AN EVALUATION OF THE IMPACT OF THE ALAMEDA COUNTY/LAND OWNER GROUND SQUIRREL MANAGEMENT PROGRAM ON SQUIRREL ABUNDANCE, RAPTOR USE, AND RAPTOR FATALITES: A Status Report

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Introduction

The availability of prey is the primary factor controlling raptor presence and abundance at a given locality. Where prey is readily available, raptor numbers will almost always be greater than where prey is less abundant and less available. This finding has been demonstrated repeatedly among raptor biologists throughout the world over the past 50 years (Craighead and Craighead 1956, Newton 1979). The superabundance and availability of ground squirrels in the Altamont Pass Wind Resource Area (AWRA) is believed to be the reason so many Golden Eagles and Red-tailed Hawks are present, putting them at risk of collision with the wind turbines.

In 1997 Grainger Hunt's tracking of radiotagged Golden Eagles showed a decline in use in some portions of the Windplant. He consulted Karen Lougheed of Kenetech Windpower who reported a decline of reported Golden Eagle fatalities in the same areas. To explain the decline, Hunt systematically surveyed ground squirrel activity in the Windplant and found few squirrels in the areas where he had few relocations of radiotracked eagles. Where there were many ground squirrels he found larger numbers of eagles. Together the Hunt and Lougheed findings suggest that ground squirrel control may be an effective means of reducing risk to eagles in wind power facilities. Previously, Orloff and Flannery (1992) and U.S. F&WS staff suggested prey base management as an option for further action to reduce Golden Eagle and other raptor use of the AWRA. Currently, ground squirrel management in the AWRA is conducted by the Alameda County Department of Agriculture (ACDA) and landowners.

As part of the Altamont Avian Plan (a mitigation plan aimed at reducing raptor fatalities), we are testing the hypothesis that eagle and other raptor use of the AWRA is influenced by ground squirrel abundance and the ground squirrel management program. To test this hypothesis, we have established a program for evaluating the effectiveness of the ACDA ground squirrel management program. We are also evaluating how the management of ground squirrels influences the numbers of Golden Eagles, Red-tailed Hawks, and other raptors that forage in the AWRA and whether or not ground squirrel management has an effect on the numbers of eagles and hawks that are killed by wind turbines.

Our test of this hypothesis involves the use of three independent data sets. The data sets included information only from that portion of the AWRA in which Kenetech model turbines are located (the Windplant). First, we established a field methodology for monitoring numbers of ground squirrels and raptor abundance and use throughout the Windplant. Second, we examined historical records of ground squirrel management from the past decade (1989-1998) to see how long-term management of ground squirrels impacts current raptor abundance and use patterns. Third, we relied on the Wildlife Response and Reporting System to compare the numbers of raptor fatalities reported on lands that are managed for squirrels as opposed to lands that are not managed for ground squirrels. By combining results from the analyses of these diverse databases, we are able to test our hypothesis and evaluate the effectiveness of the ground squirrel program for controlling ground squirrel numbers and how these numbers impact upon raptor abundance, use, and fatalities. This report summarizes the first year of this evaluation process. We also included information on the process of ground squirrel management and removing ground squirrel carcasses that remained above ground after treatment in 1997 and 1998.

Methods

Ground Squirrel Treatment Methods and Carcass Searches

The method of treatment used by the Alameda County Agriculture Department to control ground squirrels was a course of three applications of diphacinone or chlorophacinone, widely used anticoagulant rodenticides. Applications are done on three days at a treatment location, with one day between each application. Treatments usually started on Monday and were done again on Wednesday and Friday. The rodenticide was applied via spreading of treated grain (dyed blue) within a specifically designated treatment area. Three applications are used because this particular toxin must accumulate in the rodents until it reaches a lethal level.

Ground squirrel carcass searches were conducted by a field technician who buried carcasses found on the surface. This reduced the potential of secondary poisoning. The carcass searches commenced the third day after the first blue grain application and continued daily for at least seven days, after which additional searches were conducted if carcasses or sick rodents continued to be located. When sick or dead rodents were not evident, carcass searches were terminated; this following the California Division of Fish and Game procedures.

Evaluation of Treatment Effectiveness

To examine the effectiveness of the ground squirrel management program and its impact on raptor abundance, use, and fatalities within the windplant, we examined three independent data sets. The data were diverse in origin and in how they were gathered, but together they provided a means of asking several questions.

1. Field Evaluation. The first data set was from a field study we established to monitor ground squirrel abundance, raptor abundance, and raptor use in 20 sampling areas throughout the Windplant. The 20 sampling areas included two-thirds (2,279 of 3,445 Kenetech model turbines, 66.2%). These areas are circles about 1 km in diameter scattered fairly evenly throughout the windplant and over many land ownerships (Figure 1, Table 1). With the exception of two circles, where about 1% of the areas were shared, overlapping of sampling areas was avoided. Each of the circles is almost entirely within a given ranch or a uniform area of ground squirrel management. In each sample area a regular driving route was established. These routes were driven slowly (<10 mph) two times each month. Ground squirrels and raptors were counted and recorded on data sheets. For each raptor, behavioral information included whether the bird was perched within the circle, whether it was flying, its altitude of flight, and the mode of flight (soaring, gliding, contour hunting, etc.). These behavioral observations were used to determine if the bird was actually using the area within the circle or just passing through it. For our analyses, the higher of the two monthly squirrel and raptor counts were used. In some months the higher raptor count occurred on a different count than the higher squirrel counts. In these cases the higher of each was used for the analyses. Our rationale for using the higher count for each species group was that counts of ground squirrels and raptors are usually underestimates of the numbers present.

Table 1. List of 20 sampling areas used in 1998 and January of 1999 to evaluate the prey management program implemented by ranchers and the Alameda County Agriculture Department. Included are the number of turbines in each of the 20 sampling areas and the prey management regime as classified from Table 1.

Sampling Area	Number of Turbines
Treated	
1. Alameda County Waste Management 8 (ACWM8)	89
2. Alameda County Waste Management W (ACWMW)	154
3. Alameda County Waste Management E (ACWME)	115
4. North Mulqueeney (NMQ)	146
5. South Mulqueeney South (SMQS)	105
6. South Mulqueeney North (SMQN)	82
7. Ralph Properties North (RPN)	137
8. Ralph Properties South (RPS)	97
Untreated	
9. Contra Costa Water District – North (CCWDN)	98
10. Contra Costa Water District – South (CCWDS)	171
11. Walker Family Trust (WFTS)	135
12. North Walker North (NWKN)	150
13. North Walker South (NWKS)	89
14. Altamont Landfill (AL)	90
15. Pombo (PMBO)	65
16. Egan/Elliott/Rooney	132
17. Gomes North (GMN)	141
18. Gomes South (GMS)	83
19. Valhalla (VAL)	109
20. Hugh Walker (HW)	91
Total	2,279 turbines in 20 sampling areas Average of 114 per sampling area 66.1% of 3,446 Kenetech model turbines

Surveys were commenced in January of 1998 and are continuing. The data used for this report include the first year of surveys, February 1998 to January 1999. Data from January 1998 were not used because surveys during that month were used for designing the monitoring procedures and were somewhat different from the intervening surveys. No surveys were conducted in June 1998. All data were entered into an Excel spreadsheet for analysis. For analysis, the data from each circle were linked to ground squirrel management regime (see next paragraph) for the same property.

2. Historical Ground Squirrel Management Records. The second data set we employed included historical records of ground squirrel treatment from the Alameda County Department of Agriculture (ACDA) and agricultural agent Jim Smith. These records are grain purchase records for each of the landowners on which Kenetech model turbines are located (Table 2). The grain purchase records do not reflect the methods used to treat the lands nor do they reflect the exact location of the treatment. For example, grain that is purchased from the county may have been disbursed in varying ways on different ranches or by different people. Some methods are not always effective. When treated grain is applied by a county agent, it is applied using the methods recommended by the manufacturer and what that agent has found to be suited to the Altamont. In general, grain purchases usually mean that a ranch has been treated to some degree. A summary of historical treatment for the period 1989-1998 is provided in Table 3. For analysis of effectiveness in reducing ground squirrel numbers, as well as raptor abundance, use, and fatalities, we pooled several ranches into the following two categories according to the ACDA records:

> Historically Treated = lands that seem to have been treated regularly in the manner recommended by the County during the past 10 years
>
> Untreated = lands that have not been treated for more than 2 years in the last 5 years and probably have not been treated regularly in the past 10 years

The reader is referred to Table 3 in which the ACDA records are summarized for all ranches for the period 1989-1998. The classification (as above – Treated and Untreated) for each of these ranches is also provided in Table 2.

3. Records of Raptor Fatalities. The third source of data were 10 years of records of Golden Eagle and Red-tailed Hawk fatalities in the Wildlife Response and Reporting System (WRRS) from Altamont Infrastructure Company. This system includes a database of fatality records from the 3,400+ Kenetech model turbines that has been kept between 1989 and the present (10 years). Each fatality record includes the ranch and exact location where it was found, as well as date of find. These invaluable records were used to compare fatalities on areas with different prey management regimes and histories. By linking fatalities to prey management regime, we have a powerful means of determining whether prey management has a salutary effect on reducing raptor fatalities.

Table 2. Ranches listed by ground squirrel management regime, along with the number of turbines within each holding. For definitions of historically treated, untreated, and mixed treatments see Methods section.

Historically Treated		Number of Turbines
Alameda County Waste Management Authority		404
Mulqueeney		713
Dapaoli/Ralph		40
Ralph Properties North		241
Ralph Properties South		24
Guo/Lin		10
	Subtotal	1,436
Historically Untreated		
Contra Costa Water District		426
Spinnato		12
Walker Family Trust Lands		450
Hugh Walker		110
Gomes North		175
Gomes South		174
Jackson		56
Rooney		31
Egan		50
Elliott		26
Valhalla		136
Pombo		65
Haera		9
Altamont Landfill		248
Haugh		34
Frick		8
	Subtotal	2,008
	Total	3,446

Table 3. Summary of ground squirrel management history (treated and untreated areas in the Windplant) by year. Y = yes, treated for ground squirrels; P = probably treated - fide Jim Smith, ACDA; AB = associate (tenant, employee, etc.) bought grain; N = not treated for ground squirrels; 0 = no grain purchased; and ? = treatment unknown in that year. * indicates that the land was treated but only partially (specific areas were left untreated).

Landowner	Tenants/Group	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Historically Treated											
ACWMA	Depaoli	P	P	P	P	P	P	P	P	Y	N
Depaoli/Ralph	Depaoli	P	P	P	P	P	P	P	P	Y	N
Guo/Lin	Depaoli	P	P	P	P	P	P	P	P	Y	N
Spinnato	Depaoli	P	P	P	P	P	P	P	P	Y	N
Ralph (N)	Depaoli	P	P	P	P	P	P	P	P	Y	N
Ralph (S)	Depaoli	P	P	P	P	P	P	P	P	Y	N
Mulqueeney		P	P	P	P	P	P	P	P	Y	Y
		AB	AB	0	AB	AB	AB	AB	AB		
Historically Untreated											
Egan	E/E/R	AB	AB	0	0	0	0	AB	0	N	Y
Elliot	E/E/R	AB	AB	0	0	0	0	AB	0	N	Y
Rooney	E/E/R	AB	AB	0	0	0	0	AB	0	N	Y
Walker Family N	Walker	0	AB	0	0	0	0	0	0	Y	N
Walker Family S	Walker	0	AB	0	0	0	0	0	0	Y	N
Hugh Walker	Walker	0	AB	0	0	0	0	0	0	N	Y
Gomes (N)		AB	AB	0	0	0	AB	0	0	N	Y
Altamont Landfill*	Jackson	?	?	?	?	Y	N	Y	Y	Y	Y
CCWD	Jackson	?	?	?	?	?	?	?	?	N	N
Gomes (S)		0	0	AB	AB	0	0	0	0	Y	Y
Jackson	Jackson	?	?	?	?	?	?	?	?	Y	N
Pombo		AB	AB	0	0	AB	0	0	0	Y	Y
Valhalla	Jackson	?	?	?	?	?	?	?	?	N	Y

Results

Alameda County Ground Squirrel Treatment and Carcass Removal - 1998

In 1997, five ranches were treated by the ACDA for ground squirrels (Table 4A). Dates of treatment ranged from mid-August to mid- September. In 1998, seven ranches were treated for ground squirrels (Table 4B) with treatment dates ranging from June 22 to August 24. The numbers of ground squirrel carcasses found above ground on each of the properties varied dramatically with the lowest being 3 and the highest being 23 in 1998 and between 2 and 30 in 1997. A total of 64 carcasses were found in 1998 and 83 in 1997.

Table 4A. Rodenticide application schedule for 1997 and numbers of ground squirrel carcasses found and buried

Ranch (Treatment Date)	Carcasses Located Each Days After Applicaton	Total Squirrels Found
Gomes South (September 8)	0,0,0,1,0,1,0	2
Walker North (August 18)	0,0,0,0,11,4,8,7,0	30
Walker South (August 25)	0,0,0,4,1,1,2,1,0,0	9
Pombo (September 15)	0,2,0,0,2,7,8,6,1	26
Jackson (September 1)	0,0,0,2,3,8,3,0	16
	Total	83

Table 4B. Rodenticide application schedule for 1998 and numbers of ground squirrel carcasses found and buried

Ranch (Treatment Date)	Carcasses Located Each Day After Treatment	Total Squirrels Found
Gomes North (June 22)	0,0,0,0,9,8,2,1,4,2,1,0	27
Pombo (July 6)	0,0,2,6,4,2,1,0	15
Gomes South/Mulqueeney (July 20)	0,0,0,0,0,2,4,1,0	7
Valhalla (July 27)	0,0,0,0,1,4,0	5
Egan/Elliott/Rooney (August 3)	0,0,0,0,0,0,0,1,2,0	3
Hugh Walker (August 24)	0,0,0,1,2,2,1,1,0	7
Altamont Landfill (July 13)	no data available	n/a
	Total	64

Summary of 1998-1999 Ground Squirrel Management and Ground Squirrel Numbers

Between January 1998 and January 1999, 23 rounds of surveys were conducted in each of the 20 circular sampling sites (Figure 1). In January 1998, one round of surveys was completed as a means of testing and refining the field methodology and protocols. Those data are not included in this report. In June of 1998, no surveys were conducted, in part because tall grass made it difficult to see and count squirrels.

An examination of ground squirrel abundance throughout the windplant during 1998 revealed both spatial and temporal differences. The numbers of ground squirrels on all twenty circles were greatest in February and March, declining from that time until the following January when numbers began to increase (Figure 2). The numbers of squirrels counted in February 1998, when numbers were highest, ranged to more than 200 per survey for untreated areas such as the Contra Costa Water District North and Gomes North. More than 100 squirrels per survey were noted on the Pombo and North Walker-North areas in that month. Total numbers declined by nearly 20% between February and March, and by nearly 50% between March and April. After April, numbers remained low until December, when the numbers on some ranches increased.

Despite the attempt to establish sampling areas within which ground squirrel management was uniform, not all sampling areas were homogeneous. For example, on the Ralph Properties (two of the 20 circular samples) a small subset of the sampling areas was found to contain a high density of ground squirrels. This "hot spot" was found well after the survey was underway. During the early part of 1998 the survey route was shortened slightly when roads were impassable because of mud. Sampling of the entire Ralph Properties' roads resumed in August, at which time the hot spot was discovered. This small area changed the data set slightly for this area during these months, but because this increase in ground squirrel numbers accounted for such a small portion of the overall analyses, we did not adjust for the minor difference in roads surveyed.

To determine the impact of the 1998 ground squirrel treatment that occurred in mid-August and into September, we compared the numbers of squirrels counted in April and May with the numbers counted in September and October. We compared ranches that were treated in 1998 with those that were historically untreated (and not treated in 1998; Figure 3). We did not include ranches that were historically treated. The rationale for including these temporal comparisons of historically treated and untreated with ranches treated in 1998 was to control for seasonal variations in ground squirrel numbers. The comparisons showed a decline of 73% for ranches treated in 1998 as opposed to 21% for ranches untreated in 1998. Thus, the decline for 1998 treated areas was nearly four times greater than for untreated areas. Of the seven areas treated in 1998, six showed declines between 63 and 96% in numbers of squirrels counted (Figure 4A and 4B). Most profound was the decline on the Gomes North sampling circle, where there was a 96% reduction in numbers of ground squirrels counted.

The results of these comparisons demonstrate both a seasonal change in ground squirrel numbers and a change attributable to the ground squirrel treatment program. Indeed, the effect

of treatment was immediate and sizeable. Further evaluation is needed to determine the duration of the effect from the 1998 and subsequent treatments.

Summary of 1998-1999 Raptor Numbers and Use

The numbers of Golden Eagles and Red-tailed Hawks (Figure 5) observed in the 20 circles was greatest during the early months of the surveys in February and March, declining thereafter. The February 1998 surveys totaled 19 eagles and 32 Red-tailed Hawks (Figure 5) on the 20 survey areas. These numbers dropped dramatically and reached their lowest between May and November, although the numbers of Golden Eagles in January 1999 were also very low. The numbers of raptors varied greatly among areas. Several areas, especially those south of U.S. Route 580, including the ACWMA, Ralph Properties, and Mulqueeney property, had very few Red-tailed Hawks and almost no Golden Eagles present during the surveys. Other properties, especially those north of U.S. Route 580, including the CCWD, Walker properties, Pombo, Valhalla, and Altamont Landfill consistently had hawks and eagles present. These birds were present in greatest numbers on these tracts mostly in the early months of 1998.

The monthly counts of Golden Eagles and Red-tailed Hawks for the 11 months were highly correlated (Figure 6). This means that when large numbers of hawks were present, so too were large numbers of eagles. The relationship that emerged between the monthly numbers of ground squirrels and numbers of eagles observed on the surveys during the year was quite strong (Figure 7). The number of eagles observed during a month was highly correlated with the number of ground squirrels for each month when data from all 20 circles are combined.

A similar, though not as strong, relationship emerged between the numbers of ground squirrels and the numbers of Red-tailed Hawks (Figure 8). What these relationships seem to indicate is that at times of the year when squirrel abundance was greatest, so too was the abundance of eagles and hawks greatest. The relationships were both non-linear, with squirrel numbers increasing in a disproportionately greater fashion than eagle and hawk numbers during the year. What this strongly suggests is that ground squirrel abundance regulates the numbers of eagles and hawks that use the wind plant in a given month. In months when there are many ground squirrels there are many eagles and hawks and in months when there are few ground squirrels there are fewer eagles and hawks.

Because the numbers of Golden Eagles counted in a month was correlated with the numbers of Red-tailed Hawks counted in that month (Figure 6) there is a strong suggestion that the local populations of both species are regulated by the same factor. It is likely that ground squirrel abundance is that factor or correlated with that factor.

Historical Ground Squirrel Management and Ground Squirrel Abundance in 1998

Although a strong decline in ground squirrel numbers on treated ranches was evident following the 1998 treatment (Figure 3), ground squirrels were still present in varying numbers. These ranches had not received consistent treatment over the decade previous to the 1998 treatment and our surveys. Because it may take several years for treatment programs to reduce

ground squirrels effectively, it is of interest to examine whether the numbers of ground squirrels present on ranches that were historically treated were less than the numbers on ranches that were untreated (Table 3). As might be expected, the difference in numbers of ground squirrels counted on treated vs. untreated ranches was considerable (Figure 9). The average number of squirrels counted in the eight survey areas that were historically treated were lower than those counted on the 12 historically untreated ranches. This was true for all months of the year and there was virtually no overlap between the 12 untreated and eight treated sampling areas for any month. There were seldom more than 5-10 ground squirrels counted per circle-survey area in the historically treated areas during any month of the year.

If the hypothesis that raptor numbers are regulated by ground squirrel abundance is true, the numbers of raptors counted on historically treated ranches would be lower than those counted on historically untreated ranches (Table 3). When considered on a month by month basis during the year, the average numbers of eagles and hawks were lower in areas where squirrel management has been done historically as opposed to lands that were historically untreated (Figures 10 and 11). For Golden Eagles, the effect of ground squirrel treatment is overwhelming. Very few eagles were observed in the eight sampling areas that had been treated, whereas many more were seen on untreated areas. Between March and November, not one eagle was observed on the surveys on treated lands (Figure 10), whereas on untreated areas, eagles were seen in every month. In those months when eagles were seen on treated lands, the numbers were much smaller than in untreated areas.

Although a similar relationship was found for Red-tailed Hawks, the magnitude of the difference between historically treated and historically untreated areas was less than for eagles (Figure 11). However, in 10 of 11 months of surveys during the year, fewer Red-tailed Hawks were observed in treated areas than in untreated or mixed treatment areas. In some months the difference was very large, with two to three times the numbers of hawks on untreated vs. treated areas. For both Golden Eagles and Red-tailed Hawks, ground squirrel management seems to result in reduced use by these raptors.

Historical Ground Squirrel Management and Raptor Fatalities

We did not attempt to relate fatalities during 1997 and 1998 to ground squirrel management regime on properties that commenced treatment in those years because the numbers of fatalities during this short time period from the small number of ranches is not appropriate for the analysis.

Because a greater amount of time is required to evaluate the linkage between raptor fatalities and ground squirrel management, we relied on historical records of both ground squirrel management in the Windplant and the records of Golden Eagle and Red-tailed Hawk fatalities reported in the Wildlife Response and Reporting System. To quantitatively examine historical fatality rates between areas with different histories of ground squirrel management, we determined the rate of fatalities of Golden Eagles and Red-tailed Hawks per turbine per year within a given land ownership. This metric standardizes the fatality rate among areas in which there are different numbers of turbines. Our comparson of areas with different ground squirrel

management histories revealed a disproportionately greater fatality rate of Golden Eagles (Figure 12) and Red-tailed Hawks (Figure 13) on untreated areas than on areas that had been treated historically. For Golden Eagles, the rate was 2.8 times higher on historically untreated areas. The actual number of eagles killed on historically treated lands was about one-quarter that of untreated lands (42 vs 165, 25%, Figure 12). If the rate for the entire windplant was reduced to 0.0029 eagles killed per turbine per year (Figure 12), the annual rate would be slightly less than one-half (48.3%) its current rate of 0.0060 per turbine per year.

The relationship between prey management history and Red-tailed Hawk fatalities was not as strong as it was for Golden Eagles (Figure 13). The rate of fatalities for untreated areas was 1.8 times greater than for treated areas. The rate of fatalities at treated ranches was 43% lower than on untreated areas.

Conclusions and Discussion

Ground squirrel management, as implemented by the Alameda County Department of Agriculture on private ranchlands in the AWRA during the past decade, appears to have been successful in reducing the numbers of ground squirrels in some portions of the wind plant. This is true both for the short and long term. The best examples of successful long term treatment include the Alameda County Waste Management and Mulqueeney lands (south of US Route 580). Ground squirrel treatment, as indicated by grain purchases during the past decade (Table 3), has resulted in low counts of ground squirrels during our 1998-1999 field surveys.

Monitoring ground squirrel, eagle, and hawk abundance patterns throughout the wind plant via the 20-circle survey method proved to be an excellent means of detecting changes in abundance and use among sites and from month to month. On sites that were known to have been well treated over a many years, very few, if any, ground squirrels were observed. This was particularly true for the Mulqueeney and Alameda County Waste Management lands where prey management has been conducted diligently for several years. Conversely, sites like the Contra Costa Water District, Gomes North, Pombo, and the Walker Family Trust lands that have not been treated thoroughly over several years, hosted large numbers of ground squirrels during a portion of the year. Because the 1998 field surveys of squirrels were highly correlated with both short and long term ground squirrel control history, we believe that the survey method is a valid means of estimating relative abundance of ground squirrels. We also conclude that the 20-circle surveys accurately reflect the abundance and pattern of eagle and hawk use throughout the wind plant for the same reasons listed above for ground squirrels.

In addition to ground squirrel treatment, we suspect that some other factor was operating during 1998 in the Windplant that reduced the numbers of squirrels. Overall, the number of squirrels observed in February and March were much higher than any other months of the year, with the exception of a couple of individual sites. These numbers never climbed back to the February-March levels during the last months of 1998 and January 1999, although a slight climb was observed. Tall grass could, in part, explain the lower numbers in April and May, but not later in autumn when grasses matted down and visibility became better for observing and

counting ground squirrels. It is likely that some other factor or combination of factors, such as disease, cyclic fluctuations, or other, as yet unknown factors are involved.

The fact that Red-tailed Hawk fatalities were not as reduced as Golden Eagle fatalities on treated lands is attributable to differences in the ecology of these species. Eagles specialize on larger prey species than hawks. Red-tailed Hawks also hunt for mice and other small rodents that eagles rarely take. The reduction of ground squirrels undoubtedly makes some areas less attractive to hawks, but some hawks remain because mice are present. Conversely, eagles forage elsewhere when ground squirrels are scarce.

The efficacy of ground squirrel management as a means of reducing Golden Eagle and Red-tailed Hawk fatalities was suggested by the analyses presented above. We feel that ground squirrel management, if done correctly using protocols adopted by the ACDA, may result in even fewer fatalities than were reported in the treated areas. The reason for this is that even in the treated areas, there were years when treatment was not done thoroughly or effectively. This may explain the larger numbers of eagle kills on some ranches in some years. Thus, the rate of 0.0029 eagles killed per turbine per year in treated areas may be lower if treatment is continued.

Recommendations for Future of Program

Our primary recommendation is that the evaluation program for the Alameda County ground squirrel management program as described in this report be continued. Based on the facts presented in this report, the program appears to be successful in dramatically reducing numbers of squirrels, especially on ranches where treatment has been done consistently over many years. This evaluation program provides the only means of monitoring squirrel numbers over a large portion of the Windplant. Furthermore, there is strong evidence that Golden Eagle and Red-tailed Hawk abundance and use of lands that have been treated for ground squirrels is greatly reduced. There is also evidence that raptor fatalities, are lower on lands that have reduced numbers of ground squirrels than on lands that are not treated. It appears that ground squirrel management may be an indirect, but effective, means of reducing risk to eagles and hawks within the Windplant.

We further recommend thorough investigation of lands that have not been treated consistently for several years and are now being treated. We need to know how quickly and effectively the number of ground squirrels can be reduced and the resulting impact on numbers of hawks and eagles that use these lands. Such evaluation should also include the establishment of a plan that would help ranches with inadequate treatment to incorporate more effective practices. If a thorough and effective ground squirrel management regime is not established on these lands, the program will not reduce squirrel abundance significantly, nor will it likely lead to fewer raptor fatalities on those properties.

There are several properties that we feel should be given priority by the ACDA and ranchers with respect to the treatment program. These ranches would include the Ralph Properties North and South, which were not treated in 1998. These properties demonstrated an increase in numbers of ground squirrels after mid-1998, perhaps because they were not treated

in 1998. This is the first time in several years that these lands have not been treated. If they are not treated in 1999, the numbers of ground squirrels may grow so rapidly as to make the year 2000 treatments less effective.

Other priority areas should be the Pombo, Gomes N, Valhalla, and Altamont Landfill tracts. All have had significant eagle and hawk fatalities in the past and have been treated in recent years. If treatment is continued in 1999 on these properties, treatments done in 1997 and 1998 will be more effective and not wasted.

The Walker Family Trust lands would be on our priority list if not for the susceptibility of these sites to invasion by squirrels from adjacent CCWD and county park (Brushy Peak) lands. The latter properties are not treated and support burgeoning populations of ground squirrels. If the Walker Family Trust lands are to be treated, the ACDA and ranchers may wish to establish some sort of ancillary or focused programs to prevent or reduce squirrel colonization from adjacent, untreated lands.

Another important action that can be taken is communication between the biologist conducting the 20 circle survey and the ACDA agent in charge of ground squirrel treatment. This communication would consist of the biologist informing the agent about the location of ground squirrel hot spots. This information could then be used to target these areas for treatment in 1999 and in future years.

Our last recommendation is that the 20-circle surveys be continued in 1999 as a means of evaluating the treatment program as it relates to ground squirrel numbers, raptor use, and raptor fatalities. Without the information gathered by this evaluation program, we will not be able to determine whether or not the squirrel management program is efficacious with respect to preventing eagle and hawk fatalities.

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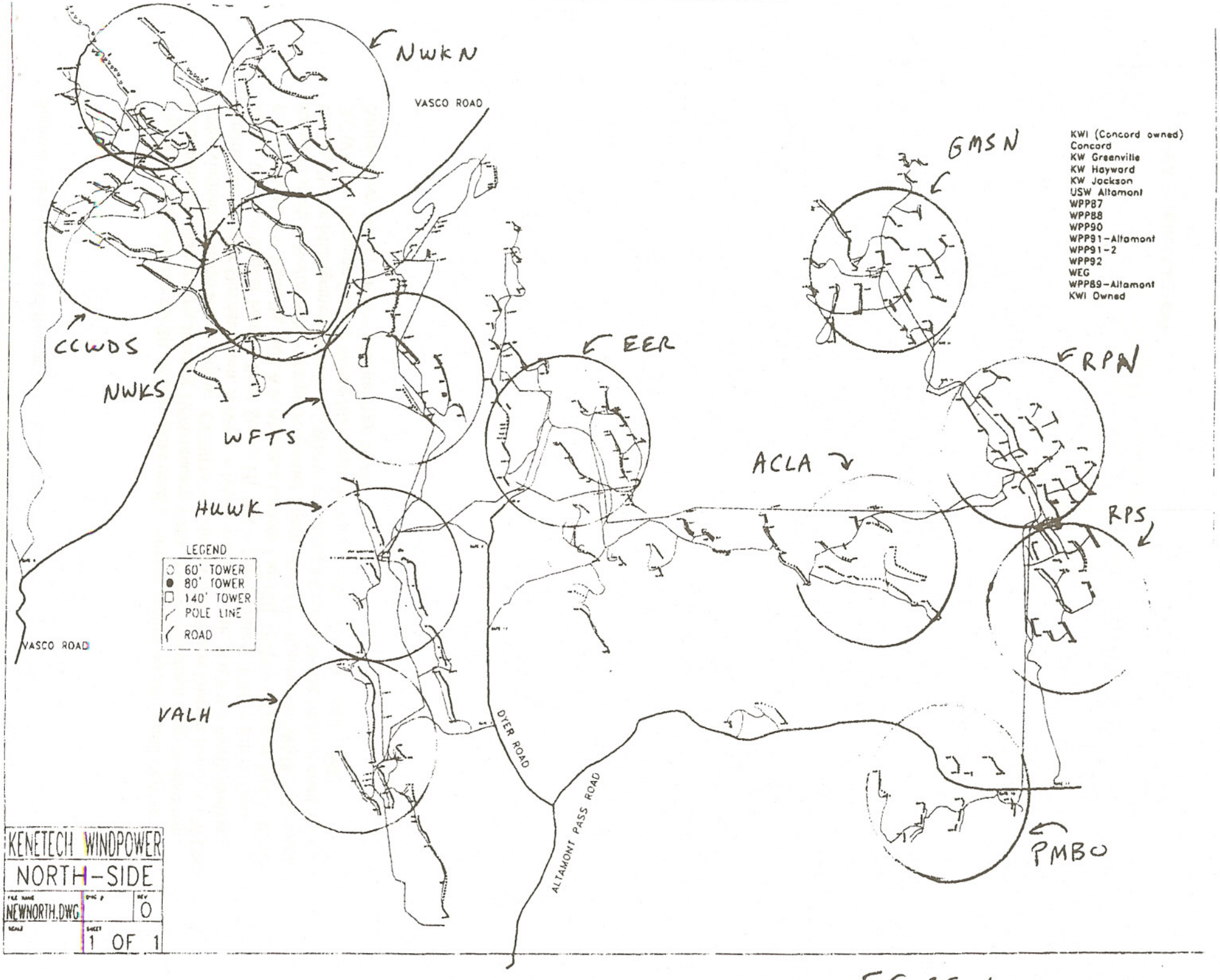
Figure 1. Map showing the 20 circular areas used to sample ground squirrels and raptors on a twice monthly basis during January 1998-January 1999. Circles are about 1 km in diameter. Abbreviations on maps are as follow: CCWDN = Contra Costa Water District North, CCWDS = Contra Costa Water District South, NWKN = North Walker North, NWKS = North Walker South, WFTS = Walker Family Trust South, HUWK = Hugh Walker, EER = Elliot, Egan, Rooney, VALH = Valhalla, ACLA = Alameda County Landfill, GMSN = Gomes North, RPN = Ralph Properties North, RPS = Ralph Properties South, PMBO = Pombo, ACWM8 = Alameda County Waste Management Area 8, ACWMW = Alameda County Waste Management West, ACWME = Alameda County Waste Management East, GMS = Gomes South, NMQ = Mulqueeney North, MQS = Mulqueeney South.


NWKN
VASCO ROAD
GMSN
KWI (Concord owned)
Concord
KW Greenville
KW Hayward
KW Jackson
USW Altamont
WPP87
WPP88
WPP90
WPP91-Altamont
WPP91-2
WPP92
WEG
WPP89-Altamont
KWI Owned
CCWDS
NWKS
WFTS
EER
RPN
ACLA
RPS
HLWK
VALH
LEGEND
60' TOWER
80' TOWER
140' TOWER
POLE LINE
ROAD
VASCO ROAD
DYER ROAD
ALTAMONT PASS ROAD
PMBO
KENETECH WINDPOWER
NORTH-SIDE
NEWNORTH.DWG
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1 OF 1

FIGURE 1

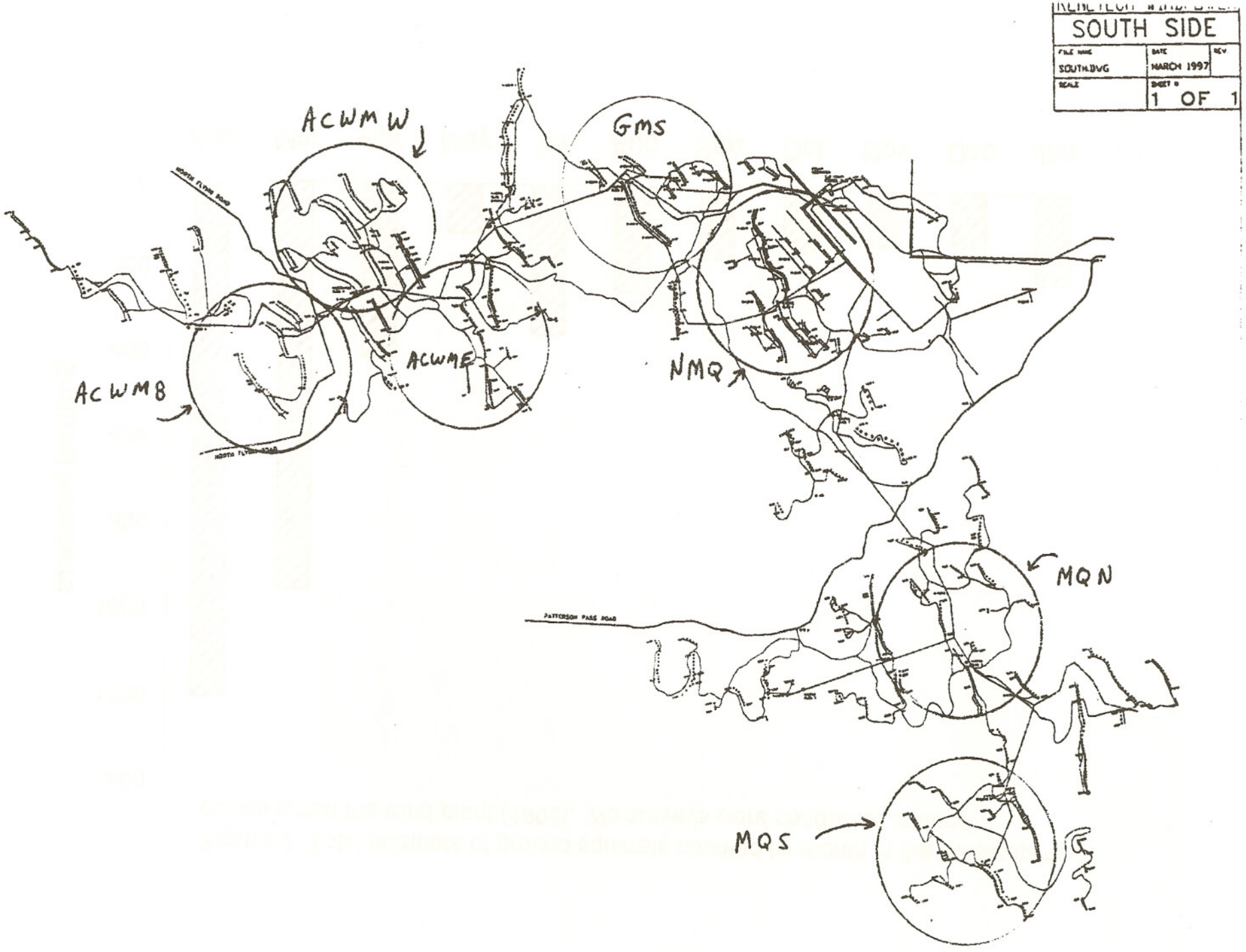

SOUTH SIDE
SOUTH.DVG
MARCH 1997
1 OF 1
ACWMW
GMS
ACWME
ACWMB
NMQ
MQN
MQS
PATTERSON PASS ROAD

Figure 2. Total numbers of ground squirrels counted by month in the 20 sampling circles within the wind plant (1998). No surveys were conducted in June.

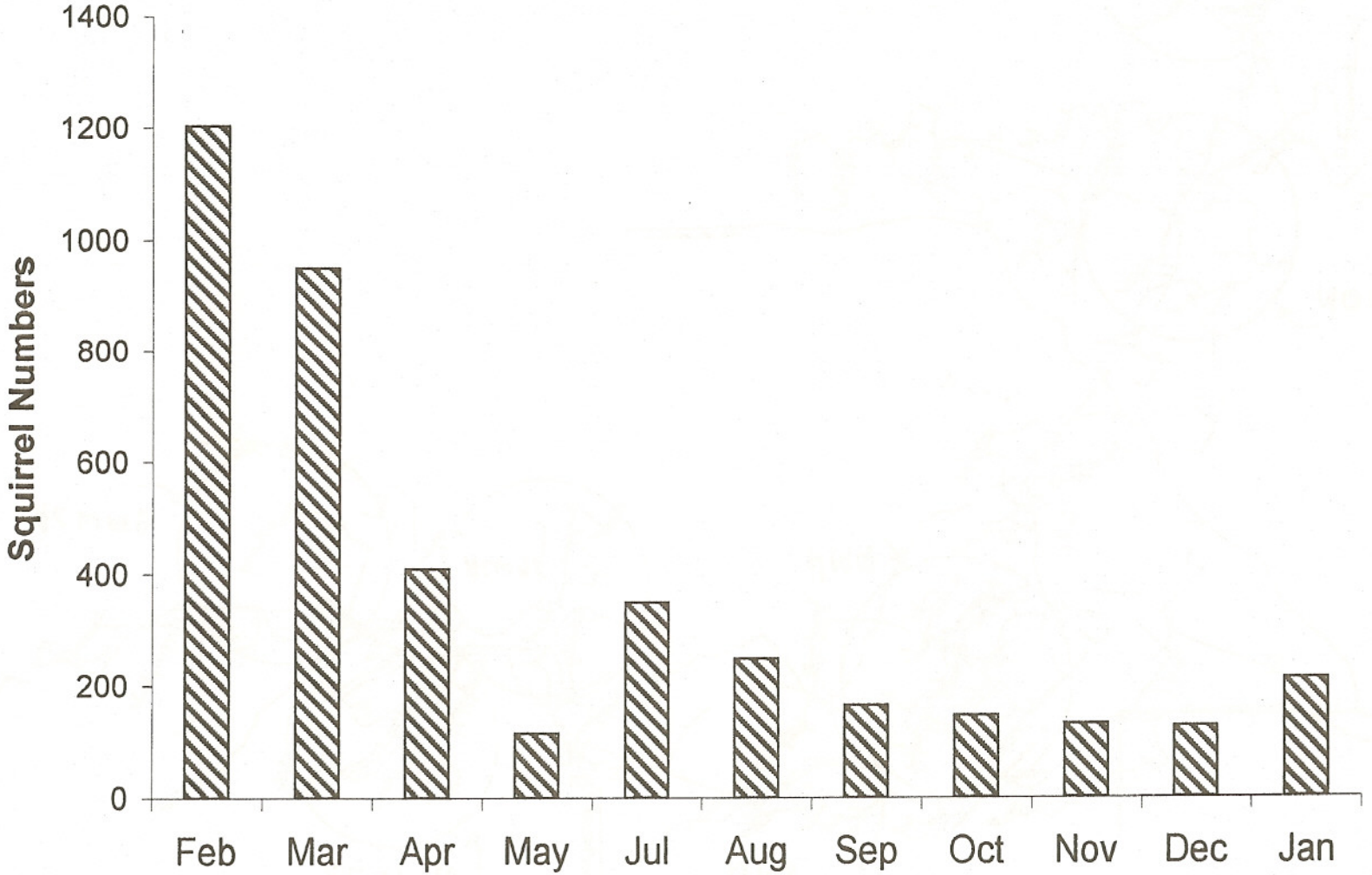


Figure 3. Ground squirrel numbers counted in areas treated (T-1998) and untreated (U-1998) in two months prior to and two months after treatment.

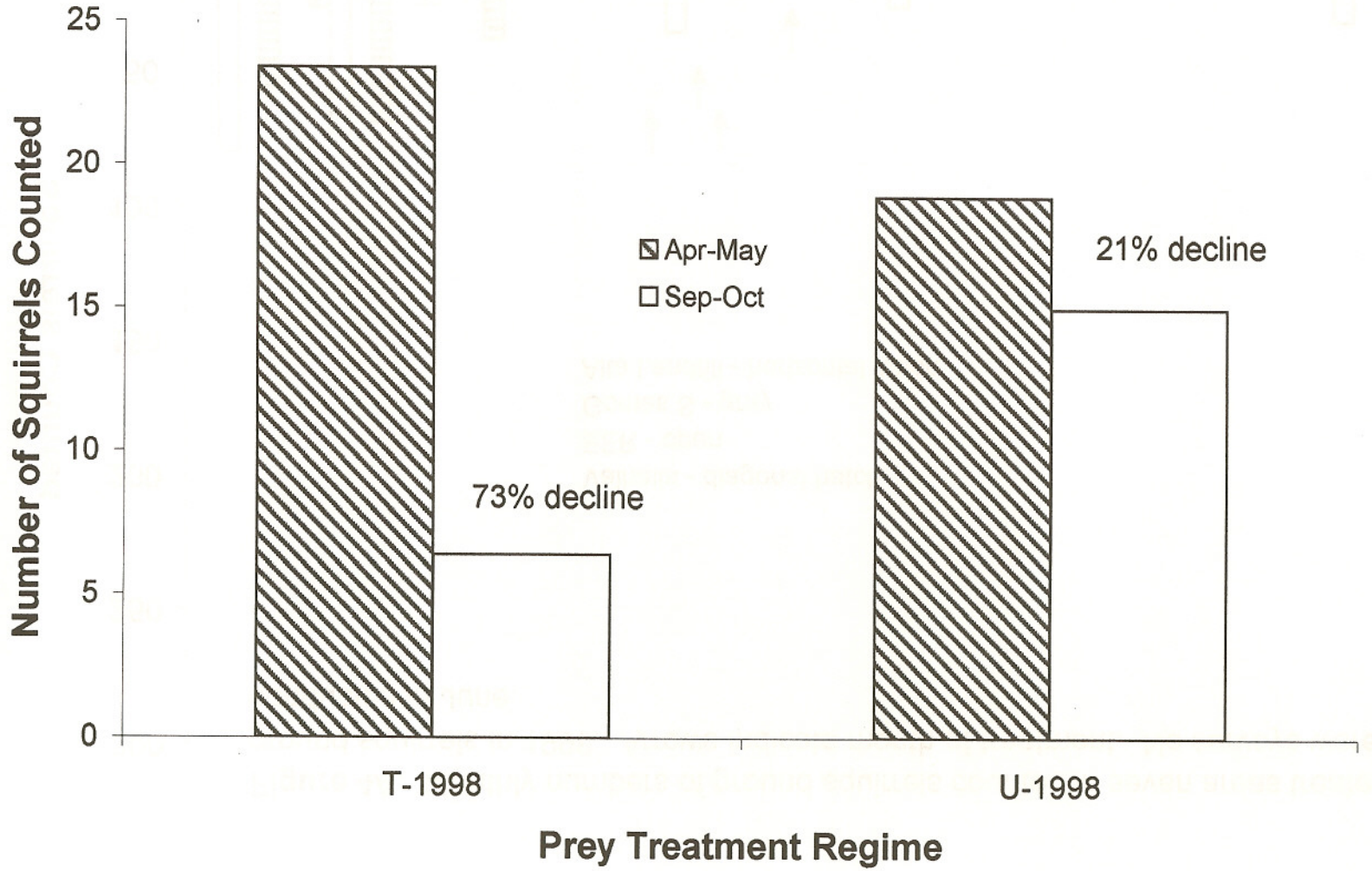
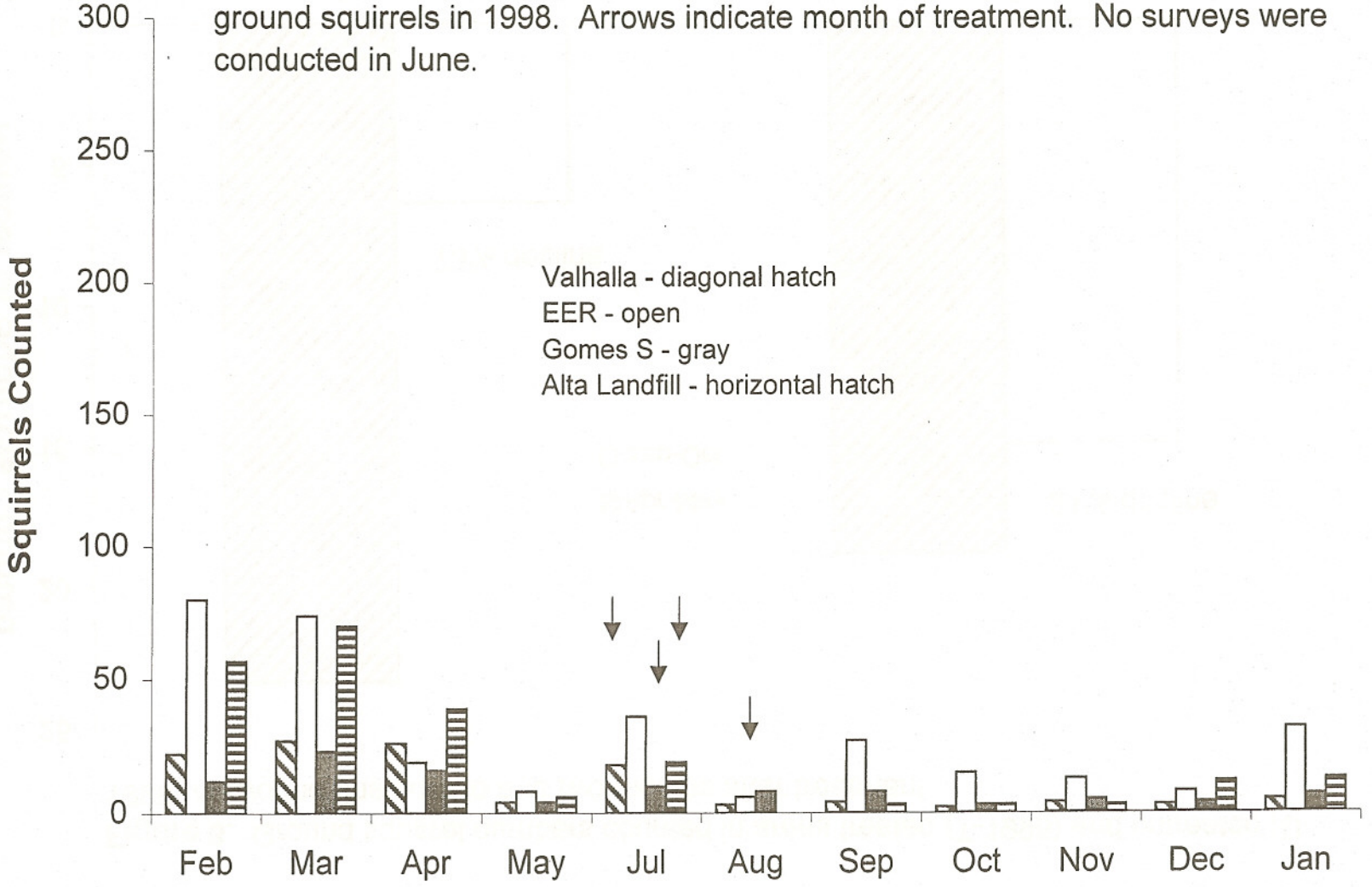


Figure 4A. Monthly numbers of ground squirrels counted in seven areas treated for ground squirrels in 1998. Arrows indicate month of treatment. No surveys were conducted in June.



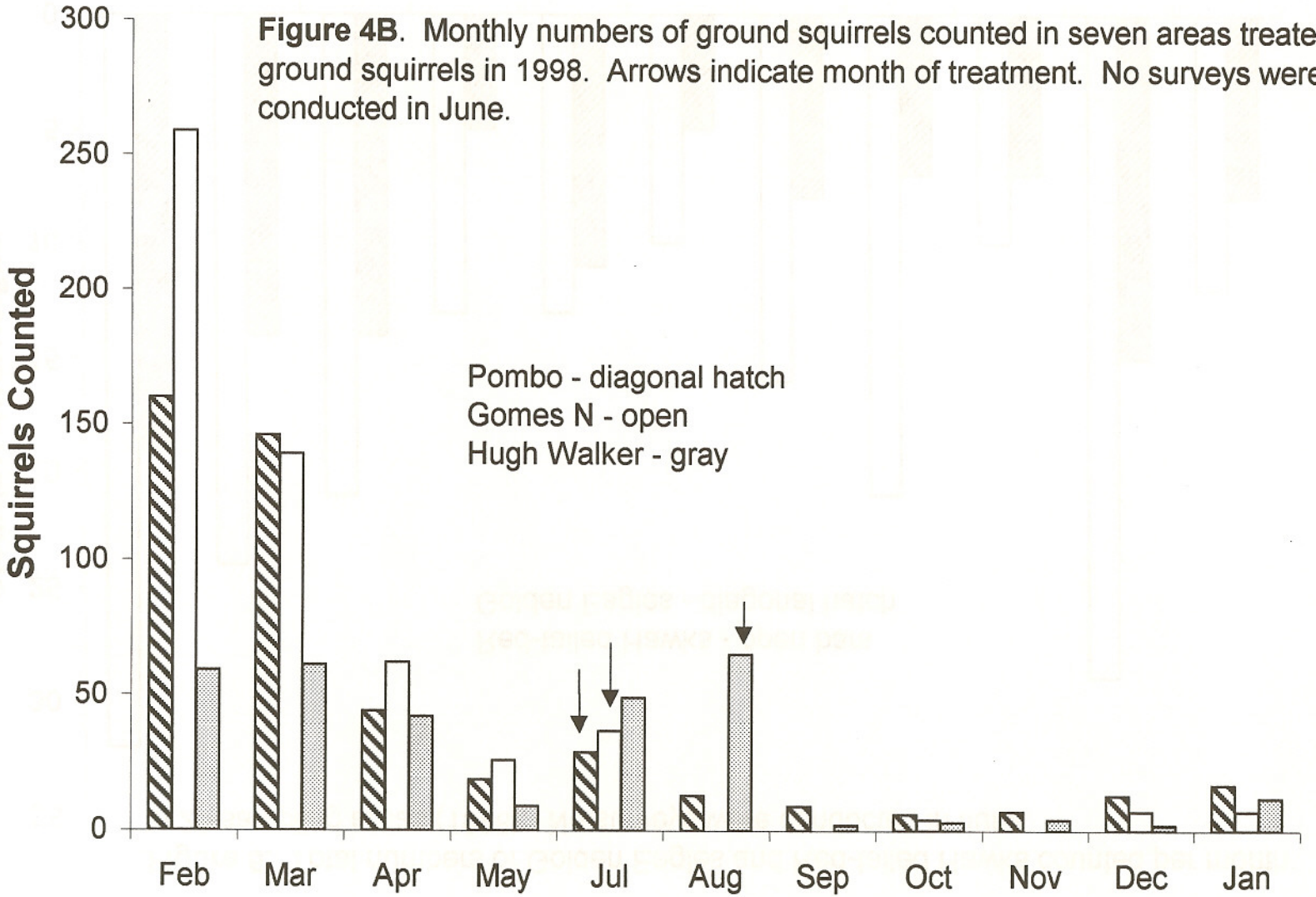


Figure 4B. Monthly numbers of ground squirrels counted in seven areas treated for ground squirrels in 1998. Arrows indicate month of treatment. No surveys were conducted in June.

Figure 5. Total numbers of Golden Eagles and Red-tailed Hawks counted per month in 20 sampling areas (1998). No surveys were conducted in June.

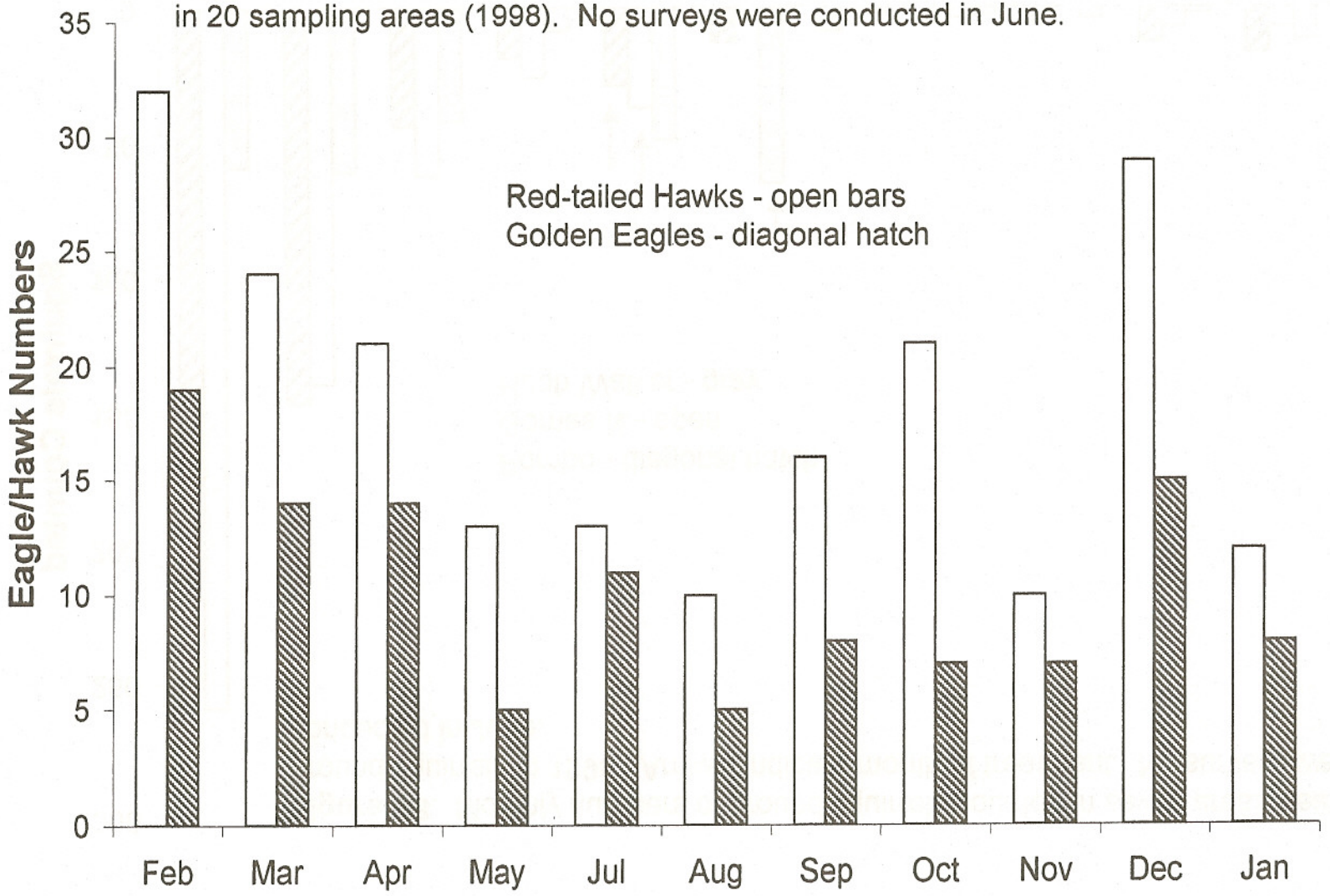


Figure 6. Relationship between total monthly numbers of Golden Eagles and Red-tailed Hawks during the year (1998) of study iin 20 sampling areas (r = correlation coefficient). Each point is one month. No surveys were conducted in June.

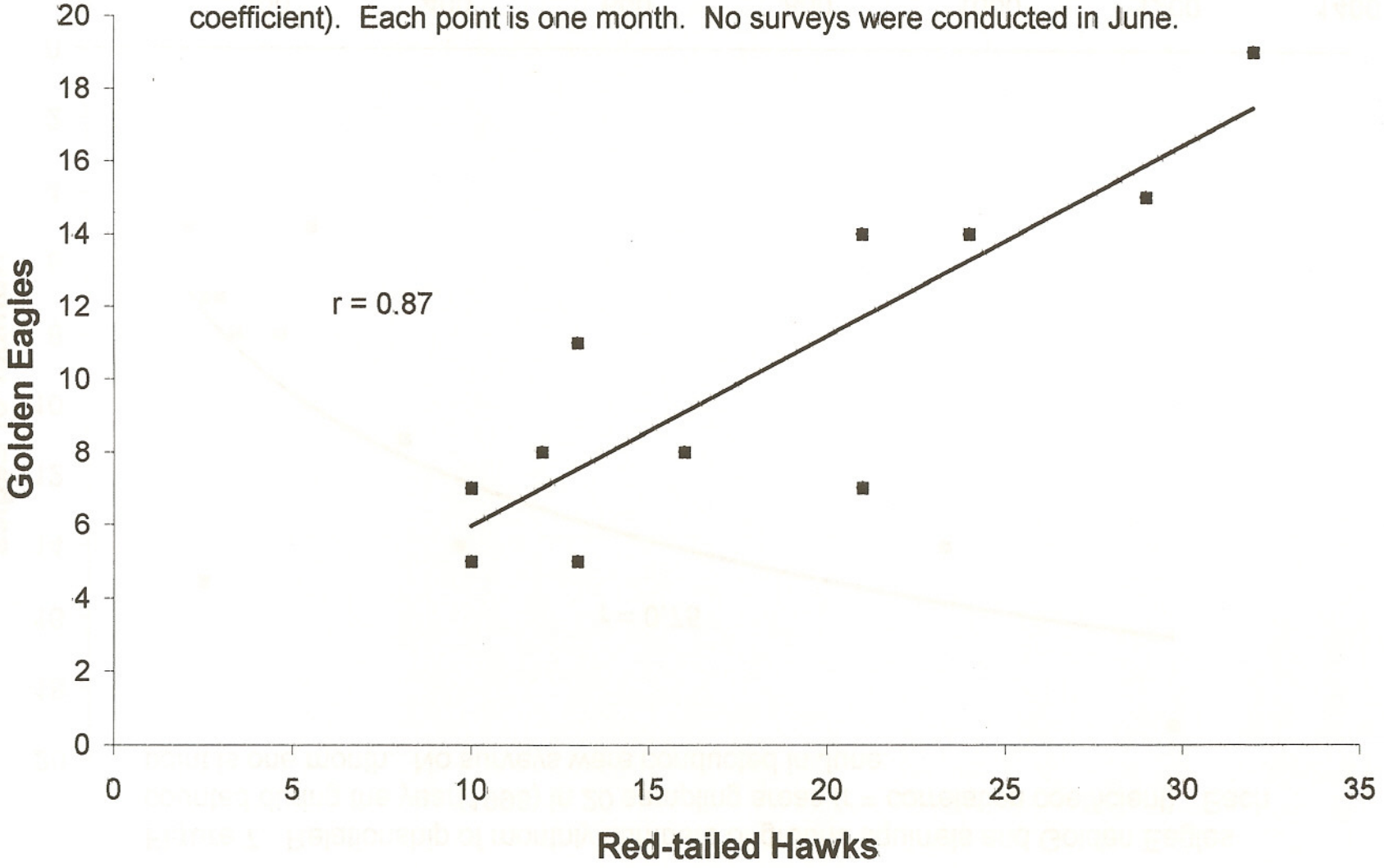


Figure 7. Relationship of monthly numbers of ground squirrels and Golden Eagles counted during the year(1998) in 20 sampling areas (r = correlation coefficient). Each point is one month. No surveys were conducted in June.

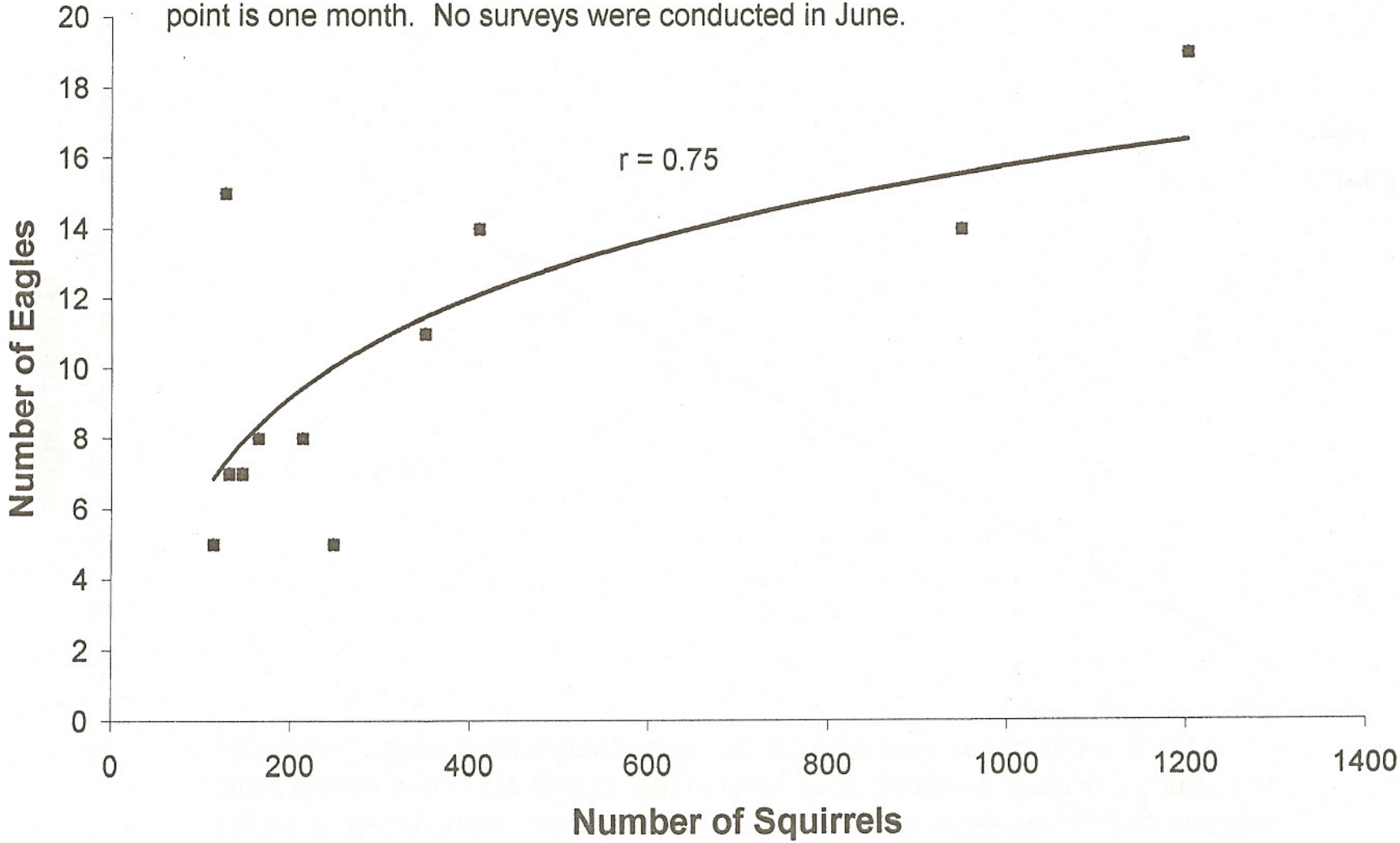


Figure 8. Relationship of monthly numbers of squirrels and Red-tailed Hawks counted during the year of study (1998) in 20 sampling areas (r = correlation coefficient). Each point is one month. No surveys were conducted in June.

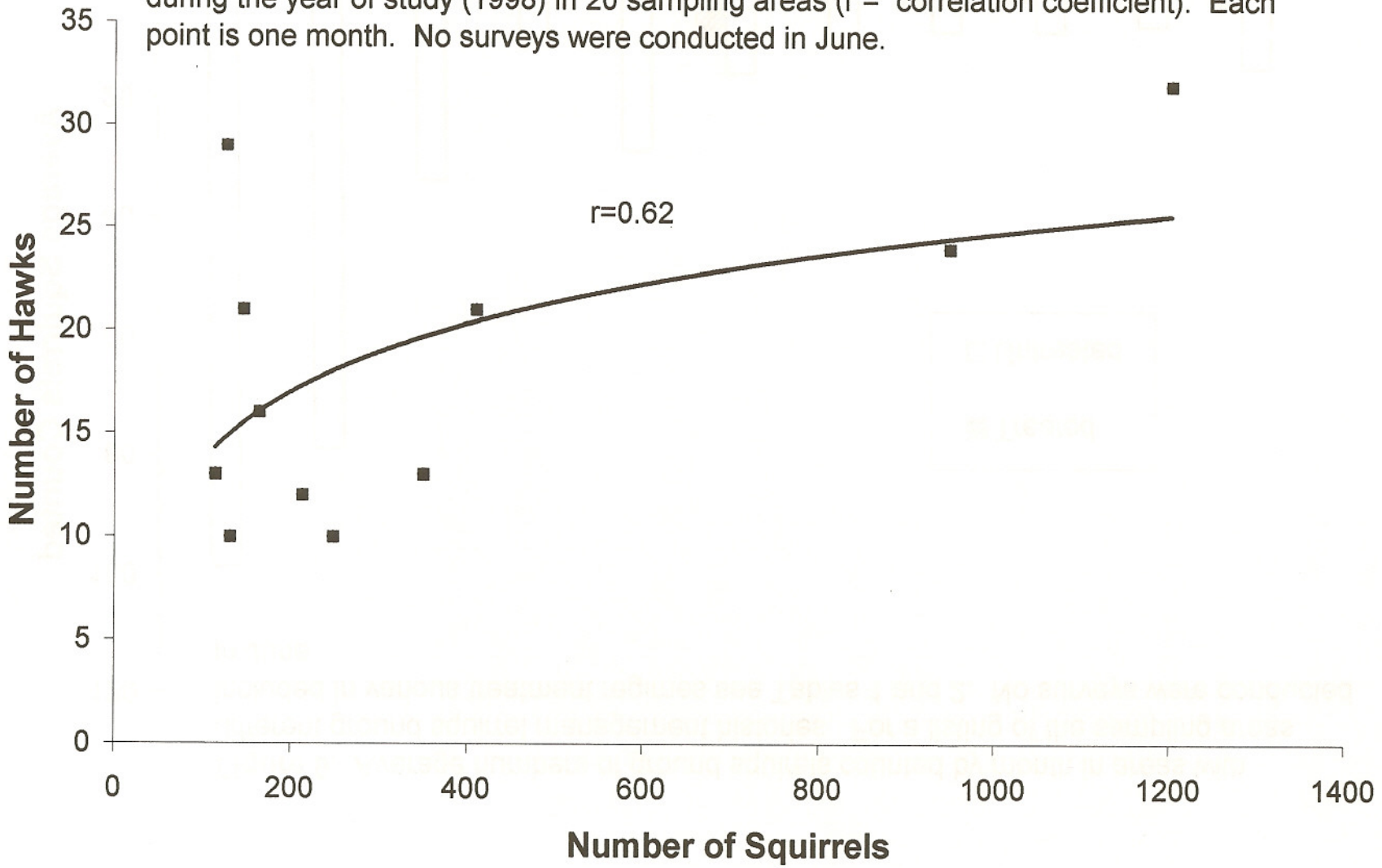


Figure 9. Average numbers of ground squirels counted by month in areas with different ground squirrel management histories. For a listing of the sampling areas included in various treatment regimes see Tables 1 and 2. No surveys were conducted in June.

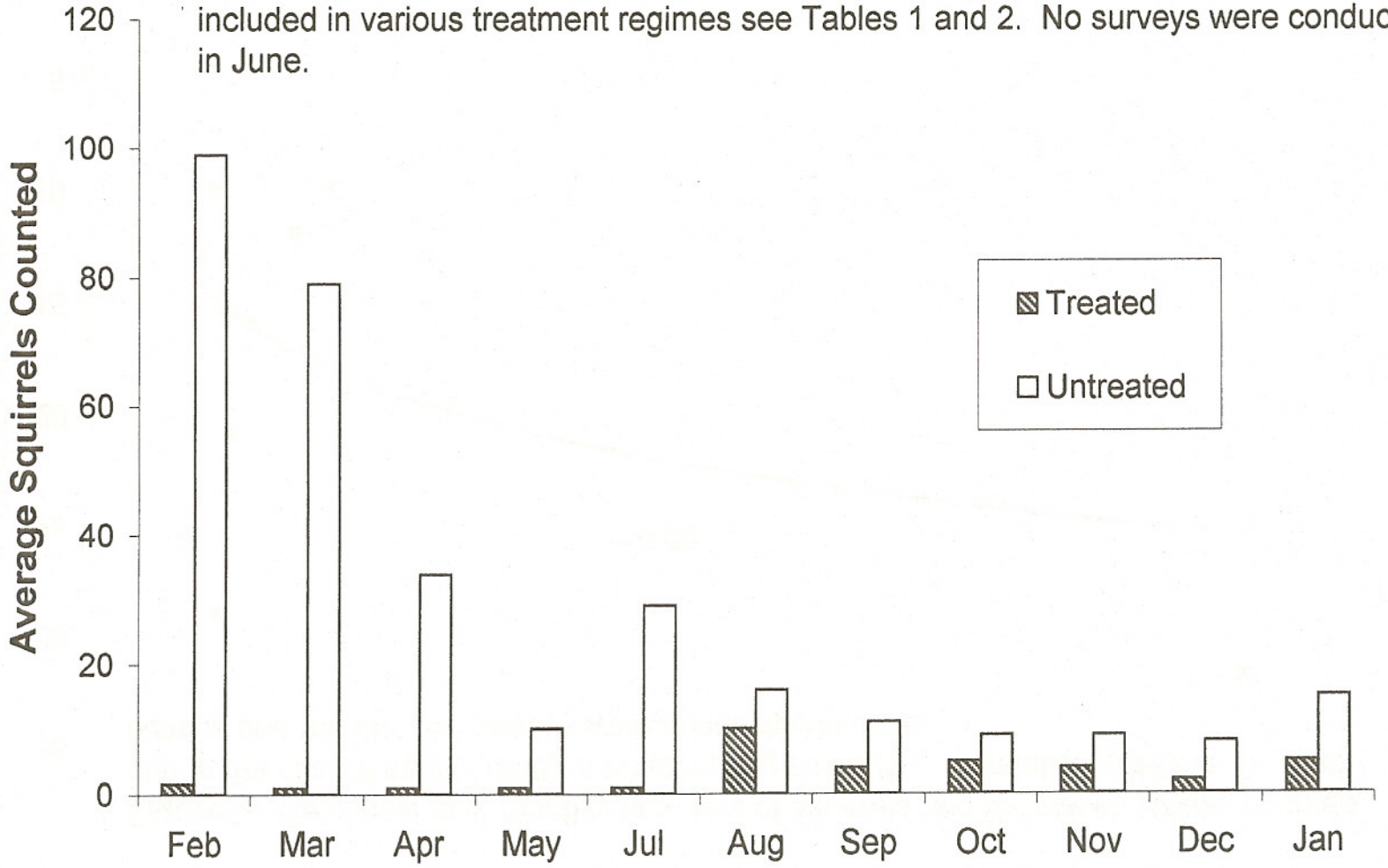


Figure 10. Monthly counts of Golden Eagles in 20 sampling areas during the year of study in areas with different ground squirrel management histories (8 historically treated, 12 untreated areas). No surveys were conducted in June.

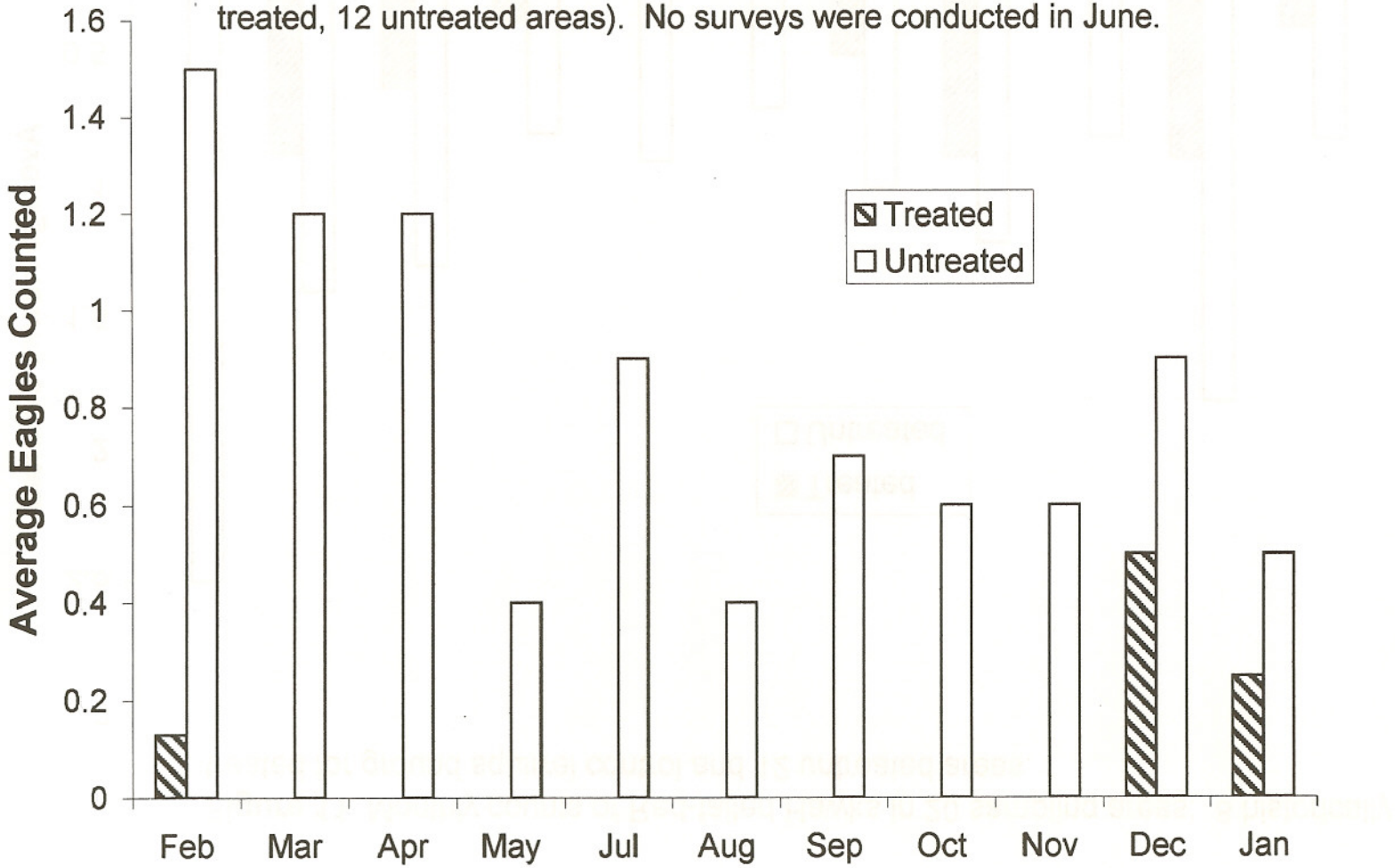


Figure 11. Monthly counts of Red-tailed Hawks in 20 sampling areas: 8 historically treated for ground squirrel control and 12 untreated areas.

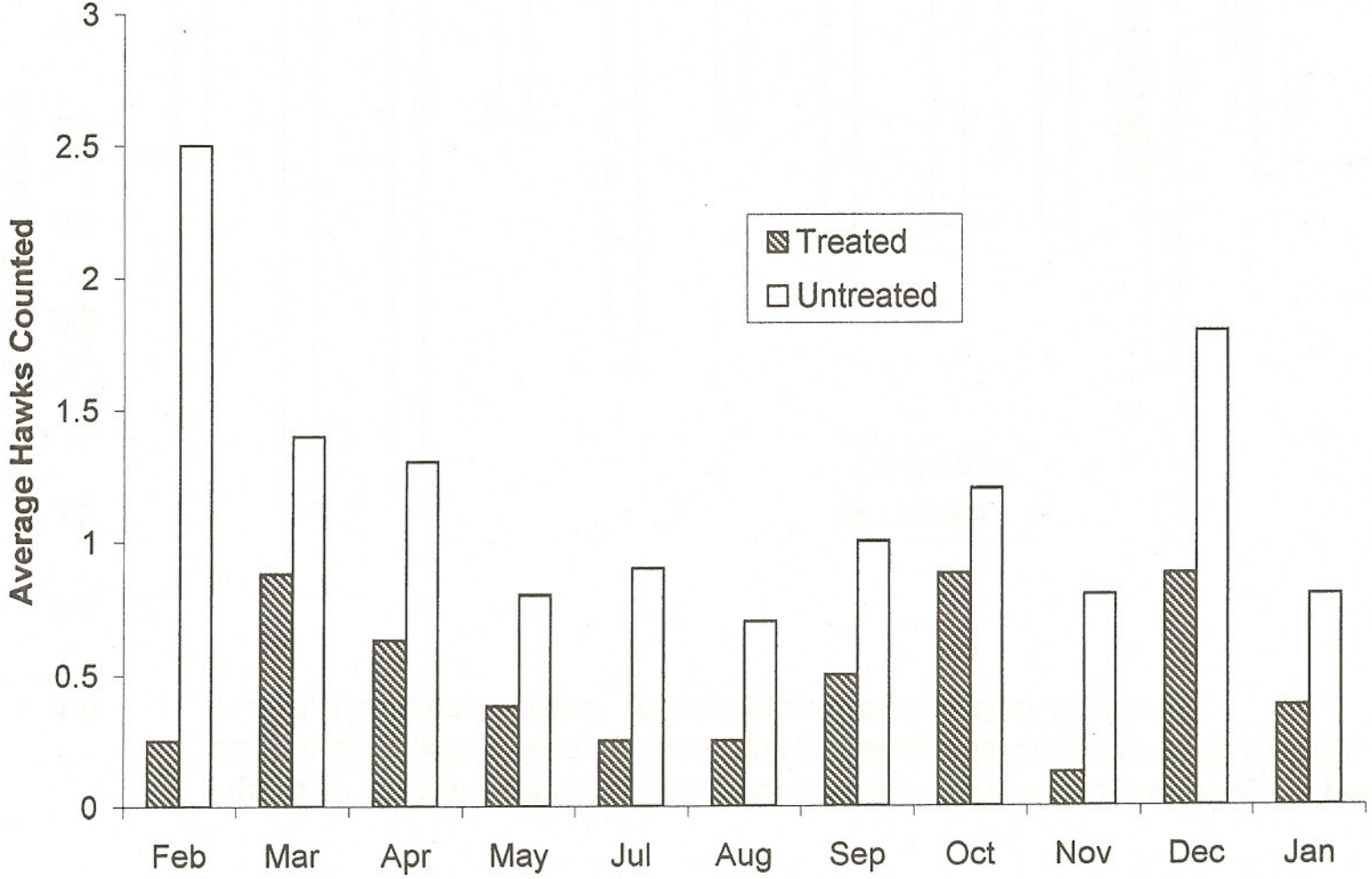


Figure 12. Comparison of Golden Eagle kills, number of turbines, and fatality rate (eagles killed per turbine) in areas with different ground squirrel management histories. 1989-1998

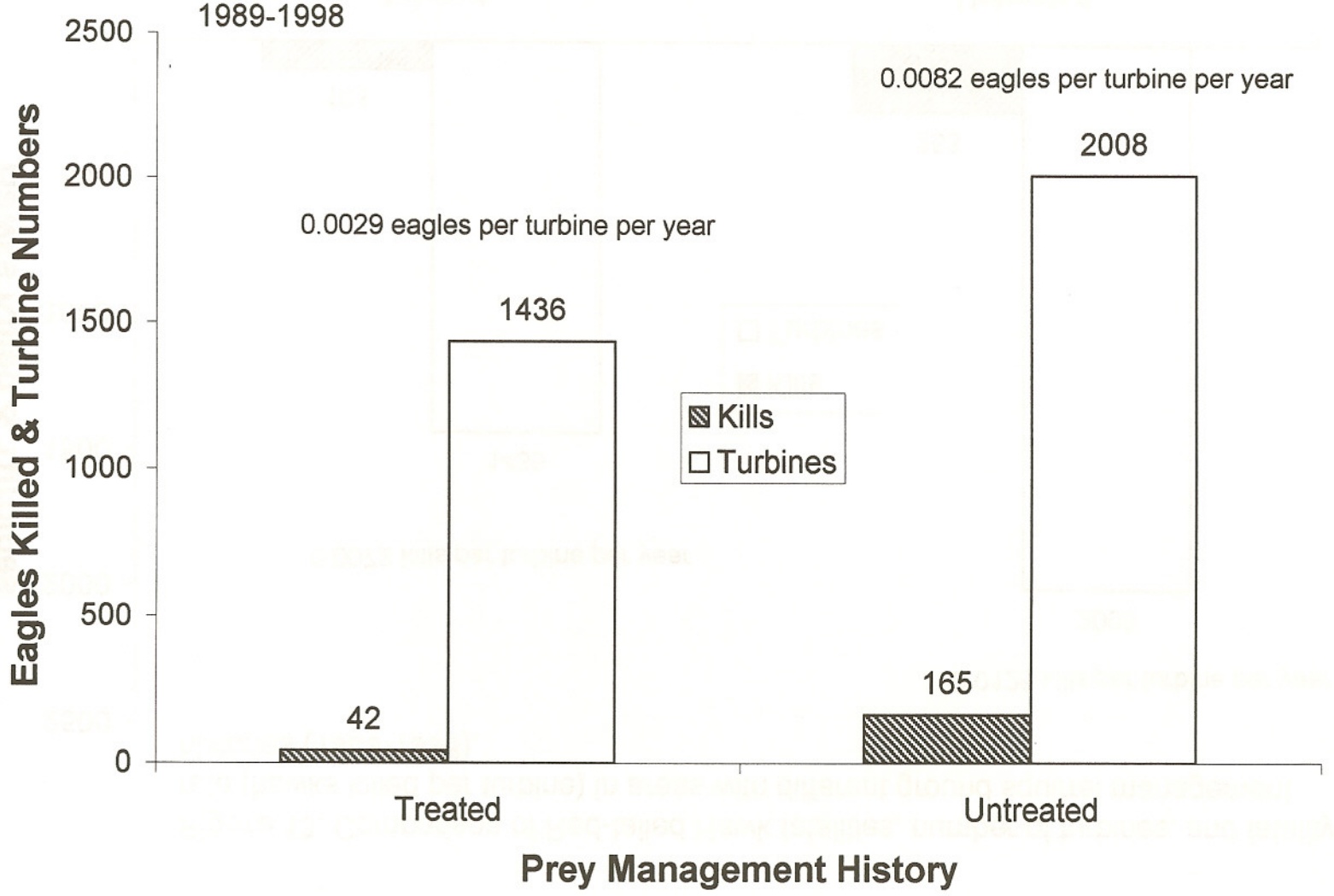


Figure 13. Comparison of Red-tailed Hawk fatalities, number of turbines, and fatality rate (hawks killed per turbine) in areas with different ground squirrel management histories (1989-1998).