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Tools and Technology

Determining and Demonstrating the Importance of Training and Experience for Managing Pocket Gophers

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ABSTRACT The pocket gopher (*Thomomys* spp.) is one of the most damaging wildlife species in California, as well as other locations throughout the United States. Several techniques are used to manage pocket gophers, including trapping and rodenticides. Improved protocols to increase the efficacy of rodenticide baiting programs, and quantifiable information on the time required to become a proficient pocket gopher trapper, would assist individuals interested in developing an Integrated Pest Management program for pocket gophers. Therefore, I initiated a study to address the following objectives: 1) determine the number of days required to become a proficient pocket gopher trapper; and 2) determine the impact of a thorough training program on efficacy of a rodenticide baiting program for managing pocket gophers. I determined that novice trappers became proficient with only 3 days experience (94% of the efficiency obtained by an expert trapper). Capture rates for novice trappers also exhibited a dramatic increase in just 3 days, although rates were not as proportionally high (77% of expert trapper). Clearly, the time required to set traps and detect active burrows should continue to decrease as trappers gain more experience. Baiting trials indicated that individuals who received a through training program on bait application were 3.6 times more likely to attain greater efficacy from baiting programs than were individuals who received only limited training. Proper training, particularly on identifying active tunnel systems, clearly increased the efficacy of baiting programs. These results should increase the applicability of both trapping and rodenticide baiting in pocket gopher management programs.

KEY WORDS California, pocket gopher, rodenticide, *Thomomys* spp., training, trapping experience.

Pocket gophers (*Thomomys* spp.) are one of the most damaging wildlife species in the state of California, USA (Marsh 1992, Baldwin et al. 2014) and are considered a major pest throughout their range (Engeman and Witmer 2000). Damage caused by pocket gophers is often varied but includes damage to irrigation drip lines from chewing, and consumption of plants and root systems resulting in reduced vigor and higher mortality in crops and lawns (Baldwin et al., 2014). Pocket gopher mounds can also serve as weed seed beds, can result in a loss of irrigation water down mounds and tunnels, and can damage farm equipment that is driven over mounds (Witmer et al. 1999, Baldwin et al., 2014). Several management options are available for pocket gophers, including trapping and rodenticides.

Several studies have shown trapping to be an effective method for removing pocket gophers from agricultural and forested areas (Smeltz 1992; Proulx 1997*a*, 2002). Trapping has many positive attributes, including the fact that it is safe for users given the lack of use of toxic baits; there is no concern of primary or secondary non-target rodenticide exposure (although there is a very remote chance of non-target captures using traps (approx. 1 non-target capture in 5,000 trap-nights in vineyard sites; Witmer et al. 1999); trapping is one of the only methods available for removing pocket gophers in organic crops; trapping provides certainty as to whether or not you removed the invading pocket gopher; and trapping has been shown to be both effective and cost-efficient once the user becomes proficient (Proulx 2002). However, the time period required to become proficient at trapping may discourage many individuals from incorporating trapping into a management program because many individuals feel that trapping is too time-consuming to be practical for large populations of pocket gophers (Engeman and Witmer 2000). This may be true in areas with heavy soils or deep pocket gopher burrows, but in areas with looser soils and shallower burrow systems (<25 cm), trapping can be practical. Data exhibiting the period of time required to become a proficient trapper are needed to provide growers, Pest Control Advisors, and Pest Control Operators with an expectation of what efficacy and efficiency they can hope to achieve if they decide to incorporate a trapping regimen into their pocket gopher management program.

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Rodenticide baits are also frequently used to manage pocket gophers. Several different active ingredients (including strychnine, zinc phosphide, and anticoagulants) have been used, although strychnine-laced grain has typically been reported as the most effective bait (Marsh 1992). Baiting for pocket gophers is often considered an easier and quicker method for managing populations. However, numerous trials baiting with strychnine have yielded varied results, with efficacy ranging from 0% to 100% (Tickes et al. 1982, Evans et al. 1990). It is unclear why these results have varied so dramatically although possible reasons include 1) differences in pocket gopher species, 2) availability of alternative food sources (Proulx 1998), 3) seasonality (Tunberg et al. 1984, Proulx 1998), 4) soil type and soil moisture (Tunberg et al. 1984), 5) behavioral or physiological resistance to strychnine (Lee et al. 1990, Marsh 1992), and 6) bait applicator experience. Little can be done to remediate the impact of the first 5 listed possibilities in this list, but a thorough training program could increase applicator proficiency and result in a more effective pocket gopher management program.

Although both trapping and baiting programs can be effectively used to manage pocket gophers, relying on any single one of these approaches is not likely to be as efficacious as the utilization of multiple management methods (i.e., Integrated Pest Management; Engeman and Witmer 2000). For an Integrated Pest Management program to be effective, all individuals should be properly trained to implement management practices, because greater experience is likely to lead to a greater reduction in pocket gopher populations. Unfortunately, time is often limited for growers and farmers, so proper training of farm laborers may not always occur. Improper training has numerous potential ramifications including low efficacy of management methods, elimination of a population reduction technique from a management program given perceived low efficacy, increased damage to commodities due to low efficacy, and unwanted mortality of non-target species. For example, minimal training on bait application for pocket gophers may result in an insufficient amount of bait being applied to pocket gopher burrow systems, thereby reducing the efficacy of this approach. Alternatively, insufficient experience with pocket gopher trapping could lead to low capture rates and cause the grower to eliminate this tool from their management program because of the perceived low efficacy of this approach. The extent to which proper training and experience reduces these pitfalls is currently unknown and in need of investigation. Therefore, I established the following objectives to elucidate the impact of user experience on trapping and baiting for pocket gophers (*Thomomys bottae*). Specifically, my objectives were to 1) evaluate the progression in efficiency of newly trained pocket gopher trappers, and 2) evaluate the merit of a thorough training program on bait application for pocket gopher management. The results from this study should aid the development of an Integrated Pest Management program for managing pocket gophers and will hopefully result in more efficacious and cost-effective management of this damaging species.

METHODS

Trapping

This study was conducted at Laguna Ranch, located approximately 6.4 km west of Santa Rosa, California. Laguna Ranch was a vineyard owned and operated by Gallo Family Vineyards. For the trapping portion of this investigation, I selected 2 and 5 novice trappers to trap pocket gophers in spring of 2010 and 2011, respectively. I provided a short 30-min training session on how to trap pocket gophers to all participants. I selected the time-period and depth of the training session to represent what I believe is the typical level of training that most farm workers receive before starting a pocket gopher removal program.

After this training session, the selected individuals initiated their trapping program. Laguna Ranch was separated into many different blocks of varying shapes and sizes. Pocket gopher activity naturally varied across differing blocks, so it was important to keep each individual trapper within the same block for the duration of the study to maximize the probability that pocket gopher activity would remain fairly consistent throughout the course of the trapping period. The 2 trappers that trapped in 2010 were in areas with greater pocket gopher activity; as such, they trapped for an 8-hour period. The individuals that trapped in 2011 were in areas with somewhat lower pocket gopher activity, so they trapped only until they placed traps into 40 burrow systems per day. Trapping occurred for 4 days in spring 2010 (11–14 May), and 2011 (22–23 March and 3–4 April), although one individual was only able to trap for the first 2 days in 2011.

In addition to novice trappers, I also monitored an expert trapper (experience of >2,000 trap-sets placed) to provide capture values to illustrate the desired level novice trappers could attain for their respective sites. This individual set a minimum of 20 trap-sets adjacent to each trapper so as to minimize potential differences in capture rates across field locations. I used the Gophinator trap (Trapline Products, Menlo Park, CA) for this study, because it has proven to be an effective pocket gopher trap for *Thomomys* spp. (Baldwin et al. 2013).

The general trapping protocol for this study involved the use of a probing device to locate a fresh pocket gopher tunnel. Once located, trappers dug down to the tunnel, placed traps into all branches of the pocket gopher tunnel, and staked the traps down with wire flags. Trappers placed traps wherever they felt there was a good probability of separate mounds representing separate burrow systems (typically >6.1 m apart). Trappers made this determination by scanning for general mounding patterns to determine whether it seemed particular mounds were likely connected to other adjacent mounds and by assessing the distance and freshness of adjacent mounds. I followed this protocol given that this is the strategy most trappers would employ when attempting to remove pocket gophers from a given area. Traps were placed and left overnight. Although trappers wore leather gloves to protect their hands while setting traps, no specific attempt was made to hide human scent from pocket gophers given no evidence that human or trap scents deter pocket gophers from traps.

I recorded the time required to place all traps for each trapper per day. I then checked the traps for activity the following day. I recorded each trap-set as either 1) a capture, 2) sprung or plugged, or 3) no action. Typically, only one pocket gopher was captured per trap-set because of the species' solitary nature. However, when I did observe multiple captures at the same trap site, I counted them as a single capture event. I removed all traps after checking for activity regardless of action at that site.

Capture efficiency and capture rate were the 2 primary response variables of interest. I defined capture efficiency as the number of trap-sets with pocket gopher captures per total number of trap-sets; this proportion was multiplied by 100 to yield a percentage. I defined capture rate as the number of pocket gophers captured per hour; this was determined by dividing the number of trap-sets with pocket gopher captures each day by the time spent setting traps for that same day.

For statistical analyses, I corrected all daily values for each individual for potential site to site differences in pocket gopher densities by dividing the expert's capture efficiency and rate values by those obtained by each novice trapper. These values were multiplied by 100 to provide a percentage estimate. This correction also provided the means to compare capture efficiency and capture rate of individuals to the expert trapper to illustrate the number of days of trapping experience required to reach the same level of proficiency as the expert trapper. I used a 2-factor analysis of variance to test for potential differences in capture efficiency and capture rates across days. The factors included in this analysis were day ($n = 4$) and trapper ($n = 7$). There were not enough degrees of freedom to test for an interaction between these 2 factors. If I determined day to be a significant factor, I used Fisher's least significant difference to determine significant differences between days (Zar 1999).

Rodenticide Application

I selected 6 individuals to apply strychnine treated milo grain (1.8%; Gopher Getter "Restricted Use" Bait; Wilco Distributors, Inc., Lompoc, CA) for pocket gopher removal in 3 fields of grapes at Laguna Ranch; the 3 fields ranged from 7.4 to 9.0 ha in size. The fields were split in half, with one half treated by an individual who received limited training on bait application, while the other half was treated by an individual who received thorough training. Each individual treated only half of 1 field (i.e., 3 individuals received limited training, and 3 individuals received thorough training). I designed the limited training program to mimic the training a typical farm laborer receives before starting bait application, because farm laborers are responsible for much of the pocket gopher abatement work done in agricultural fields in California. This limited training program included information on how to identify pocket gopher mounds, how to locate tunnel systems, how to dispense bait via the bait application probe (Wilco Gopher Bait Applicator, Wilco Distributors, Inc.), and how often to apply bait per burrow system (bait was applied 2–7 times per burrow system depending on the size of the burrow system). The entire training program lasted for approximately 15 min.

I instructed individuals who received the thorough training program on the same points as those who received the limited training program. However, the thorough training program contained additional training components, including more specific guidance on discerning between pocket gopher and other burrowing mammal sign, an emphasis on the importance of properly functioning bait application equipment, and extensive training on finding active tunnel systems. Of these additional training components, I spent the most time on finding active tunnel systems. I required the individuals who received thorough training to use their probe to find what they believed to be an active tunnel system (i.e., not back-filled). They then dug down into the soil to identify whether they found an extant tunnel, or whether they found a back-filled tunnel. I required the bait applicators to repeat this exercise until they correctly identified extant tunnels 9 out of 10 times. This process took between 1 and 1.5 hr for the 3 trainees. I felt it was important that bait applicators be able to discern back-filled tunnels from active tunnels, because bait applied to back-filled tunnels will not be consumed by pocket gophers, which will reduce the efficacy of the baiting program.

During the training period, I continued to provide guidance to individuals receiving the thorough training program on techniques to increase the likelihood of finding extant tunnels, on differentiating between pocket gopher mounds and other burrowing mammal sign, and by reminding applicators to regularly check their bait application equipment to ensure it was functioning properly. Such extensive training is rarely provided to novice bait applicators. All bait application training and actual bait application occurred from 22 to 23 March 2011.

To determine whether thorough training increased the efficacy of a pocket gopher baiting program, I needed to assess pocket gopher activity before and after treatment. For this, I established 15 9.1-m × 9.1-m indexing plots in each treatment area ($n = 6$). Within these plots, I used the open-hole method (Engeman et al. 1993) to determine pocket gopher presence. This approach required digging a hole into a pocket gopher tunnel. I left these holes open with 2 holes opened per indexing plot. I checked these plots 2 days later to verify presence or absence. Because pocket gophers maintain a closed burrow system, if no holes were plugged, I considered the plot "unoccupied." If any of the 2 holes in that plot were plugged, I considered it "occupied." I completed pre-treatment indexing the day before bait was applied. I again indexed pocket gopher activity 13 days after bait application to identify the percent reduction in pocket gopher occupancy post-treatment.

I used the Cochran–Mantel–Haenszel (Cochran 1954, Mantel and Haenszel 1959) test to determine potential differences in efficacy observed between individuals who received limited training versus those who received thorough training. This approach allowed me to test for differences between the 2 training programs while accounting for potential differences across fields. If significant differences were detected, I used odds ratios to describe this relationship (Agresti 1996). For this study, the odds ratio described the

probability that a thorough training program would result in an increase in efficacy. Finally, I used the Breslow–Day test (Breslow and Day 1987) to ensure that odds ratios did not differ between fields. All aspects of this project were approved by the University of California, Davis' Institutional Animal Care and Use Committee (protocol no. 16344).

RESULTS

Trapping

During this study, I observed 523 pocket gopher captures over 192.1 hr of trapping. Capture efficiency ranged from 10% to 74% and was generally below the level observed for the expert trapper, although in 3 situations, the novice trappers attained higher values (Fig. 1a). The novice trappers did exhibit a significant improvement in capture efficiency over the course of the 4-day period ($F_{9,16} = 3.8$, $P = 0.004$, $r^2 = 0.68$); both day ($F_{3,16} = 4.9$, $P = 0.013$) and, to a lesser extent, trapper ($F_{6,16} = 2.6$, $P = 0.058$) were significant variables in the model. Efficiency was significantly different across all days except for days 1 and 2 and days 3 and 4 (Fig. 2a). By day 3, novice trappers were already capturing pocket gophers at 94% of the efficiency value obtained by the expert trapper (Fig. 2a).

The capture rate for novice trappers ranged from 0.5 to 6.2 pocket gophers per hour (Fig. 1b). Only once was capture rate for a novice trapper greater than that observed for the expert trapper (Fig. 1b). The capture rate for novice trappers increased significantly over the 4-day period ($F_{9,16} = 4.2$, $P = 0.006$, $r^2 = 0.70$), with both day ($F_{3,16} = 3.7$, $P = 0.033$) and trapper ($F_{6,16} = 3.6$, $P = 0.018$) significant variables in the model. As with capture efficiency, capture rate was significantly different between all days except for days 1 and 2 and days 3 and 4 (Fig. 2b). Although novice trappers showed the same trend in an increase in proficiency over time, they did not attain the same level as that seen for capture efficiency (94% vs. 77% for capture efficiency and capture rate, respectively; Fig. 2) indicating that capture efficiency is more quickly attained than speed in setting traps.

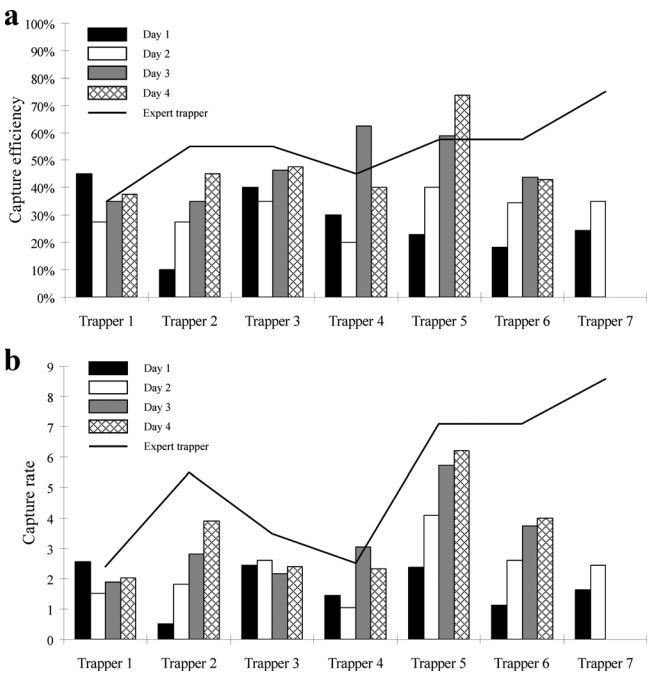

Figure 1. Capture efficiency (a; no. of pocket gophers captured per no. of trap-sets) and capture rate (b; no. of captures/no. of hour trapped) of 7 novice pocket gopher trappers and 1 expert trapper over the course of a 4-day trapping period at Laguna Ranch, California, USA, during spring 2010 and 2011.

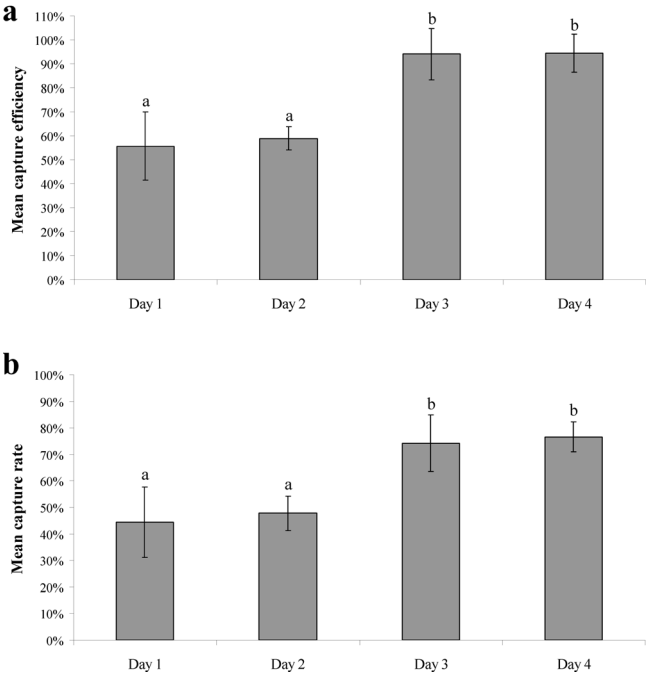

Figure 2. Mean capture efficiency (a; no. of pocket gophers captured per no. of trap-sets) and capture rate (b; no. of captures/no. of hour trapped) of 7 novice pocket gopher trappers over a 4-day trapping period adjusted for capture efficiencies attained by an expert trapper (see text for description of adjustment procedure) at Laguna Ranch, California, USA, during spring 2010 and 2011. Capture efficiencies for days denoted with the same letter did not differ ($\alpha = 0.05$).

Rodenticide Application

Individuals who received a thorough training program for poison bait application were consistently more successful in reducing pocket gopher populations, with mean reductions in plots occupied by pocket gophers of 27% (SE = 10) and 58% (SE = 4) for limited and thorough training programs, respectively (Fig. 3); this difference was significant ($\chi^2_1 = 8.7$; $P = 0.003$). Odds ratios were not significantly different between fields ($\chi^2_2 = 5.0$; $P = 0.082$); individuals who received the thorough training program were 3.6 times (95% CI = 1.5–8.5) more likely to attain a greater reduction in pocket gopher occupancy than were those who received only limited training.

DISCUSSION

This study clearly indicates a substantial increase in capture proficiency of pocket gophers with as little as 3 days experience by novice trappers that were given limited training. This increase in proficiency was most strongly

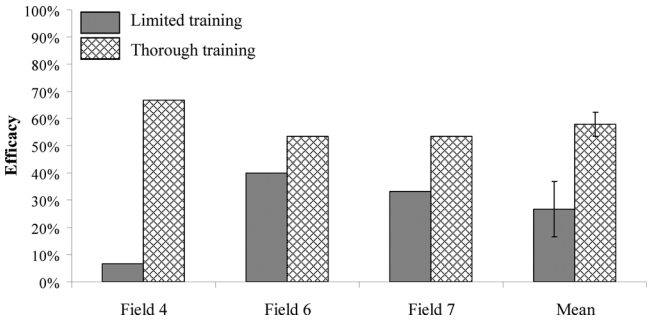

Figure 3. Percent efficacy of bait (1.8% strychnine) applicators who received limited and thorough training regarding bait application procedures for pocket gopher control across 3 fields of grapes at Laguna Ranch, California, USA, during spring 2011. Mean efficacy differed significantly between the individuals who received limited and thorough training ($\chi^2_1 = 8.7$; $P = 0.003$).

influenced by the novice trappers' ability to rapidly increase capture efficiency, with $\bar{x}$ capture efficiency at 94% of that attained by the expert trapper after just 3 days. High capture success is clearly an important component of an effective pocket gopher management program. I observed higher capture efficiency for novice trappers by day 3 ($\bar{x} = 47\%$) than has been reported in most other studies of presumably experienced trappers (e.g., $\bar{x} = 15$–23%, Smeltz 1992; $\bar{x} = 16$–35%, Proulx 1997*b*; $\bar{x} = 18$–42%, Pipas et al. 2000). One potential explanation could be due to higher pocket gopher densities in the sampled areas, or it could be due to our use of the Gophinator trap, which has proven more effective than the Macabee trap (Macabee Gopher Trap Co., Los Gatos, CA; Baldwin et al. 2013). Regardless, the rapid increase in efficiency of novice trappers indicates that trapping is a viable option to include in many pocket gopher management programs.

Capture rates also substantially increased over the 4-day sampling period although this effect was not as pronounced as it was with capture efficiency. Clearly a longer period of time is required for pocket gopher trappers to gain speed than to attain capture efficiency. Still, trappers were able to increase the number of pocket gophers they removed per hour by approximately 100% after just 4 days (Fig. 2b).

The individual doing the trapping also influenced trapper proficiency, although this effect was less pronounced than was trapper experience. As expected, some trappers were more proficient than others. Nonetheless, most trappers exhibited an increase in capture efficiency over the course of a 4-day period. The primary exception was Trapper 1. Trapper 1 had very good capture success on day 1, given abundant pocket gophers in their field. However, the abundance of pocket gophers rapidly dissipated, which led to substantially lower capture efficiency and capture rates in subsequent days. This illustrates the fact that many factors can influence the proficiency of trappers. Nonetheless, this study indicates that most individuals can be trained to be efficient pocket gopher trappers.

Past investigations have shown that pocket gopher trapping can be an effective method for managing pocket gophers in agricultural and forested areas (e.g., Smeltz 1992, Proulx 1997*a*). Even so, many growers and farmers do not consider trapping to be a viable tool for managing pocket gophers because they feel that trapping is too time-consuming to be practical (Engeman and Witmer 2000). Part of their reasoning likely stems from their low proficiency when they first initiate a trapping program. As I have shown, proficiency rapidly increases over the course of a few days, thereby greatly increasing the viability of trapping as a tool for managing pocket gopher. Even so, trapping is just one of several potentially effective management tools for pocket gophers.

Baiting with rodenticides such as strychnine is also extensively used and will likely continue to be an important component of an Integrated Pest Management program for pocket gophers given the need for additional methods that maximize the efficacy of management programs (Baldwin et al., 2014). Unfortunately, results from baiting programs have varied widely (e.g., 0–100%; Tickes et al. 1982, Evans et al. 1990). This was the case in our investigation as well; I observed 7–67% reductions in pocket gopher populations from strychnine application. A multitude of reasons may impact the efficacy of these baits (see Introduction for potential list), although most of the proposed possibilities remain in need of further investigation. That being said, applicator experience certainly appears to have an impact. Many growers and Pest Control Advisors do not regularly manage croplands for vertebrate pests. Therefore, they may not have the experience required to implement, or effectively train individuals to implement, management programs. As such, many baiting programs likely fall short of attaining the desired reduction in pocket gopher populations.

Based on my experience, one of the most important components of an effective training program is to ensure that bait is actually applied into active pocket gopher tunnels. Pocket gophers often back-fill old tunnels with loose soil that they remove while excavating new tunnels. Although these back-filled tunnels are filled with loose soil, they often feel similar to non-filled tunnels when probing. A more experienced trapper can discern this difference, resulting in a several-fold increase in the probability of a more successful baiting program.

Other aspects that factor into a thorough training program include regular monitoring of bait application equipment and correct identification of pocket gopher mounds. For example, bait application equipment has a tendency to plug up, particularly in moist soil conditions. Regular monitoring for properly functioning equipment is needed to maximize efficacy because malfunctioning equipment will not apply the appropriate amount of bait. Likewise, it is important for bait applicators to identify the difference between pocket gopher, mole (*Scapanus* spp.), and vole (*Microtus* spp.) burrows so that applicators do not mistake pocket gopher mounds for those of non-target burrowing mammals.

Although training did significantly increase the efficacy of our baiting program, pocket gopher removal levels obtained from bait application by thoroughly trained individuals ($\bar{x} = 58\%$) still fell short of the minimal level desired for rodent control (>70%; Capp 1976, Fagerstone et al. 1981). I

observed thick vegetation growth concealing mounds and partially muddy conditions that potentially limited bait applicator functionality; both of these factors likely reduced efficiency. During spring 2011, above-normal precipitation fell, resulting in prolific vegetation growth. The resultant wet soil conditions precluded mowing cover crops before baiting trials, which likely limited the ability of bait applicators to find all pocket gopher mounds. The wet soil conditions led to increased plugging of bait probes which, if unnoticed, could have led to insufficient bait application in some burrow systems. To maximize the efficacy of bait application in a consistent manner, we need to more thoroughly identify to what extent other factors influence the efficacy of baiting programs, so that steps can be taken to increase the consistency of these baiting programs. Nonetheless, a thorough training program is needed to increase the effectiveness of baiting regimens for managing pocket gophers.

MANAGEMENT IMPLICATIONS

Effective pocket gopher management programs typically rely on several management tools, including rodenticide baiting and trapping. When effective, baiting can provide a relatively quick method for treating a large number of burrow systems. It is apparent that bait applicators need to be thoroughly trained to increase the efficacy of such baiting programs. Training sessions should focus largely on correct identification of active burrow systems. Other key factors to address are proper identification of pocket gopher mounds and proper maintenance of bait application equipment. However, even with proper training, baiting alone may not attain the level of reduction needed to effectively manage pocket gopher populations. Trapping has proven to be an effective tool in such situations, with novice trappers attaining effective trapping skills in as little as 3 days of trapping experience. I recommend that, where feasible, trapping be included in Integrated Pest Management programs for pocket gophers given its high efficacy and lack of secondary toxicity risk.

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