a 1 ½” to 2” space between the sand and the opening of the elbow. The dowel should be touching the inside of the elbow and the top of the dowel should be touching the top of the elbow (Fig. 2).
- Tracking papers can be inserted by removing the end cap and sliding the paper in so that the ink pad is towards the elbow. Papers can be curled slightly so that they will slide easily into the tubes.
- Place the bait on the end of the paper that is near the end cap, or in the end cap itself.
- Place a small amount of seed on the ground near the opening of the tube.

Figure 2. Assembled tracking tube.

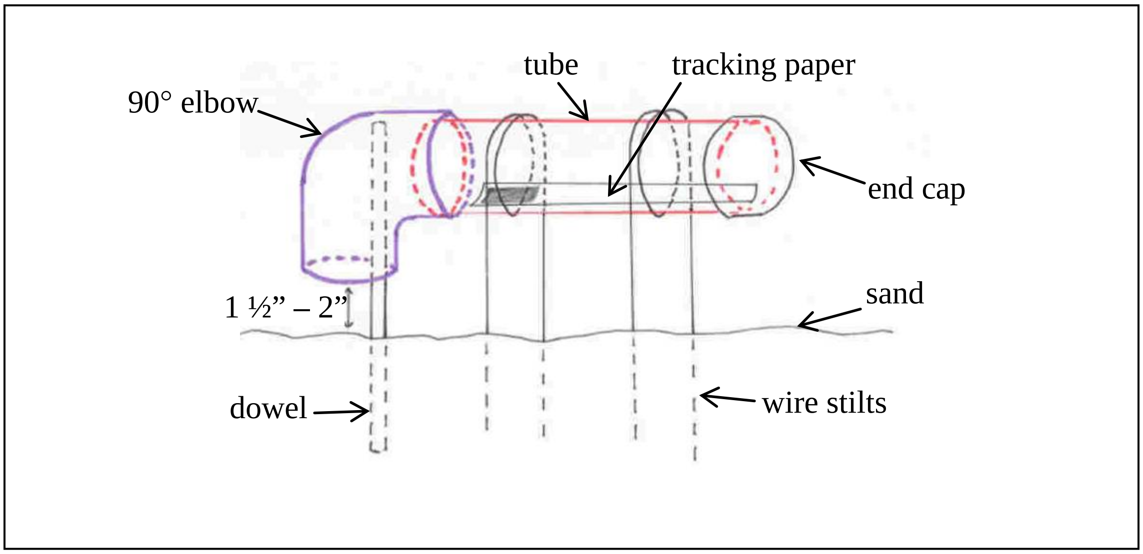


Figure 3: Setting tracking tube in the sand

Figure 4: Inserting inked paper and bait into tube

Figure 5: A set tracking tube

C. Tube Placement

In the field, tubes should be placed in a grid or at designated points depending upon sampling design. Tube placement should be marked with a pin flag or flagging tape. Also, a GPS location should be recorded for each tube.

D. Interpreting Tracks on the Tracking Papers

The tracking tubes are designed to exclude raccoons and other large predators. However, anything beach mouse sized can potentially enter the tube and leave tracks. This could include other rodents (e.g., house mice or cotton mice), lizards, frogs, or snakes. The bait will help to draw in rodents, and, therefore most of the tracks collected will be of rodents. Some tracks from mice species can be fairly easily distinguished based on size. Beach mouse tracks may range in size from 5.0mm to 7.0mm in width while cotton mouse tracks may vary from 7.0mm to 10.0mm in width.

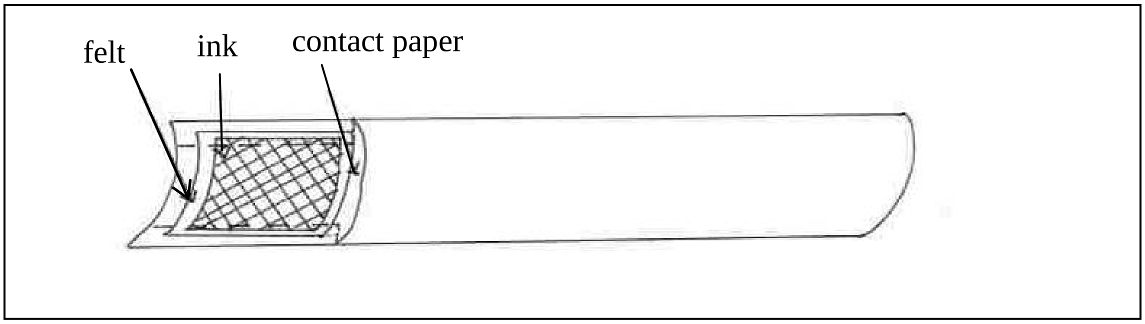
E. Paper Components

- 2” wide strips of cardstock paper
    - Wausau Paper Exact® Index, white, 110 lb., smooth finish, #49411
- 1.5” x 1.5” pads of felt
    - 8.5” x 11” craft felt, white
- 2.5” x 2.5” square of contact paper (6x6 grid)
    - Kittrich Clear Plastic Film, 18” x 7.5’
- All-purpose sealant
    - Liquid Nails® brand Sealant, Clear Seal

F. Preparing Papers

- Cut cardstock paper into strips
- Cut felt into squares
- Cut contact paper into squares
- Stick contact paper square on end of paper strip and overlap the sides
- Glue the felt pad onto the contact paper so that it does not touch the paper
- Ink is applied by gloved hands with an aspirator bulb so that the felt pad is covered, but no ink is touching the edges of the pad (Fig. 6).

Figure 6. Tracking paper with ink.



G. Ink Components

- Food Grade Mineral Oil
  http://www.steoil.com/
  Catalog #70FG-5GAL
  STE Oil Company
  2001 Clovis Barker Rd
  San Marcos, TX 78666
  (800) 967-1931

- Carbon Lampblack
  https://www1.fishersci.com/index.jsp
  Fisher Scientific
  Catalog # C198-500
  1-800-766-7000

H. Preparing Ink

- Mix 2 ½ parts mineral oil to 1 part powder
- Measure powder into container first, then add oil
- Seal container tightly and mix thoroughly
- IMPORTANT SAFETY TIP – Wear protective goggles and dust mask when working with carbon powder. Latex gloves are recommended for cleanliness. Follow all safety instructions provided by supplier.
- It is recommended to store a large quantity of mixed ink in a lab or other facility and carry small containers of ink into the field or other areas where tracking papers will be inked. Before using ink from any container, be sure to mix thoroughly, as the carbon powder will settle to the bottom over time.
- A small shallow container with a screw off lid works best to carry ink into the field without leakage. Ink can be drawn from container with the aspirator bulb and applied to the tracking papers. Enough ink should be applied to soak the felt, but it should not wick or run off the felt even if the paper is turned on its side.
- Several papers can be prepared at once and carried in a plastic bag or box. These papers should be carried with inked pads facing one another so the ink does not come in contact with adjacent papers.

I. Collecting the Papers

Tubes can be checked at anytime during the day by removing the end cap and sliding the paper out. Tubes may stay in the field with no papers if personnel or equipment are not available to remove them when the survey is complete.

NOTE OF CAUTION: When checking tubes during the day, poisonous snakes may be curled inside! Tubes should always be opened away from you and visually inspected before reaching fingers inside!

When the tracking tubes are checked, any tracking papers with prints or marks of any kind should be collected and recorded. Data sheets should be filled out in the field as papers are being collected. For each tracking paper with marks or tracks, cut the inkpad off and dispose of it into a plastic bag. On the back of the tracking paper record the:

- Date
- Location
- Grid #
- Species (if known)

Store tracking papers and submit with data sheets. If there is a question as to the species leaving a track, record as unknown and submit with the rest of the tracking papers and data sheet. If there are distinguishable tracks from more than one species, record both species on the tracking paper and the data sheet.

J. Tracking Tube Ink Safety

Carbon lampblack suspended in mineral oil for use as an ink in animal tracking was proposed by (Mabee 1998). Subsequently several authors (Glennon et al. 2002; Nams and Gillis 2003) have used it successfully in investigations of small mammal populations. Both chemicals were evaluated for their potential effects on beach mice by reviewing the Material Safety Data Sheet (MSDS) for each product. The routes of exposure of greatest potential for both chemicals were determined to be through skin absorption in the feet and ingestion.

Based on the MSDS information for the 70 weight food grade mineral oil from STE Oil Co. Inc. (San Marcos, TX), it was deemed to be safe to animals for short term exposure having a health hazard rating of insignificant. The health hazards section of the MSDS for mineral oil indicated that no skin irritation was expected from short-term exposure. Further, ingestion of the mineral oil may produce a laxative effect and be irritating to the digestive tract. This avenue of exposure could occur if the beach mouse ingests the mineral oil when grooming. We believe that the amount of mineral oil consumed would be insignificant as much of the oil would likely be removed from the animals feet as it traveled across the tracking paper and through the substrate and leaf litter surrounding the trap. Lastly, the MSDS listed no significant signs or symptoms indicative of any adverse chronic health effects related to the exposure.

Based on the MSDS information for the carbon lampblack from Fisher Scientific (Pittsburgh, PA), it was deemed safe to animals for short term exposure. The health hazards section of the MSDS for carbon lampblack indicated that some skin irritation may occur. We believe that this risk is mitigated by the fact that carbon lampblack, along with the mineral oil, is quickly transferred to the tracking surface and would likely be removed from the feet while walking across the substrate and leaf litter surrounding the trap. The MSDS indicated that ingestion of carbon lampblack in large amounts may cause gastrointestinal irritation. The amount of carbon lampblack ingested by any animal would not be great. Further the oral LD50 for rats is >15,400 mg/kg (15.4 g/kg). There are no chronic health effects listed in the MSDS associated with exposure to carbon lampblack. Therefore the risk to exposed animals is minimal.

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