Prairie Vole *(Microtus ochrogaster)* Population Monitoring at Fort Custer Training Center 2020 – 2021

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Cover Photo(s): Prairie vole handling during live capture (left) and setting Sherman traps in South Unit (right).

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Study area showing designated Threatened/Endangered Species zone (South Unit) at dusk while setting Sherman traps for live capture.

Abstract

In 2020–2021, we monitored Michigan's only known extant population of the state endangered prairie vole (*Microtus ochrogaster*) at Fort Custer Training Center (FCTC). This rare vole was last documented at FCTC in 2014 and most recently monitored in 2017 (Legge 2017). We followed the survey design of previous vole monitoring efforts to enable quantitative comparison among years (Legge 1995; Cooper 2000; Legge 2007; Legge 2017). We completed 921 trap nights, with 303 trap nights in 2020 and 618 trap nights in 2021. In 2020 we captured one meadow vole (*Microtus pennsylvanicus*), and in 2021 we recorded 25 capture events at 14 unique traps, including 23 captures of *Microtus* spp. Of these, two were determined to be prairie voles, both of which were captured during the second trapping session in August. We also tested a novel method of vole monitoring using camera traps. In 2020 we recorded 18 detections of small mammals, one of which was a vole. In 2021, with improved methods, we recorded 62 detections of small mammals, of these, 97% were of voles and 42% of voles had a discernable hair-clip from live capture. Confirming the continued presence of the prairie vole at FCTC stresses the need for habitat management for this rare mammal. We suggest that FCTC land managers implement shrub removal and prescribed fire in the South Unit of the prairie vole site. In the North Unit, which serves as a Medevac site for the military installation, we recommend a decrease in the frequency and extent of mowing, while continuing to maintain the Medevac site. We also suggest regular population monitoring and adding genetic sampling to confirm species and sex identifications, as this species may be misidentified with the more common meadow vole (*M. pennsylvanicus*).

Prairie vole study area showing the boundary distinguishing the Threatened/Endangered Species zone (right half of image) and mowed MEDEVAC zone (left half of image).

Introduction

The prairie vole (*Microtus ochrogaster*) is a state endangered species in Michigan where it is found in the southwestern region of the state, an area known as "the prairie peninsula" (Norris 2014). It has been documented in four Michigan counties (Berrien, Cass, Kalamazoo, and Van Buren), and all but the Kalamazoo County record are from before 1965. Insufficient survey effort likely underrepresents this species' current distribution in southwestern Michigan. In this study we report on the only known extant population in Michigan, located at Fort Custer Training Center (FCTC), Kalamazoo County.

The prairie vole inhabits a diversity of grasslands, including tall grass prairie communities, abandoned fields and pastures, cultivated fields, fencerows, railroad rights-of-way, roadside corridors, and lawns; in general, it lives wherever grass is sufficiently thick for nesting cover and runway construction (Getz 1985; Stalling 1990). Home ranges are typically less than 0.1 hectares (0.25 acres) in extent (Evers and Albert 1994; Kurta 1995). The animals are most active at dusk and dawn and utilize runways in vegetation to move around their home range (Norris 2014). Short and shallow burrows are used by prairie voles in colder months for nesting and feeding while above-ground nests are used in warmer months (Kurta 1995).

In southwestern Michigan, the prairie vole is sympatric with the meadow vole (*M. pennsylvanicus*), which may displace the prairie vole to areas of short or sparse vegetation (Klatt and Getz 1987). External characteristics can be used to differentiate between the meadow vole and prairie vole species, but in the field these characteristics may be unreliable due to intraspecific variation (Henterly et al. 2011). The meadow vole is slightly larger and has five to six plantar tubercles on each hind foot, while prairie voles typically have five (DeCoursey 1957; Henterly et al. 2011). Meadow voles have four pairs of mammary glands and prairie voles have three (Kurta 1995). In addition, meadow voles typically have longer tails (35–60 mm) than prairie voles (26–40 mm; Baker 1983).

The FCTC prairie vole population has been intermittently monitored since its discovery in 1994 (e.g., Cooper 2000; Legge 2007; Legge 2017). However, variability in survey effort (e.g., four trap nights vs two trap nights) preclude reliable long-term monitoring of this prairie vole population status. Prairie vole abundance has varied from 0.0 to 10.2 captures per 100 trap nights during surveys done between 1995 and 2017 (Cooper 2000, Legge 2017). This species was last documented at FCTC in 2014, with subsequent trapping in 2017 resulting in no prairie vole captures. Results presented in this report from 2020–2021 represent the only monitoring effort since 2017.

Prior to 2020, prairie vole monitoring at FCTC had been conducted exclusively using Sherman live traps. These traditional trapping methods are resource-intensive, requiring considerable effort and funds, and may result in trap-related injuries or mortalities to captured animals (Stanley and Royle 2005; Wiewel et al. 2007; Villette et al. 2016). Recent developments in remote motion-sensor technologies have opened new possibilities for non-invasive monitoring of animal populations. Camera-trapping for the detection of small mammals has proved to be an effective tool in some cases (De Bondi et al. 2010; Visoiu and Driessen 2018). Camera-trapping surveys compared favorably to those of live-trapping surveys with the former considerably more cost-effective, particularly when presence data are the primary goal of the survey (De Bondi et al. 2010).

Threatened/Endangered Species signage demarcating the boundary between the North Unit and South Unit.

Previous monitoring at FCTC also sought to determine the impact of disturbance caused by military vehicles on the prairie vole population. Four treatment units were defined for monitoring purposes based on how recently they had been seriously disturbed by military training or other activities. Surveys in 1994 provided evidence that impacts from heavy vehicles have a negative effect on the population (Legge et al. 1995). These studies also noted that shrubby encroachment and competition with meadow voles may negatively impact FCTC's prairie vole population (Cooper 2000; Legge 2017).

The South Unit is dominated by a mix of native prairie grasses and forbs, as well as numerous non-native and invasive plant species.

Objectives

Our primary objective was to continue the long-term monitoring of this prairie vole population to determine its current abundance and compare its status to previous abundance estimates as they relate to habitat condition (e.g., human impact, vegetation composition). We adhere to the survey design of past monitoring efforts using traditional live-trapping methods to permit direct comparison with previous relative abundance (captures/100 trap nights) estimates. However, we sought to increase trapping effort to ≥600 trap nights, with a minimum of 100 traps for six nights, to increase detection probability and determine the minimum number of trap nights needed to meet FCTC natural resource management needs. Based on our results, we provide management and monitoring recommendations for assuring population persistence of prairie voles at FCTC.

Secondly, we test the ability of remote motion-sensor cameras (i.e., camera traps) to detect prairie voles and other small mammals, as well as to identify uniquely marked individuals during the live-trapping survey period. This hybrid monitoring program will be used to evaluate the potential of camera traps to support and/or enhance live-trapping methods for estimating prairie vole occupancy and/or abundance. Testing these new methods in conjunction with traditional methods is important for evaluating the efficacy of emerging technologies to reduce survey costs, minimize risk to focal species, and improve wildlife conservation decision making.

As a supplementary objective to this project, we began to address the potential for erroneous field identification between the superficially similar prairie and meadow voles due to intraspecific variations in morphological characteristics (Henterly et al. 2011). To address the issue of misidentification, we collected tissue samples in 2021 for future genetic testing of species identification.

Study Area

FCTC encompasses 7570 acres and is located between the cities of Battle Creek and Kalamazoo. The FCTC is a federally-owned, state-operated Michigan Army National Guard Training Facility. The FCTC is located in southwestern Michigan within the Southern Lower Peninsula Hills and Plains physiographic region (Comer et al. 1995). The only known extant population of the prairie vole in Michigan occurs in Training Area (TA) 7 in the Kalamazoo County portion of FCTC (Figure 1). This site is a degraded field (likely abandoned agricultural land) that was heavily used for military training activities until the discovery of the vole population in 1994 (Legge et al. 1995). Currently, the southern portion (South Unit; Legge 2017) of the field is protected from military and civilian vehicles, while the northern half (North Unit; Legge 2017) is mowed and maintained as a Medevac site. The site was likely historically oak barrens and, while it is ecologically degraded, provides suitable habitat for the prairie vole where sufficient grass cover is present. The South Unit contains a mix of native and non-native prairie grasses and forbs, while the North Unit is dominated by non-native species, with some natives persisting primarily along its perimeter (Table 1).

Figure 1. An aerial image of the prairie vole field in Training Area 7 at Fort Custer Training Center. The North Unit is mowed frequently for use as a MEDEVAC Landing Zone, while the South unit is preserved as a designated Threatened/Endangered Species zone. Note dense shrub encroachment along site perimeter.

Methods

Live-Trapping

We followed the survey design (trap spacing and density) of previous vole studies at FCTC to enable quantitative comparison among years (Legge 1995; Cooper 2000; Legge 2007; Legge 2017), but exact replication was precluded due to lack of available georeferenced information as well as changes in suitable prairie vole habitat and landmarks that had previously been used in lieu of georeferenced trap locations. We used ArcGIS Pro (ESRI 2020) to establish a 195-m^2 hexagonal grid over the study area to allocate survey effort randomly and evenly. We then selected grid cells whose centroid occurred within the survey area, resulting in 157 potential trap sites. The geographic center of each randomly derived grid cell served as an initial location for selecting trap placement, with one trap per grid cell. This design ensured that a minimum distance of 15 m was maintained between nearest neighbor sites, resulting in trap density consistent with previous survey efforts (Legge 1995). We also used a reel tape measure and compass to pace trap distance starting from the northernmost trap in each grid column (Figure 2). We omitted potential trap sites that occurred in unsuitable vole habitat (e.g., road or high tree/shrub density), as determined by satellite imagery and visual inspection in the field. This resulted in 101 (37 in North Unit, 65 in South Unit) and 105 (40 in North Unit, 65 in South Unit) trap sites during the 2020 and 2021 survey efforts, respectively (Figure 2).

Sherman live traps (Model LFG; H.B. Sherman Traps, Inc., Tallahassee, FL, USA) were placed near burrow entrances or along runways when detected within 1 m of the grid centroid; otherwise, traps were placed within vegetation and terrain that permitted access by voles. Cotton balls and hay were placed inside each trap

Table 1. Vegetation species composition of the prairie vole site at Fort Custer Training Center. Abundance categories include dominant, abundant, frequent, occasional, rare.

Species	Common name	Abundance
Bromus inermis	Smooth brome	Abundant
Poa pratensis	Kentucky bluegrass	Abundant
Schizachyrium scoparium	Little bluestem	Abundant
Centaurea stoebe	Spotted knapweed	Frequent
Andropogon virginicus	Broom-sedge	Occasional
Antennaria parlinii	Smooth pussytoes	Occasional
Asclepias tuberosa	Butterfly milkweed	Occasional
Dactylis glomerata	Orchard grass	Occasional
Danthonia spicata	Poverty grass	Occasional
Elaeagnus umbellata	Autumn-olive	Occasional
Hieracium caespitosum	King devil	Occasional
Potentilla simplex	Old-field cinquefoil	Occasional
Rhus copallina	Winged sumac	Occasional
Robinia pseudoacacia	Black locust	Occasional
Rubus flagellaris	Northern dewberry	Occasional
Asclepias viridiflora	Green milkweed	Rare
Carex muehlenbergii	Muhlenberg's sedge	Rare
Juglans nigra	Black walnut	Rare
Turritis glabra	Tower mustard	Rare

to provide captured individuals with nesting material to increase survival in inclement weather. In addition, cover boards and hay were placed on top of each trap to minimize exposure to extreme temperatures and precipitation.

In 2020, COVID-19 travel bans and weather issues precluded a pre-baiting schedule. In 2021, traps were pre-baited for two nights before each trapping session. During each pre-baiting night, we opened the side panel of the Sherman live traps to allow voles to freely enter and leave the trap while procuring a small amount of peanut butter and oat mixture. Bait was replaced daily as needed during each pre-bait period. We then activated traps for live capture at sunset on the night following the last pre-bait day. The same bait mixture was placed inside each trap on top of the trap treadle. All traps were checked just after sunrise the following morning and left closed during daylight hours.

We deployed traps during a single trapping session from 20–23 September 2020 and abandoned a second round of trapping after pre-baiting traps on 15 October 2020, due to a combination of poor weather (cool and rainy for 10 subsequent days) and complications due to COVID-19. In 2021, we successfully deployed traps during two independent trapping sessions. Session 1 occurred during 27 July – 1 August (two nights pre-baiting) and session 2 occurred during 22–27 August (two nights pre-baiting).

We identified all captured small mammals to species and recorded their weight. For vole (*Microtus* spp.) captures, we determined sex, age class, reproductive condition, and presence of scarring. We also counted the number of plantar tubercles on a hind foot and measured total body, hind foot, and tail length. These morphometrics were used to support differentiation between the meadow vole (*M. pennsylvanicus*) and prairie vole (*M. ochrogaster*). All voles were given a unique mark by clipping dorsal hair patches to aid in identification of recaptures. On the final day of the trapping season, we did not mark newly captured individuals. Live-trapping efforts followed protocols approved by the Michigan State University Institutional Animal Care and Use Committee (IACUC; PROTO202000131/ AMEND202100399).

__Camera-Trapping__

We deployed three Hobbs HALT-2 near infrared (NIR) triggers coupled to Bushnell NatureView HD Cam camera traps (Model 119740; Hobbs and Brehme 2017) during 2020–2021 surveys (Figure 2). Since this was a pilot effort, we attempted to maximize vole detection by placing camera traps near successful Sherman traps and/or intersecting vole surface runways (non-random placement). In 2020, we placed a peanut butter and oat mixture on the HALT-2 trigger device to increase detection probability, but due to trap damage caused by non-target animals, we did not continue use of bait during the 2021 survey effort. We programmed cameras to take a three-shot still image burst followed by a 10-second video with a 5-second delay between successive bursts. All small mammal species were classified to species or genus and whether a unique hair clip could be detected for live-captured vole species.

Genetic Sampling

Tissue samples for future genotyping were collected from all voles for confirmation of sex and species-level identification between the prairie vole and meadow vole. Ear notch samples were collected by clipping 2-mm^2 of ear pinnae with sanitized fine-point dissecting scissors. The notches were then stored in 95% alcohol at room temperature. Fecal samples were also collected from traps where voles were captured. Fecal samples were stored in 95% alcohol at room temperature and contamination was limited by fully emptying and cleaning traps with a diluted (10%) bleach solution between deployments. The paired fecal and ear notch samples for each vole will be genotyped at the Michigan Department of Natural Resources' (MDNR) Disease Ecology Laboratory to confirm vole species identification and sex. Results are not currently available as sample collection preceded processing funding at the time of this survey.

Results

2020 Survey

We conducted trapping for three nights during 20–23 September 2020, resulting in 303 trap nights. On 23 September 2020 at trap I-10 one meadow vole *(M. pennsylvanicus*; deceased, female, pregnant) was recovered. We preserved this individual and submitted it to the Michigan State University Museum (c/o Laura Abraczinskas, Collections Manager, Vertebrate Collections). Experts at the Museum determined this specimen to be a meadow vole based on dentition characteristics (Abraczinskas 2021).

The three camera traps were deployed on 20 September 2020 and two cameras were retrieved on 15 October 2020 and one on 5 November 2020 (96 total trap nights). Cameras were triggered 2,466 times, including 18 detections of small mammals (Table 2). All small mammal detections were collected on camera 2, located in the South Unit. Detections at camera 2 were primarily of *Peromyscus* spp. (86%), but also included two detections of a shrew (likely *Sorex cinereus*) and one detection of a *Microtus* spp. Most trigger events were caused by various insects (e.g., grasshoppers, crickets, ants), frogs, snakes, and rabbits. Eastern cottontail rabbits (*Sylvilagus floridanus*) were observed chewing camera trap cables, resulting in damage to two of the camera traps.

2021 Survey

We conducted trapping for six nights over two survey sessions in 2021, for a total of 618 trap nights (303 in July and 315 in August). We added three traps in August to sample suitable habitat on the northwest portion of the study area (Figure 2). We set 40 traps in the North Unit and 65 traps in the South Unit within the designated endangered species zone (Figure 2).

We processed 25 capture events at 14 unique traps (13%) during live trapping sessions in July and August 2021, including 23 captures of *Microtus* spp. Of these, two were determined to be prairie voles, both of which were captured during the second trapping session (25–27 August 2021). Both prairie vole captures were males and species identification was determined, in part by the presence of five plantar tubercles on their hind feet and shorter head/body length, hind foot length, and tail length compared to captured meadow voles (Table 3). Relative abundance (captures/100 trap nights) across all trap nights was 0.3 for prairie voles and 3.4 for meadow voles. To permit a general comparison to previous survey efforts (e.g., Legge 2017), relative abundance during the first two trapping days of the first session (i.e., 210 trap nights) was 0.0 for prairie voles and 6.2 for meadow voles.

The remaining 21 vole captures were determined to be meadow

Table 2. Camera trap results for each camera. Events refers to total number of camera triggers. Detections refers to number of small mammal triggers.

Year	ID	Events	Detections
2020	1	461	0
2020	2	1101	18
2020	3	904	0
2021	1	94	7
2021	2	180	23
2021	3	222	32

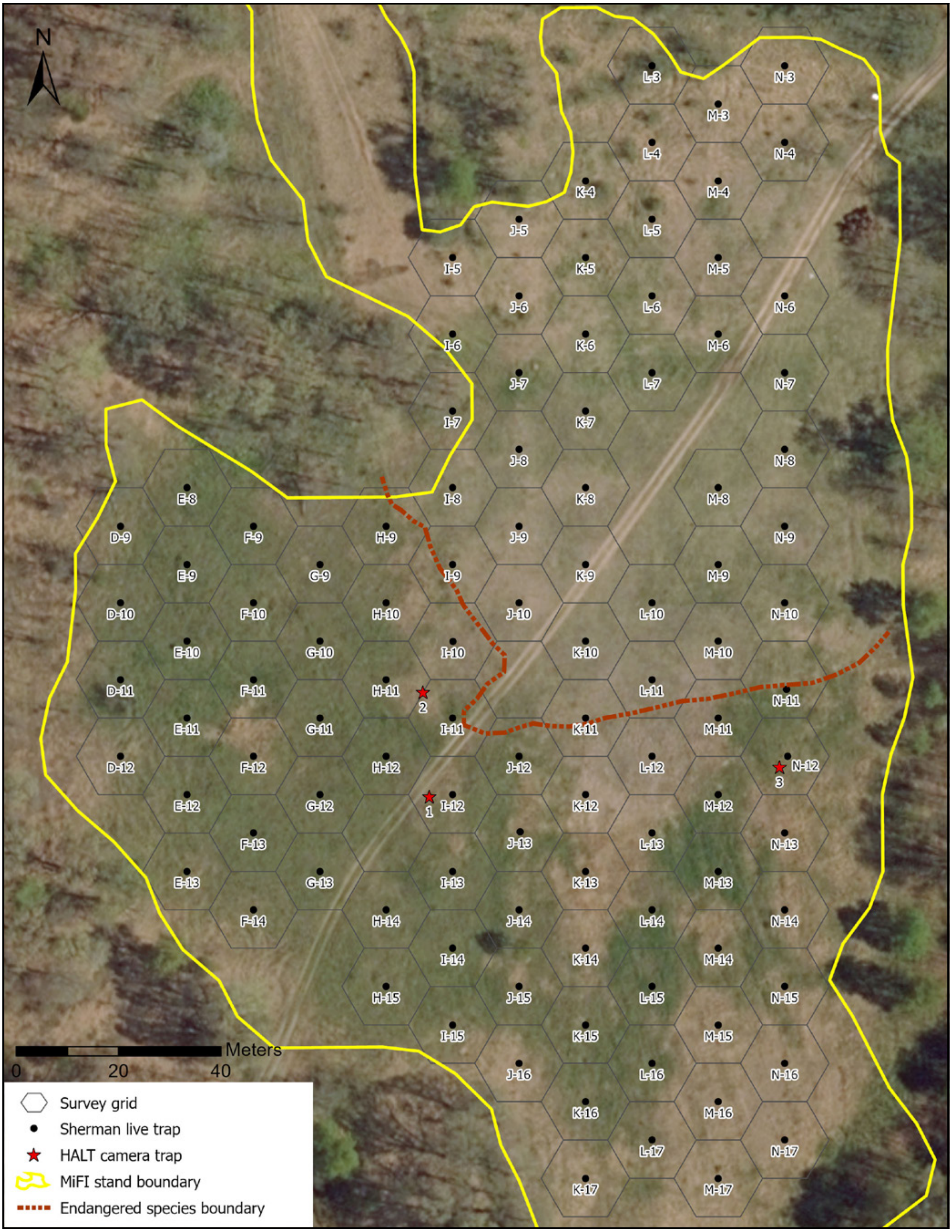

Figure 2. Prairie vole survey design showing Sherman live trap and HALT camera trap locations. Note that traps J-5, K-4, and L-3 were not set in 2020.

voles, including at least eight unique individuals that were recaptured nine times across the two trap sessions (Table 3). One meadow vole was captured four times and three were captured three times. Other non-target captures included two meadow jumping mice (*Zapus hudsonius*) (Table 3). All but two vole detections occurred within the designated endangered species zone, primarily clustered in the northern portion of the South Unit, and the two detections outside this zone occurred along the South Unit's northern boundary with the North Unit (Figure 3). Individuals were detected at the same trap site no more than twice and 1–3 unique meadow voles were detected at the same trap site throughout the two trapping sessions (Figure 3).

In 2021, three camera traps were deployed from 30 July to 26 August (81 total trap nights) and were triggered 496 times, including 62 detections of small mammals (Table 2). Of these, 97% were of voles with 42% having a discernible hair clip from live capture. Species level classification for voles was precluded for most nighttime images due to poor image quality. Small mammals were detected in 31 (50%) video clips and enabled or enhanced detection of marked individuals in 11 unique detection events. Detections were greatest during 0200–0600 hours and 2100–2200 hours, with peak vole activity occurring at 0600 hours.

Table 3. Live capture results for 2021 survey effort of all *Microtus* spp. (MV = meadow vole, PV = prairie vole) detections (excludes two *Zapus hudsonius* captures). Length (L) measurements are in millimeters.
* = unmarked or hair-clip mark not distinguishable
† = recapture event (measurements not collected for recapture events)
\- = data not recorded

Date	Session	Trap	Hair Clip	Species	Sex	Tubercles (Left)	Tubercles (Right)	Weight (g)	Head/ Body L	Foot L	Tail L
7/30/2021	1	I13	C	MV	F	6	-	48	140	19	47
7/30/2021	1	I10	DF	MV	F	6	6	40	114	20	47
7/30/2021	1	N12	E	MV	M	6	-	39	97	20	43
7/30/2021	1	I9	F1	MV	M	6	6	39	111	20	45
7/31/2021	1	J13	C†	MV	F	-	-	-	-	-	-
7/31/2021	1	I10	CD	MV	M	6	-	28	100	21	44
7/31/2021	1	I13	CE	MV	M	6	6	35	92	20	47
7/31/2021	1	N12	E†	MV	M	-	-	-	-	-	-
8/1/2021	1	I10	*	MV	F	6	-	33	92	20	47
8/1/2021	1	K12	BD	MV	M	6	6	26	97	19	39
8/1/2021	1	J12	C†	MV	F	-	-	-	-	-	-
8/1/2021	1	I13	CE†	MV	M	-	-	-	-	-	-
8/1/2021	1	N13	E†	MV	M	-	-	-	-	-	-
8/25/2021	2	N12	*	MV	M	6	6	37	107	-	47
8/25/2021	2	I9	DF†	MV	F	-	-	-	-	-	-
8/25/2021	2	F9	F2	PV	M	5	5	33	98	-	36
8/26/2021	2	J15	*	MV	M	6	6	38	100	-	48
8/26/2021	2	J13	A	MV	F	6	6	21	87	20	43
8/26/2021	2	H10	B	PV	M	5	-	34	97	17	36
8/26/2021	2	H12	DF†	MV	F	-	-	-	-	-	-
8/27/2021	2	J15	*	MV	F	6	6	41	106	19	46
8/27/2021	2	N12	CE†	MV	M	-	-	-	-	-	-
8/27/2021	2	H12	DF†	MV	F	-	-	-	-	-	-

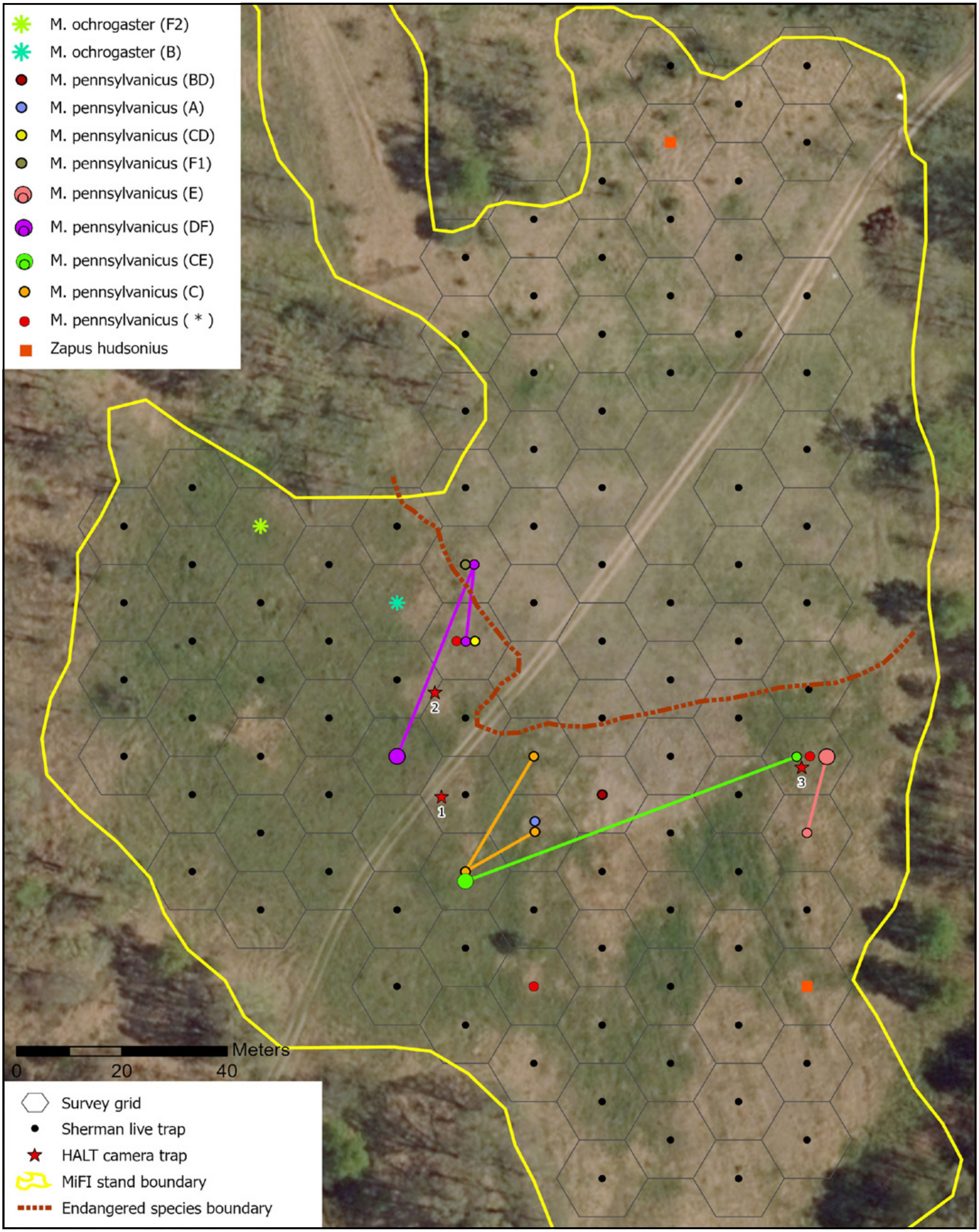

Figure 3. Capture results of all small mammal species during July–August 2021. Small circles represent a single capture at a trap site and larger circles indicate two captures. Sites with captures of more than one unique individual are staggered for viewability. Lines indicate detections of the same individual at different traps.

One of two prairie voles captured during the second trapping session in 2021. Photos illustrate characteristic ochraceous ventral pelage (left photo) and five plantar tubercles on the hind foot (right photo) of prairie voles.

Discussion

During the 2020–2021 surveys, we increased sampling effort compared to recent prairie vole monitoring at FCTC. With an initial goal of 600 trap nights, we concluded this study with 921 trap nights (303 in 2020, 618 in 2021). Due to a combination of poor weather, staff illnesses, and travel restrictions related to COVID-19, prairie vole monitoring in 2020 was canceled after one trapping session, yielding a single small mammal (meadow vole) capture. In 2021, with greater survey effort and the addition of pre-baiting, we documented the presence of the state endangered prairie vole at FCTC with two unique individuals detected. Differences between 2020 and 2021 capture results may be a result of multiple interacting factors, including increased survey effort, the addition of pre-baiting in 2021, and weather conditions, in addition to naturally occurring fluctuations in small mammal abundance. However, the abundance and frequency of meadow vole captures in 2021 during both trapping sessions compared to the near absence of detections in 2020 suggests at least some population increase of meadow voles occurred. Given low prairie vole detections in 2021, we suggest that the 2020 population abundance was also low, but undetectable given our low trapping effort.

Prairie vole relative abundance has ranged from 0.0–10.2 captures/100 trap nights since survey efforts began at FCTC in 1995 (Cooper et al. 2000, Legge 2007, Legge 2017), indicating that the prairie vole population is currently at the low end of its observed range of site abundance. Meadow vole relative abundance has also experienced drastic swings since surveys began in 1995, ranging from 1.2–16.1 captures/100 trap nights (Legge

2017). Our survey efforts also indicate that the meadow vole population currently persists at the low end of documented site abundances, though still much greater than current prairie vole abundance. Although not a target species of this project, it is interesting to note that deer mouse (*Peromyscus* spp.) has been detected at the site during every survey effort since 1995 but were absent from both 2020 and 2021 live captures (*Peromyscus* spp. were detected on camera traps in 2020). Overall species richness was also low, with five of nine historically documented species being detected across both live trapping (three species) and camera trapping (≥3 species) efforts in 2020 and 2021.

Our pilot study investigating the efficacy of specialized active infrared camera traps provided mixed results. Application of a peanut butter bait on the infrared threshold in 2020 attracted many non-target animals that caused numerous false positive triggers and likely attracted the cottontails that chewed through the camera trap cables. Moreover, the lack of small mammal detections suggests adding bait had little to no benefit. Refraining from bait in 2021 reduced false triggers from non-target animals and targeting camera placement at or near vole runways greatly increased small mammal detections. Moreover, we were able to identify hair-clip patterns on previously live-captured voles on both still images and videos. Although voles were only detected in 50% of video trigger events, they were valuable for identifying hair-clip markings, particularly during nighttime when still images were typically blurry from animal movement. As we predicted, differentiating *Microtus* spp. from camera trap images or videos was typically not possible. Therefore, these camera traps will not suffice in monitoring the status of unmarked prairie voles but may still be useful in conjunction with traditional live-trapping efforts. Combining camera-trapping with live-trapping and unique markings visible from above (i.e., hair clip, ear tag) may provide additional recapture events necessary for estimating abundance. This may be especially useful for maximizing available trap nights when sufficient live-trapping is unfeasible. These camera traps may also have utility in monitoring annual trends in small mammal relative abundance. For example, camera traps could be deployed annually both during and between live-trapping survey efforts to better understand small mammal population cycles at this site. Finally, these camera traps may serve as an efficient scouting tool for determining if other sites at FCTC have potential for supporting prairie voles and warrant more rigorous live-trapping efforts.

Habitat Management

Encroaching woody vegetation can decrease grassland-dependent small mammal diversity, and the likelihood of prairie vole presence decreases as woody vegetation increases (Matlack et al. 2008). Previous studies at FCTC have noted that shrub and tree encroachment occurring at the edges of the prairie vole site have impacted the habitat for this state-endangered species (Cooper 2000; Legge 2017). The primary species of management concern are winged sumac (*Rhus copallina*) and black locust (*Robinia pseudoacacia*). The increase in woody vegetation, and subsequent decrease in grass-dominated habitat, caused by these two species is the primary threat to the prairie vole population at FCTC.

Previous investigators have noted that prescribed fire has not impeded the woody encroachment with winged sumac resprouting after being top killed by fire (Legge 2017). Due to the resprouting of woody vegetation after prescribed fire, we agree with previous investigators by recommending mowing with blades raised to leave 20–30 cm of grass stubble to ensure sufficient cover (Cooper 2000). We recommend a multifaceted vegetation management approach, where prescribed fire should be deployed in prairie vole habitat coupled with mechanical woody vegetation removal, as aggressive resprouting after fire may encourage woody species. Management with prescribed fire is appropriate to promote prairie vole habitat, as other researchers have found that prairie voles increased in abundance in recently burned habitats while its competitor (meadow vole) shows decreased abundance after fire (Schramm and Willcutts 1983).

The northern half of the prairie vole field is currently managed as a Medevac Landing Zone (LZ). Over the two years of this study, we have observed mowing regimes of varying extent in this area. Occasionally, mowers would cut a larger extent than might be necessary to maintain the LZ. We detected no voles in the northern portion of the prairie vole site, where grass was mowed with such frequency that much of the site resulted in

Boundary between South Unit (Threatened/Endangered Species zone) and North Unit (mowed MEDEVAC zone).

bare ground with little cover for voles to construct runways or nests. The optimal size of an LZ is 100 ft x 100 ft (Divver 2012), and we recommend flagging this footprint for mowing to leave occasional grassy habitat for small mammals. Reducing mowing frequency, when possible, would likely benefit the prairie vole population.

Future Monitoring

Prairie vole populations studied over a 25-year period were found to fluctuate consistently in 3- to 4- year cycles across multiple habitat types (Getz et al. 2001). Due to these fluctuations, a minimum of four years of monitoring is considered necessary to accurately assess a prairie vole population (Gaines & Rose 1976; Kurta 1995, Getz et al. 2001). We recommend that FCTC continue prairie vole monitoring to determine if this population persists, particularly considering the reduction in habitat due to shrub encroachment.

No prairie voles were detected in the North Unit and only two meadow voles were detected once along its boundary with the South Unit. Most of the North Unit is frequently mowed and comprised of sparse bunch grasses with frequent bare ground, and invasive spotted knapweed. Although most previous surveys consistently observed greatest prairie vole detection rates in the South Unit and lowest within the North Unit, they were detected widely in the North Unit during the 2006 survey (Legge 2007). Shifts in prairie vole distribution within and among survey units may be driven by several dynamic ecological and environmental factors, including density-dependent exclusion by meadow voles and density-dependent dispersion among prairie voles themselves, successional changes in vegetation composition, and mowing and vehicular activities in the North Unit. Therefore, we recommend continued monitoring of the North Unit, despite its apparent absence of prairie voles in 2020 and 2021.

Although two trap nights yielded most detections during 2002–2007 surveys, our surveys in 2020 and 2021 did not detect prairie voles until the first night of the second trapping session (i.e., three total trap nights), corroborating results of Legge 2017 that did not detect prairie voles under a two trap-night protocol. Prairie vole abundance was relatively high during 2002–2007 compared to other survey periods and may explain greater observed capture rates during the first two trap nights. Capture rates are likely influenced by site abundance, where two trap nights may suffice during high vole abundance but fail when populations are low. Therefore, to ensure sufficient detection rates during low abundance years, we recommend following survey protocols implemented during our 2021 survey effort (i.e., six trap nights over two trap sessions) or at least four nights as done during Legge et al. (1995) efforts.

Extensive small mammal trapping was conducted at 18 sites at FCTC from 1994 to 1997, with no additional prairie vole populations found (Legge et al. 1995; Cooper 1998). However, their persistence as an isolated population solely within our survey site seems unlikely. Given the amount of time that has passed since the last sampling effort, future monitoring efforts should revisit nearby sites to sample for other potential prairie vole populations, especially during known or expected high prairie vole population years (Legge et al. 1995).

Genetic Research

Recent work using species-specific genotype markers found that morphological characteristics resulted in field-based misidentification for ~5% of captured prairie voles and 29% of captured meadow voles (Henterly et al. 2011). For example, the number of plantar tubercles is one of the primary characters used to distinguish the two species, but genotypes of captured voles revealed that 87% of field-based misidentifications were caused by individuals having an atypical number of plantar tubercles. Relying on tail length, hind foot length ratio was even less reliable, with nearly half of the prairie voles deviating from expected ratios (Henterly et al. 2011).

Results from Henterly et al. (2011) strongly suggest that intraspecific variability among morphological characteristics merit species identification supported by diagnostic genotyping of all captured *Microtus* spp. Differentiating between these two sympatric voles is particularly important, considering the state endangered status of the prairie vole in Michigan. Tissue samples for future genetic analysis (pending funding) were collected from individual voles for confirmation of sex and species-level identification in August 2021.

Camera trap detection of a marked meadow vole. Note trigger mechanism intersects a vole runway.

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