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A northern pocket gopher (*Thomomys talpoides*) border control strategy: promising approach

Gilbert Proulx
Alpha Wildlife Research & Management Ltd, 9 Garnet Crescent, Sherwood Park, Alberta, Canada T8A 2R7

From 1994 to 1996, the use of perimeter traplines to intercept immigrating northern pocket gophers (*Thomomys talpoides*) and maintain forage fields with low pocket gopher populations was evaluated in alfalfa (*Medicago* spp.) fields in central Alberta. In April–May 1994, all northern pocket gophers inhabiting six 8-ha study plots were trapped out. In two of these plots, no more trapping occurred after the spring removal. In the other four study plots, 20–60 m wide perimeter traplines were established within the plots' boundaries. In two plots with low pocket gopher population densities (< 10 animals/ha) and in two plots with high pocket gopher population densities (> 10 animals/ha), the perimeter trapline intercepted ≥ 75% of immigrating pocket gophers. At the end of the summer, there were ≥ 213 mounds/ha in study plots without perimeter traplines. In the protected sections of plots with a perimeter trapline, there were ≤ 19 mounds/ha. The evaluation of the border control strategy was continued for two more years in one of the study plots where there were 22.4 pocket gophers/ha in spring 1994. In spring 1995, there were only 1.4 pocket gophers/ha and the perimeter trapline intercepted 81% of immigrating animals during summer. In spring 1996, only one animal inhabited the study plot (density of 0.1/ha). The border control strategy is a promising approach that should be further investigated to control northern pocket gopher populations. © 1997 Elsevier Science Ltd

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Introduction

The digging and feeding activities of northern pocket gopher (*Thomomys talpoides*) populations may reduce the annual productivity of hay fields by as much as 25% (Turner, 1973). Baiting with toxicants is perceived as the most economical method of control (Moore and Reid, 1951; Tietjen, 1973), but current pre-mixed strychnine and zinc phosphide baits are inadequate either because they do not cause death or they are not well accepted by pocket gophers (Tickes, Cheatheam and Stair, 1982; Tickes, 1983; Lee, Howard and Marsh, 1990). Sullivan (1986) also showed that pocket gopher populations were resilient to control methods, i.e. they bounced back by efficiently recolonising depopulated areas. For this reason, he concluded that standard control methods such as poison baiting cannot effectively suppress these populations for long.

Other rodent control programs have achieved success by controlling dispersing animals. Black rat (*Rattus rattus*) control occurred in Alberta with the establishment of a control zone on the eastern border of the province to intercept individuals dispersing from Saskatchewan (Alberta Agriculture, 1989). A control buffer zone has also been suggested to reduce the rate of reinvasion by Californian ground squirrels (*Spermophilus beecheyi*) (Stroud, 1982).

While pocket gophers can invade fields within 7 days after control (Tunberg, Howard and Marsh, 1984), it may be possible to intercept immigrating animals at the borders of depopulated fields. My objective was to assess the efficacy of a perimeter trapline to intercept immigrating animals and maintain forage fields with low population densities of pocket gophers.

Materials and methods

1994 study

Within a multifaceted pocket gopher control research program (Proulx, 1995) to assess toxicants and different trap models and sets, six ≥ 20-ha alfalfa fields surrounded by other crops and haylands were selected in central Alberta. An 8-ha plot was established ≥ 10 m from the edge of each field where pocket gopher activity was obvious inside and outside the plots' boundaries. From 18 April to 27 May 1994, all pocket gophers were trapped from the centre to the borders of the plots with 48 ConVerT (L. Bachelder, Calgary, Alta.) kill box traps. This trap is more efficient than other brands (Proulx *et al.*, 1992). Traps were left at a given burrow system for a maximum of two consecutive trap nights. As soon as an animal was captured, the trap was moved to a new burrow system.

The empty burrow system was plugged and the mounds were levelled. However, because more than one gopher may inhabit a given burrow system in spring and early summer (Wight, 1930; Hansen and Miller, 1959), and gophers from adjacent areas may invade unused burrow systems, a 3 cm diameter hole in the main tunnel of each trapped burrow system was kept open on the surface. The presence of open holes through the duration of the trapping season indicated that no other pocket gophers were occupying the trapped burrow systems. Traps were reset in burrow systems with plugged holes to ensure total capture of all pocket gophers. Animals were individually marked in the field, and sex and age were determined in the laboratory. Female uterine tracts were inspected for placental scars. At the end of May, all pocket gophers had been trapped out, all the burrow system holes on the surface were open, and there was no sign of burrowing activity. All the study plots were free of pocket gophers. Population densities, expressed as the number of pocket gophers/ha, were calculated for each study area by dividing the number of captures by the area trapped. It was assumed that pocket gopher populations that inhabited the grounds immediately adjacent to the study plots had a density similar to that of the trapped populations.

On the basis of trapping results, three plots (P1, P2 and P3) had low population densities of pocket gopher (< 10 animals/ha) and three others (P4, P5 and P6) had high densities (> 10 animals/ha).

In study plots P3 and P4, no more trapping occurred after the spring removal of pocket gophers. These plots were maintained as controls to monitor the summer immigration of pocket gophers. In the four other study plots, perimeter traplines were established within plot boundaries and maintained from 27 May to 22 September to protect the middle section from immigrating pocket gophers. Different perimeter trapline widths were used in various plots to determine the effect of size on the efficacy of traplines to intercept immigrating pocket gophers. In P1 and P2, a 20 m wide and 40 m wide perimeter trapline were established. A 40 m wide and a 60 m wide perimeter trapline was established in P5 and P6, respectively. Between 80 and 180 traps were set in perimeter traplines depending upon the number of previously trapped burrow systems and new digging activity. Traplines were visited twice weekly. The protected sections were visited at least once every 2 weeks. Traps were set in the protected section as soon as pocket gopher activity was noticed. Capture locations were carefully recorded. When possible, animal age was determined in the field according to size. However, because many animals were in an advanced state of decomposition or scavenged, they were not kept for sex determination in the laboratory. The age or sex of animals captured in P6 was not determined.

In mid-summer, traps were removed for a period of 1 week in P5, 2 weeks in P2 and P6, and 4 weeks in P1 to allow for hay harvesting. At the time of trap removal, study plots were free of pocket gophers. During the hay harvest, pocket gophers immigrated into the study plots and some reached the protected sections. After the hay was removed, traps were immediately set in the protected sections of the study plots to capture the animals that had crossed the perimeter traplines when they were inoperative. The removal of these pocket gophers lasted for 1 week and traps were concurrently set in the perimeter traplines.

The ability of perimeter traplines to intercept immigrating pocket gophers was assessed during two periods: from 27 May to the first hay harvest, and from the re-establishment of traplines after the hay removal to late September. The success of interception was estimated as the percentage of all the captures in a study plot that occurred in the perimeter section. Pocket gophers that had reached the protected section when the perimeter trapline was inoperative were not included in the calculation of the success of interception of the perimeter trapline.

Cessation of trapping activity occurred in September and coincided with the termination of summer field staff. From 20 to 23 September, pocket gopher mounds were flagged and counted in all the study plots except P1 where trapping had ceased 3 weeks before the mound inventory. In P2, the mound count occurred 1 week after cessation of trapping activity.

Sex ratios were analysed with Chi-square statistics. Two-by-two contingency tables were used to test for independence between trapline width and pocket gopher captures in the perimeter trapline and the protected section. Contingency tables were also used to determine if, in each study plot, the relative frequencies of animals captured in the perimeter trapline and the protected section during the pre-haying period were similar to those observed during the post-haying period (Siegel, 1956).

1995 and 1996 studies

In 1995 and 1996, because of lack of resources, the evaluation of the border control strategy was carried out in P5 only. At the end of September 1994, 11 more pocket gophers were captured and, in October, the field was free of pocket gophers. Following the methodology used in 1994, spring removal was carried out from 18 April to 3 May. From 4 May to 29 September, the 40 m wide trapline was re-established within the study plot boundaries and checked once a week. Animal age was determined in the field.

From 13 to 27 June (2 weeks) and 4 to 21 August (3 weeks), traps were removed to allow cattle to graze. As in 1994, pocket gophers that immigrated into the protected section during trapping inactivity were removed one week after the removal of cows and were not included in the assessment of the success of interception of the perimeter trapline.

In 1996, the spring removal was repeated from 6 to 17 May to estimate the pocket gopher population density and compare it with that of previous years.

Results

1994 study

Spring removal. Pocket gopher population densities ranged from 5.6 to 22.4 pocket gophers/ha (*Table 1*). Only adults were captured during the spring removal. The sex ratio was not significantly different ($P > 0.05$) from a 1:1 ratio in P2, P3, P4 and P6 (*Table 1*). However, the ratio significantly favoured females ($P < 0.05$) in P1 and P5. None of the females from P1, P3 and P4, where

all the animals were captured before mid-May, had given birth. In the other study plots, between 41 and 64% of the females had given birth by the time of capture.

Study plots with low population densities. The pre-haying immigration period occurred between the end of May and the beginning of July. More immigrating pocket gophers were captured in P2 than in P1 (*Table 2*). However, the relative frequency of animals captured in the protected and perimeter sections of P1 was the same as the relative frequency of animals captured in each section of P2 ($\chi^2 = 0.05$, df = 1, $P = 0.90$). The perimeter trapline intercepted 83% and 85% of immigrating pocket gophers in P1 and P2, respectively (*Table 2*). A similar number of adults ($n = 8$) and juveniles ($n = 10$) immigrated into P1. In P2, however, the immigrating population was dominated by juveniles (24 or 71% of 34 captures) (*Table 2*).

During the first hay harvest, when perimeter traplines were inoperative, dispersing pocket gophers reached the protected sections of the study plots. During the week following hay removal, 10 (1 adult and 9 juveniles) and 13 (11 juveniles and 2 unknown) pocket gophers were captured in the protected sections of P1 and P2, respectively.

The post-haying period started in late July–early August. Trapping activities lasted until 1 and 14 September in P1 and P2, respectively. As before, a greater number of immigrating pocket gophers were captured in P2 than in P1 (*Table 3*). There was no difference ($\chi^2 = 0.83$ df = 1, $P = 0.50$) between P1 and P2 in the relative frequency of captures in the protected and perimeter sections. The perimeter trapline intercepted 83% and 69% of immigrating pocket gophers in P1 and P2, respectively (*Table 3*). Juveniles dominated the immigrating population of both study plots (*Table 3*).

The same number of immigrating pocket gophers was removed from the protected and perimeter sections of P1 during the pre-haying and post-haying periods. In P2, the number of immigrating pocket gophers was larger during the post-haying period. However, there was no significant difference ($\chi^2 = 1.40$, df = 1, $P = 0.30$) in the relative frequency of captures in the protected and perimeter sections of the pre-haying and post-haying periods of P2. Overall, the perimeter trapline intercepted 83% of immigrating pocket gophers in P1, and 75% of them in P2 (*Table 4*).

Study plots with high population densities. The pre-haying period lasted from the end of May to the beginning of July in P5. In P6, it ended in late July and the number of captured animals was markedly greater than in P5 (*Table 2*). However, the relative frequencies of animals captured in the protected and perimeter sections of P5 and P6 were similar ($\chi^2 = 0.02$, df = 1,

Table 1. Structure and density of pocket gopher populations trapped from 18 April to 27 May, 1994 in six study plots in Alberta

Study plots	Adults				Density of pocket gophers/ha
	Male (%)	Female (%)	U (%)	Total (%)	
P1	22 (36)	39 (64)		61 (100)	7.6
P2	30 (51)	29 (49)		59 (100)	7.4
P3	17 (38)	28 (52)		45 (100)	5.6
P4	43 (44)	54 (55)	1 (1)	98 (100)	12.3
P5	74 (41)	104 (58)	1 (1)	179 (100)	22.4
P6	51 (42)	70 (57)	1 (1)	122 (100)	15.3

U, unknown.

Table 2. Distribution of pocket gopher captures in the protected and perimeter sections of four study areas during the pre-haying period, in summer 1994

Study plots	Trapline width (m)	Captures								Total (%)
		Protected section				Perimeter section				
		A	J	U	Sub-total (%)	A	J	U	Sub-total (%)	
P1	20	1	2	0	3 (17)	7	8	0	15 (83)	18 (100)
P2	40	3	1	1	5 (15)	6	23	0	29 (85)	34 (100)
P5	40	4	11	0	15 (24)	10	34	4	48 (76)	63 (100)
P6	60	5	18	3	26 (23)	22	50	13	85 (77)	111 (100)

A, adults; J, juveniles; U, unknown.

Table 3. Distribution of pocket gopher captures in the protected and perimeter sections of four study areas during the post-haying period, in summer 1994

Study plots	Trapline width (m)	Captures								Total (%)
		Protected section				Perimeter section				
		A	J	U	Sub-total (%)	A	J	U	Sub-total (%)	
P1	20	0	3	0	3 (17)	0	15	0	15 (83)	18 (100)
P2	40	0	14	3	17 (32)	0	33	4	37 (68)	54 (100)
P5	40	0	14	11	25 (25)	1	58	16	75 (75)	100 (100)
P6	60	0	0	19	19 (16)	0	0	100	100 (84)	119 (100)

A, adults; J, juveniles; U, unknown.

$P = 0.90$). The perimeter trapline intercepted 76% and 77% of immigrating pocket gophers in P5 and P6, respectively (*Table 2*). In both plots, the immigrating population was dominated by juveniles (*Table 2*).

During the the first hay harvest, when perimeter traplines were inoperative, 22 juveniles and 40 pocket gophers of unknown age reached the protected sections of P5 and P6, respectively. These animals were trapped immediately after hay removal.

The post-haying period began in early July in P5 and in early August in P6. Trapping activities lasted until late September in both study plots. A slightly higher number of immigrating pocket gophers were captured in P6 than in P5 (*Table 3*). There was no difference ($\chi^2 = 2.23$, df = 1, $P = 0.20$) between the relative frequency of captures in the protected and perimeter sections of both study plots. The perimeter trapline intercepted 75% and 84% of immigrating pocket gophers in P5 and P6, respectively (*Table 3*). In P5, the immigrating population was dominated by juveniles (*Table 3*).

In P5, a greater number of immigrating pocket gophers were captured during the post-haying period ($n = 100$) than during the pre-haying period ($n = 63$). In P6, the difference between the number of animals captured during the post-haying (119) and the pre-haying (111) periods was not as marked. However, the relative frequency of captures in the protected and perimeter sections was independent from the study period in P5 ($\chi^2 < 0.01$, df = 1, $P = 0.99$) and P6 ($\chi^2 = 1.58$, df = 1, $P = 0.30$). Overall, the perimeter trapline intercepted 75% of immigrating pocket gophers in P5 and 80% of them in P6 (*Table 4*).

Mound counts. In the control plots (P3 and P4) where there were no perimeter traplines, 1703 and 2306 mounds were counted in September (*Table 5*). There were at least 11 times as many mounds/ha in the control plots as in the protected sections of plots with perimeter traplines (*Table 5*). Although mound densities in the perimeter sections varied greatly from one study plot to another, they were consistently greater than those of the protected sections (*Table 5*). However, they were markedly lower than those of P3 and P4.

Table 4. Success of interception of perimeter traplines in four study plots during summer 1994

	Captures (%)		
Study plots	Protected section	Perimeter section	Total
P1	6 (18)	30 (83)	36 (100)
P2	22 (25)	66 (75)	88 (100)
P5	40 (25)	123 (75)	163 (100)
P6	45 (20)	185 (80)	230 (100)

Table 5. Pocket gopher mound counts and densities in five study plots, September 1994

	Area (ha)	Number of mounds	Mounds/ha
Control			
P3	8.0	1703	213
P4	8.0	2306	288
Perimeter sections			
P2	4.0	172	43
P5	4.0	88	22
P6	5.4	534	99
Protected sections			
P2	4.0	50	13
P5	4.0	67	17
P6	2.6	50	19

1995 and 1996 studies (P5 only)

In 1995, only three female and eight male adults were captured during the spring removal. None of the females had reproduced. The density of pocket gophers was estimated at 1.4/ha.

During the first pre-grazing period (4 May to 13 June), only three pocket gophers (one adult and two juveniles) were captured, all in the perimeter trapline.

Two juveniles immigrated in the protected section during the first grazing period. A total of 38 animals were captured between the first and second grazing periods: 14 (37%) in the protected section and 24 (63%) in the perimeter section. The immigrating population was dominated (76%) by juveniles.

Eleven juveniles entered the protected section during the second grazing period and were removed. A total of 31 pocket gophers were captured after the second grazing period, all in the perimeter trapline. The immigrating population was dominated (77%) by juveniles.

Overall, a total of 72 animals were captured in P5 when the perimeter trapline was operative: 14 in the protected section and 58 in the perimeter section. Therefore, the perimeter trapline intercepted 81% of the immigrating population.

In 1996, one pocket gopher (unknown sex) was captured during the spring removal, at the border of the plot. The density of pocket gophers was 0.1/ha. In May, the field was completely free of pocket gophers.

Discussion

Sullivan (1986) showed that when northern pocket gophers were removed from a 1 ha grassland, the species quickly recolonized the depopulated area and had a recovery ratio of nearly 70%. The present study also showed that pocket gopher immigration into depopulated areas was tremendous and could compensate for a major reduction in densities in the spring. Knowing the importance of immigrating movements, and the fact that pocket gophers readily inhabit unoccupied burrow systems (Howard and Childs, 1959; Proulx *et al.*, 1995), a border control strategy is a unique way to maintain constant control of pocket gopher populations. Such a strategy would therefore allow a farmer to prevent rather than react to pocket gopher colonisation.

In this study, despite differences between study plots in the time periods during which perimeter traplines were operative, implementation of the border control strategy resulted in the control of > 75% of the pocket gopher populations. This control level is markedly greater than the < 45% control accomplished with diverse poison grain baits currently available on the market (Tickes *et al.*, 1982; Tickes, 1983; Proulx and Cole, 1996). The control level accomplished with the border control strategy exceeds the acceptable

performance standard of 70% set by the US Environmental Protection Agency Draft Registration Guidelines (Fagerstone, Matschke and Elias, 1981).

Despite the obvious success accomplished with the border control strategy in intercepting immigrating pocket gophers, more work should be carried out to better understand the animals' movements. For example, while the spring populations of P1 and P2 were similar, and both plots were subject to complete depopulation, there were more immigrating pocket gophers in P2 than in P1. Also, in all study plots, pocket gophers did not enter fields equally from all sides. Some regions of the perimeter traplines were more used than others. The availability of empty burrow systems, intraspecific pressure, local soil or vegetation conditions, or individual variation in the pocket gopher exploratory behaviour may all contribute to the fact that some pocket gophers moved deeper than others into the depopulated plots. In practice, a better understanding of pocket gopher movements would allow for a better distribution of traps along the edges.

In P5, the effect of the 1994 border control was apparent the following year. Indeed, the 1995 spring population density was markedly lower than that in 1994. I propose that as pocket gophers were being removed at the edge of the study plot in 1994, more animals from adjacent areas may have extended their home range over the boundaries of the perimeter trapline or simply entered the depopulated plot. As these animals were captured in the perimeter trapline, the pocket gopher population bordering the study plot apparently was reduced. With a smaller adjacent breeding population in spring 1995, the number of immigrating pocket gophers was also lower. By 1996, the bordering population had been decimated and the study plot was essentially free of pocket gophers.

The border control stragety consists of a series of steps that must be maintained in order to ensure a high level of control of pocket gopher populations. It is important to initiate trapping as early as possible in spring in order to remove reproducing females and eliminate the production of juveniles. In this study, perhaps because traps were visited twice weekly and were continuously set, the width of the trapline did not appear to play a major role in the overall interception of pocket gophers. However, where traps could not be checked on a weekly basis, a $\geq$ 40 m wide trapline may be advisable. The larger the trapline area, the slower the immigration in the field's protected section should be. Independent of the border width, an attempt should be made not to interrupt perimeter control during the growing season. In this study, only one week without border control in P5, in 1994, was sufficient to allow pocket gophers to reach the protected section.

In 1994, field staff gathered various data on trapping methodology and pocket gopher biology which were irrelevant to this study. Therefore, the amount of time spent implementing the spring removal and the perimeter trapline could not be accurately estimated. In P5 and P6, two plots with high population densities, the maximum time required by one person to carry out the work was estimated at 470 h per study plot or, on average, 20 h per week. In P2, the same work with low population densities required, on average, 13 h per week. Obviously, it is more advantageous to implement the border control strategy in young hay fields with low population densities. Spring removal with traps is labour-intensive and time-consuming during the first year. In the second year, however, implementation of the border control strategy is less work with lower pocket gopher populations. In P5, in 1995, one person spent, on average, 2 h per week. Promotion of the border control strategy was initiated in central Alberta (Proulx, 1995, 1996), and farmers who adopted it have indicated their satisfaction in spite of the initial amount of work required to remove spring populations (L. Lounsbury, Agricultural Fieldman, County of Red Deer, pers. commun.).

Because of limited resources, the sample size of this study was small. However, the study pointed out that the border control strategy can undoubtedly maintain pocket gopher population densities, and the number of mounds which interfere with hay harvest, at low levels. Additional field work should be carried out with larger sample sizes, different pocket gopher population densities, and in different agricultural regions to further assess and improve this new management approach.

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