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Assessment of Avian Use and Mortality Related to Wind Turbine Operations

Altamont Pass,

Alameda and Contra Costa Counties, California
September 1988 Through August 1989

FINAL REPORT

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EXECUTIVE SUMMARY

Lack of sufficient information about avian mortality from collisions with wind turbines led to this study. Although most prior studies concluded losses represented small fractions of populations, it has become apparent that some species, such as golden eagles, are more susceptible to impacts from wind turbines. The average activity of raptors observed in the Altamont Pass was lower annually than expected from reports by bird watchers such as Richmond (1985). Activity rates were lower than rates observed in the Montezuma Hills, Solano County (Howell et al. 1988).

Over the 12 months of this study 359 turbines were sampled for bird mortality, and 42 birds and 1 mammal were recovered. Site differences between Dyer and Midway contributed some of the more interesting results of this study. Based on nest counts, Dyer had almost 3 times as many nests as Midway, which had significantly higher mortality. Of six young birds banded, none were recovered as turbine strikes. A prairie falcon was recovered in Billings, Montana several months after banding.

Midway and Dyer had locations with multiple strikes. Inspection of topographic maps and the distribution of turbine strings indicated that multiple strikes tended to occur at swales, that is depressions, and at shoulders of hills, that is where ridge lines have a stairstep effect. From this study and U.S. Windpower data from the two study sites 28 possible strikes occurred at the ends of strings and 56 occurred within the interior of strings.

Based on our observations that carcasses were located down wind near the turbines and multiple strikes occurred in swales or shoulders of hills, we think the majority of strikes occurred among birds in transit. We suspect that they were moving with the wind or sheering across the wind at an acute angle to the rotation of the turbine blades. Birds would have difficulty seeing the rapidly moving turbine blade along its narrow axis. Turkey vultures had no mortality during this study and very low mortality during U.S. Windpower's self monitoring program. They exhibited a relatively slow soaring flight.

Mortality rates among golden eagles from natural and human causes are not well defined even in light of recent statewide and local surveys completed in the past 17 years. The number of golden eagle mortalities at U.S. Windpower's facility may have a significant effect on local populations. Studies of this effect should be implemented in cooperation with regulatory agencies to clarify the actual impact. Because of problems with habituation to noise and the unremarkable hearing of birds, acoustic devices will probably not be effective in reducing collision mortality in the near future. Hypotheses about the relationship of visibility, topography and mortality should be tested to evaluate methods to reduce avian mortality in the Altamont Pass, California.

INTRODUCTION

Birds of prey, known collectively as raptors, have captured the imagination of human beings since the beginning of recorded history. Ancient Egyptians included images of falcons in their hieroglyphics and the Roman Empire used eagles to symbolize their power. Today the Bald Eagle is our national symbol. Birds of prey evoke emotional reactions; they are admired for their beauty, grace and power, or are despised for their predatory efficiency, when directed towards domestic fowl and livestock. The fate of these predatory birds rests upon their value as perceived by society. Policies directing raptor management were formed both within this framework and the biological context of sound raptor management.

Congress's first act to protect birds was the Migratory Bird Treaty Act of 1918 which was subsequently approved by Great Britain, Canada, and the United States, and later by Mexico. In 1964, Congress enacted the Bald Eagle Protection Act which included protection of golden eagles from persecution, primarily from livestock managers. In 1978 Congress passed the Endangered Species Act responding to declining populations of species caused by environmental poisoning, habitat loss and persecution. The Act prohibited the taking of any species listed by the U.S. Fish and Wildlife Service, an Agency of the Department of the Interior. California administratively considers birds of prey as species of special concern and by law some species are classified as threatened or endangered. Taking these protected wildlife species, by shooting, harassment, or disturbance engendered higher penalties over time. A recent newspaper story from Sonoma County, California, reported that a pigeon fancier was fined $5,000 for shooting and killing a Peregrine Falcon, a Federally listed endangered species.

Mortality among birds of prey recently became an issue for the windpower industry and the public as windfarm maintenance personnel discovered dead and injured birds. Stories spread verbally, eventually appearing in newspaper articles. U.S. Windpower's initial concern was focused on avian electrocutions. In 1984 U.S. Windpower (USW) began retrofitting their powerline system to reduce avian mortality from electrocution. The modifications were directed at poles and lines in areas with a history of avian mortality. After 1987 the company recorded a large decline (90%) in electrocutions. Field maintenance personnel also found birds whose deaths could not be attributed to electrocution.

In 1987, U.S. Windpower commissioned studies of pre-wind energy site development to gauge impacts to raptors and waterfowl in Solano County during 1987-89 (Howell et al. 1988, Howell and DiDonato 1988a, 1988b, 1989a, 1989b, Howell 1990a, 1990b). An industry wide study began in November 1988. Alameda, Contra Costa and Solano Counties using a grant from the California Energy Commission contracted with Biosystems Analysis, Inc. to assess mortality of birds in the tri-county area.

Few published reports existed about raptors specifically in the area of the Altamont Pass where most of U.S. Windpower's turbines are located. Richmond (1985) reported good raptor watching in the locale but differentiated two categories, good and best. Species reported were golden eagle, turkey vulture, black-shouldered kite, northern harrier, red-tailed hawk, rough-legged Hawk, prairie falcon, American kestrel, merlin, accipiters, common barn owl, great horned owl and possibly long-eared owl. Bald eagles were reported near Frick Lake in the Livermore valley at the western base of the Altamont Pass (Richmond 1985). Local ranchers reported that raptors hunted rabbits in the Livermore Valley but were displaced as habitat was lost to residential and commercial development (Gomes pers. comm. through J. Stewart pers. comm.).

Reports and data about bird mortality at man-made structures has accumulated at an increasing rate over the past 100 years. Much of the scientific literature pertains to radio and television transmission towers and associated guy wires, lighthouses and smokestacks, tall buildings, and electric power transmission lines. Avery et al.(1980) estimated 200 million bird collisions occurred among 5 billion bird deaths from all causes annually. McCrary et al. (1986) reported that a new solar energy power plant contributed to avian mortality. Olendorff et al.(1981) provided detailed guidelines about structural modifications to reduce raptor mortality from electrocution at powerlines. In 1986 Olendorff and Lehman reviewed and summarized field observations of raptor collisions with powerlines for the State of California. Since wind turbine technology is relatively new, data on related effects is not abundant. Rogers et al.(1977) and Johnson and Cheslak (1985) provided quantified data about large (100m tall) turbines. Leitner (Environmental Science Assoc. 1982) succinctly summarized avian collision mortality and noise effects literature related to wind energy development. Data on effects of large windfarm configurations are not available in the literature.

STUDY SITE LOCATION

This study began in September 1988. The purposes of this study were to; 1) provide a focused description of raptor use patterns in related to U.S. Windpower's windfarm operation and the existing topography, 2) examine avian mortality rates and estimate variances, 3) assist USW management and field staff to develop organizational mechanisms to deal with raptor injuries and mortality, and 4) recommend and implement experimental measures in an attempt to reduce mortality among raptors.
This study was conducted in the general location of the Altamont Pass, eastern Alameda and south eastern Contra Costa Counties

(Figure 1).

The two primary study areas were established for this research:

A. Dyer Site encompassed approximately 5 mi^2 (12.95 km^2), located in Sec. 21, T1S, R3E; Sec's 35, 36, T1S, R2E; and Secs 1, 2 T2S, R2E.

B. Midway Site encompassed approximately 5 mi^2 (12.95 km^2), located in Sec's 27, 33, 34, 35, TS2, R3E; and Sec. 4, T3S, R3E.

The two study areas were 6.8 mi (10.98 km) apart. Dyer lies north of U.S. Interstate Highway 580, and Midway lies south of U.S. Interstate Highway 580 (Figure 1). An observation point was established at each study site.

The primary habitat of this area is annual grassland with some grain fields. The area consists of steep rolling hills with towers spaced at approximately 80-100 foot (24.4-30.5 m) intervals along prominent ridges in linear formation perpendicular to prevailing winds. The winds are produced when heating in the Central Valley of California draws in the cooler, dense marine air through topographic gaps in the Coast Range such as the Altamont Pass. U.S. Windpower operated over 3000 wind turbines in the Altamont Pass during this study. Three tower heights present at the windfarm are 60 ft (18.3 m), 80 ft (24.4 m), and 140 ft (402.7 m). Each tower supports a wind turbine with three blades, diameter 59 feet, which rotate on the downwind side of the tower and operate at 72 rpm's.

METHODS

Three primary tasks were necessary to meet the project objective. First, we identified and observed diurnal patterns of bird activity, movement and behavior. Second, we surveyed avian mortality along randomly selected turbine strings and estimated the bias from scavenging loss. Third, we located and identified raptor nesting sites.

Diurnal Flight Patterns

This study monitored general avian movement, behavior in response to wind turbines, species composition, and numbers from two observation points located on prominent hills within the study area. The hilltop and central placement maximized observer visibility for 180 degree viewing of adjacent areas. One observation point was on the Dyer site and one was on the Midway site. The Dyer observation point (designated by the letter A within the text) was located at Tower No. 2736, elevation 1230 ft (375 m) in the SW 1/2, NE 1/4 Sec 34, T2S, R3E (Universal Transverse Mercator (UTM) Zone 10: 614,150 m E, 4,183,610 m N). The Midway observation point (designated by B) was located at Tower No. 1338, elevation 1250 ft (381 m) in the NE 1/2, NW 1/4, Sec. 1, T2S, R3E (UTM Zone 10: 621,150 m E, 4,175,050 m N.

Observations required two observers scanning a 180^{o} view at each observation point. Observations were made one day each week alternating between each site for the year, September 1988 to August 1989, with a potential of 26 observation days per site. Observers recorded numbers and species of raptors, waterfowl, and passerines, during four 10 minute intervals each hour from 10:00 a.m. to 3:00 p.m. each observation day. Observers conducted late afternoon to evening samples (two hours before sunset) and early morning samples (one hour after sunrise) to evaluate these time periods. They also estimated distance and altitude relative to turbine height using standardized scales adapted from Howell et al. (1988); 0= on the ground, 1= between ground and turbine blade, 2= turbine blade diameter, 3= one turbine blade diameter above the turbine and 4= above. (Appendix A). In addition, they recorded behavior such as soaring, powered flight, reaction to wind turbine, direction of the bird from observer and flight bearing corresponding to the eight points of the compass. Weather conditions were recorded for the day of observation to examine the effect on raptor activity. Five categories were used: clear, haze, overcast, fog and rain.

Mortality

Twenty randomly selected tower strings comprising 359 towers were surveyed for mortality. Random number tables from Zar (1974) were used to select tower strings for mortality estimation. This amounted to approximately 10% of U.S. Windpower's Altamont operations. At Dyer a total of 183 towers (59.97%) comprising 11 strings were randomly selected. The strings varied in length from 5 to 40 towers (400 feet to 3600 feet (122 m to 1097 m). At Midway a total of 176 towers (49.03%) comprising 9 strings were randomly selected. The strings varied in length from 8 to 40 towers (640 ft to 3200 ft (195 m to 975m)). Two observers walked a randomly selected sample of 20 wind turbine strings at biweekly intervals alternating between the two study areas (Appendix A). The transects, 150 ft (46 m) wide, were walked either before or after the 10:00 am to 3:00 pm observation period. Observers also walked control transects on the up wind side adjacent to the wind turbine string transects. Dead birds were recovered and identified using standard field guides. Their distance and compass direction from the tower were recorded.

We estimated scavenging rates for a two week period in November and again in April to examine biases associated with the biweekly timing of the mortality survey. Six 50 ft x 100 ft study plots were established with 32 fresh, plucked game hen carcasses placed randomly in each plot. Four plots were placed under turbines as treatments and 2 were placed in the open as controls (Appendix A). The plots were examined each morning for scavenging for 14 days. In April eight additional transects were established to examine a change in distribution and density of game hen carcasses.

Raptor Nesting

Observers examined spring raptor nesting through a combination of driving all roads and walking all ridges in the area of the study sites from mid-March to mid-May of 1989. Nests of raptor species were located and mapped (Appendix C)(Map delivered under separate cover). Each nest was examined and productivity was recorded. Nestlings were banded with U.S.F.W.S. bands to identify individuals and origins for later assessment (Appendix C).

Statistics

Chi-square test for comparisons between sites followed procedures presented by Lehmann (1975). Statistical analyses were conducted using SPSS PC+ software (Norusis 1988). Linear regression was used to examine the relationships between distance, direction, flight height, time of day, month, and number of birds for 10 minute intervals.

Non-parametric Chi-square test were used to examine differences between weather and bird observations and between observers and site. For all statistical tests the level of significance was set at 0.05. Values and probabilities (p) less than or equal to 0.05 were considered significant.

RESULTS

Species Abundance and Distribution

Two sites in the Altamont Pass, one in Alameda and one in Contra Costa Counties, California, the study area, were monitored for up to 20 days each between September, 1988, and August 18, 1989. A total of 1768 individual observations was made among 21 species or general bird groups (Table 1). Forty seven percent (760) of the observations were made at Midway and 53% (854) of the observations were made at Dyer. These observations occurred during 1,061 ten minute observation intervals by 1 primary observer and 1 of 14 secondary observers working as a pair.

Timed interval counts were used to develop a bird activity index to examine relative numbers of different species or groups of species. The activity rate was the average number of individuals of that species or group observed during a 10 minute observation interval. This activity rate index was used to examine intersite variation at Solano County (Howell et al. 1988) and was applied to this study to maintain consistency of methodology between studies for U.S. Windpower. All raptors combined had the highest activity rate per 10 minute observation interval ($\bar{x}$ = 1.108/10 min, SE 0.114, n = 945) among the major groups of birds such as waterfowl and passerines (Table 2). Figure 2 graphically presents these data for a comparison with observation data gathered at Montezuma

Hills, Solano County (Figure 3). Songbird flocks were second most abundant ($\bar{x}$ = 0.569/10 min, SE = 0.029, n = 945) followed by duck flocks ($\bar{x}$ = 0.002/10 min, SE = 0.002, n = 945) and goose flocks ($\bar{x}$ = 0.001/10 min, SE = 0.001, n = 945). Songbird numbers per flock were higher than either duck or geese numbers (Table 2). Songbird observations were predominantly single individuals but varied up to five individuals in a flock (Table 3). Within the raptor group the higher average activity rates were among the more common species (Table 2). The rarer observations included one Double-crested Cormorant (Phalacrocorax, auritus). Among 945 observation time intervals 42 bird observations (4.6 %) were recorded in a general category called OTHER including; 15 Buteo, 11 Raptor, 4 Gull, and 12 Rock Dove observations (Table 2).

Analyses of variance (ANOVA) was used to examine differences in bird activity between Midway and Dyer. Given the low numbers of ducks and geese observed, there were no significant differences between the two sites. Passerines were significantly different with more flocks/10 minute interval and greater numbers/flock at Dyer than at Midway (ANOVA: flocks p = 0.0171, number/flock p = 0.003). Red-tailed hawk and golden eagle activities per 10 minute interval were not significantly different between the sites.

Table 1. **Bird Species Observed at Altamont Pass Study Area, Alameda and Contra Costa Counties, California.**

Common Name	Code	Species Name	Number
Raptors			**(n=1768)**
American Kestrel	AMKE	*Falco sparverius*	43
Cooper's Hawk	COHA	*Accipiter cooperii*	1
Ferruginous Hawk	FEHA	*Buteo regalis*	47
Golden Eagle	GOEA	*Aquila chrysaetos*	175
Northern Harrier	NOHA	*Circus cyaneus*	12
Prairie Falcon	PRFA	*Falco mexicanus*	13
Red-tailed Hawk	RTHA	*Buteo jamaicensis*	298
Rough-legged Hawk	RLHA	*Buteo lagopus*	4
Sharp-shinned Hawk	SSHA	*Accipiter striatus*	2
Turkey Vulture	TUVU	*Cathartes aura*	248
Raptor (Unknown)			47
Geese			
Geese			1
Ducks			
Duck			2
Shorebirds			
Killdeer	KLDR	*Charadrius vociferus*	4
Gulls			
Gull	GULL		8
Dove			
Rock Dove (Pigeon)	RODO	*Columba livia*	16
Corvids			
Common Raven	CORA	*Corvus corax*	237
Songbirds			
Cliff Swallow	CLSW	*Hirundo pyrrhonota*	1
Songbird (Passerines)	PASS		564
Missing values			16
		TOTAL	1,768

Table 2. Bird Activity Rates per 10 Minute Intervals: Altamont Pass, CA. 1988-89.

Species	Mean (x̄)	Standard Error (SE)	Number of Observation Periods (n)
Raptors			
Red-Tailed Hawk	0.356	0.023	959
Ferruginous Hawk	0.056	0.009	"
Rough Legged Hawk	0.004	0.002	"
Northern Harrier	0.010	0.005	"
Sharp Shinned Hawk	0.002	0.001	"
Cooper's Hawk	0.001	0.001	"
Golden Eagle	0.198	0.017	"
Prairie Falcon	0.014	0.004	"
American Kestrel	0.046	0.007	"
Turkey Vulture	0.415	0.045	"
TOTAL	1.108	0.114	
Non-Raptor			
Common Raven	0.477	0.046	"
OTHER**	0.042		"
Rock Dove	1.000	0.012	"
Goose Flocks	0.000	0.000+	"
Numbers/flock	0.000	0.000	"
Duck Flocks	0.002	0.002*	"
Numbers/flock	0.018	0.018	"
Passerine Flocks	0.569	0.029	"
Numbers/flock	2.445	0.413	"
Unidentified			
Raptor 11			
Buteo 15			

** 4.6% Unidentified
+ 1 goose flock of 3 individuals
* 2 duck flocks of 2 and 8 individuals

A comparison of Altamont results to the Solano County, Montezuma Hills, study permitted a relative assessment of the amount of bird activity in the area. Calculations were made in an effort to derive similar activity values.

The relative activity of raptors in the Altamont Pass was different than that observed in Solano County's Montezuma Hills (Table 3, Figures 2 & 3). Although designed to examine the interactions of raptors and wind turbines, the present study provided indexes of relative abundance for the Altamont Pass and Montezuma Hills. In general, bird activity tended to be greater in the Montezuma Hills than at Altamont Pass (Table 4). However, the Montezuma Hills data were biased toward higher estimates, because the rates were derived using counts taken during the fall and winter when bird numbers would be expected to be greater from winter habitat use patterns. Even if one takes into account seasonality, Altamont Pass tended to have lower activity among raptors and other species. Twelve species of raptor were observed in the Montezuma Hills and 10 species of raptor were observed at Altamont Pass.

The three most abundant raptors in the Altamont Pass were turkey vulture, red-tailed hawk and golden eagle, respectively. The three most abundant raptors in the Montezuma Hills were red-tailed hawk, turkey vulture and American kestrel in 1987-88 and red-tailed hawk, turkey vulture and rough-legged hawk in 1988-89.

At the Montezuma Hills some ranks changed for species, up or down by one unit, but the same relative ranks were maintained by each species in the Montezuma Hills from one year to the next. The most important difference among raptors between the two locations was the rank for golden eagles. Golden eagles were the third most abundant species of raptor observed in the Altamont Pass while they were the sixth or seventh most abundant in the Montezuma Hills. In the Altamont Pass golden eagles were observed at a frequency of 0.169 per 10 minutes while in the Montezuma Hills golden eagles were observed at a frequency of 0.043 in 1987-88 and 0.060 per 10 minutes in 1988-89. These observations indicated that golden eagles were approximately 3 times more active in the Altamont Pass. The proximity of Golden Eagle habitat to Altamont Pass and the lack of habitat in the Montezuma Hills supports this observation.

Table 3. Ranks of Raptors in Order of Relative Abundance for Altamont Pass and the Montezuma Hills, CA.

Species	Location: Altamont Pass 1988-89	Location: Montezuma Hills 1988-89	Montezuma Hills (1987-88)
Turkey Vulture	1	1	(2)
Red-tailed Hawk	2	2	(1)
Golden Eagle	3	7	(6)
Ferruginous Hawk	4	-	-
American Kestrel	5	4	(3)
Northern Harrier	6	6	(4)
Prairie Falcon	7	-	-
Rough-legged Hawk	-	3	(5)
Black-shouldered Kite	-	5	(7)

Table 4. Comparison of Activity Rates of Bird Groups between Altamont Pass and Montezuma Hills, California.

Group	Location: Altamont Pass 1989 n*/10 min	Location: Montezuma Hills 1989 n*/10 min
Raptors	1.11	3.06
Geese	0.00	0.02
Ducks	0.01	0.11

* = mean number

Physical Parameters and Habitat

Weather

Observations were conducted during five general weather conditions: clear, haze, fog, overcast and rain. No significant difference in red-tailed hawk and golden eagle activity was detected between weather conditions (Table 5).

Table 5. Percent Of 10 Minute Bird Observations Intervals During Different Weather Conditions, Altamont Pass, Alameda and Contra Costa Counties, California.

		WEATHER				
Species	n	Clear	Haze	Fog	Overcast	Rain
Observations	1208	65.0%	3.6%	5.4%	21.0%	5.0%
Red-tail Hawk	280	61.4%	8.9%	2.5%	15.3%	2.8%
Golden Eagle	162	59.8%	3.1%	1.8%	21.6%	4.9%

Chi-square = 52.98, p = 0.2878

Topography

Altamont Pass exhibited wide diversity in topographic relief. Hill top elevations to the north of Highway I-580 vary from about 750 ft (229m) to 1,200 ft (366m) above sea level. The valley elevations vary from about 250 ft (76m) to 600 ft (183m) above sea level. Hill top elevations to the south of Highway I-580 vary from about 1,100 ft (335m) to 1,500 ft (457m) above sea level. The valley elevations vary from 600 ft (183m) to 1,100 ft (335m) above sea level. The average difference between hill tops and valleys is approximately 450 ft (137m) (s = 145.99, SE = 51.61, n = 8)). These statistics derived from topographic data represent the high variability of the topographic relief, but Dyer and Midway were not different in the amount of topographic relief.

Flight Patterns

Data regarding flight direction, distance from observer and relation to turbine height were collected to examine the relationship between bird movements and their physical environment. Flight direction was not significantly different from a random distribution, indicating that bird movements tended to be evenly distributed around the eight points of the compass. No correlation existed between flight direction and time of day. Seventy-two percent of distance observations were greater than 350 feet from the observer (Figure 4) and 66% of angle observations were at or below the horizon (Figure 5).

Flight heights were observed relative to the turbine height. Most observations were passerines foraging on the ground. Of the aerial flight observations, approximately half were at turbine blade height (Figure 6).

Mortality

Avian mortality in this study consisted of 25 probable strikes (60.46%) at Midway and 17 probable strikes (39.54%) at Dyer (Chi-square = 1.844, df = 1, $0.25>p>0.10$). Of the 43 probable strikes collected during this survey, 26 (60.46%) were non raptors, 2 (4.65%) were Golden Eagles and 15 (34.89%) were other raptors (Table 6). The two most unusual recoveries were a red bat (Lasiurus borealis) and a California Brown Pelican (Pelecanus occidentalis), a Federally listed endangered species. The cause of mortality to this bird was unknown.

Table 6. Mortality Recoveries from Randomly Selected Turbine Strings, Altamont Pass, CA. 1988-89.

Species	Number
Raptors	
Red-tailed Hawk	9
Golden Eagle	2
Buteo	1
Common Barn Owl	2
Great-horned Owl	4
Common Raven	1
Brown Pelican	1
Rock Dove	12
Passerines	
Brewer's Blackbird	1
Horned Lark	1
Mountain Bluebird	1
Red-winged Blackbird	1
Starling	1
Western Bluebird	1
Western Meadowlark	2
Passerine	1
Unidentified Bird	1
Mammal	
Red Bat	1

Since the golden eagle was the species of primary concern in the Altamont Pass (U.S. Fish and Wildlife Service), a statistical test of the pooled data for U.S. Windpower and this study suggested, but by no means was conclusive that golden eagles tended to be more vulnerable to turbine strikes than were red-tailed hawks based upon their observed relative activity (Table 7).

Table 7. Chi-square Test of Pooled Data for Three Most Abundant Raptors and Wind Turbine Mortality in the Altamont Pass, CA. Data were pooled from this study and U.S. Windpower self monitoring program.

Species	Observed Mortality Rate	Expected From Proportion of Activity+
Red-tailed Hawk	46 (55.4%)	29 (35.0%)
Golden Eagle	35 (42.2%)	17 (20.0%)
Turkey Vulture	2 (2.4%)	37 (45.0%)

Chi-square = 62.11, df = 2, $p < 0.001$
+Derived from mean activity rates during 10 minutes.

Table 8. Chi-square Test of Pooled Data for Red-tailed Hawks and Golden Eagle Wind Turbine Mortality in the Altamont Pass, CA. Data were pooled from this study and U.S. Windpower self monitoring program.

Species	Observed Mortality Rate	Expected From Proportion of Activity
Red-tailed Hawk	46 (56.8%)	51.5 (63.6%)
Golden Eagle	35 (43.2%)	29.5 (36.2%)

Chi-square = 1.6539, $0.25 > p > 0.10$

Comparison of USW Self Monitoring Program and This Study

U.S. Windpower began a systematic self monitoring program of avian mortality in 1985 and continued throughout this study. A summary of U.S. Windpower data for 1985 through 1989 indicated a seasonal pattern of mortality with greater numbers during the fall and winter months (Figure 7). We examined the mortality recoveries from our study for a similar monthly pattern during 1988-89. The pattern from our study tended to be more uniform throughout the year (Figure 8). During self monitoring program from 1985 to 1989 U.S. Windpower reported avian mortality recoveries, 94% of which were raptors. During this study 43% of the avian mortality recoveries were raptors, 57% were non-raptors, indicating the smaller birds were not reported during the self monitoring program. This was mostly the result of emphasis placed on raptors, their large size, greater ease of discovery and differential scavenging rates.

Injury types during U.S. Windpower's self monitoring program were categorized into four groups, 1) power pole or line, power failure, 2) power pole, no power failure, 3) tower collision, bird recovered with missing parts and 4) near tower or power pole, cause of death undetermined (bird found in vicinity but no direct evidence of electrocution or collision). From 1985 to 1989 U.S. Windpower reported 115 cases with injury codes, 19 power pole, power failure, 17 power pole, no power failure, 35 missing body parts and 44 undetermined cause or type of injury near tower or pole. In 1984 through 1986, and in 1988, U.S. Windpower retrofitted specific power poles to prevent electrocutions, resulting in a drop from 7.5 electrocutions per 852 poles to 2.5 electrocutions per 1432 poles. During our study 35 carcasses were recovered which were classifiable into two injury categories, 7 recovered with missing parts and 28 cause of death undetermined. The remaining 8 carcasses were decomposed beyond usefulness. Carcasses were deposited at the U.S. Windpower refrigerator for later burial or transport to the U.S. Fish and Wildlife Service.

Distribution of Mortalities

In our study bird carcasses recovered near the turbines were characterized by direction and distance from the tower. All carcasses we recovered were located within 100 feet of the towers and tended to lie in an easterly, north-easterly configuration, which indicate that they were found predominately down wind of the turbine (Figures 9 & 10), because of the prevailing winds at Midway and Dyer were westerly and south-westerly, respectively. Five recoveries were located in the control areas upwind of the turbines, and 38 recoveries were located downwind.

Mortality Relationship to String Length

The amount of mortality related to turbine string length was examined to explore the hypothesis that turbine strings might act like a "picket fence" creating a barrier to flight paths. Regression analysis for our data at Altamont showed correlation (R^2 = 0.32, F = 8.30, p = 0.009, n = 21) between string length and mortality (Figure 11). By separating the two areas, the regression for Dyer showed correlation between string length and mortality (R^2=0.41, F = 8.01, p = 0.017, n = 11) (Figure 12) while Midway did not (Figure 13).

Scavenging

Scavenging rates between treatment and controls and between Midway and Dyer were not statistically different. These rates were higher than the rates observed in a comparable study in Solano County during the same season (Figure 14). Within three days almost 50% of the fresh game hen carcasses were removed from the Altamont Pass plots (Figure 14). During the spring, eight game hen transects were established in addition to the game hen study plot design. Spring removal rates between game hen plots and transects were not different from the fall removal rates on game hen plots alone.

The average number of days for game hen carcasses to show evidence of scavenging was 3.17 days, and the average number of days for game hen carcass to be removed was 4.19 days. In Solano County scavenging occurred on average in 9.24 days and removal occurred on average in 7.13 days. This latter value is lower than the average for scavenging because several carcasses disappeared early without showing other signs of scavenging. This skewed the average to a lower level.

Nesting

A total of 26 nests were located during the spring surveys. Nineteen were located at Dyer, and seven were located at Midway (Table 8). Six young raptors were banded, 3 red-tails, 2 golden eagles, and 1 prairie falcon (Appendix C). No banded birds from this study were recovered on the mortality transects or during U.S. Windpower's self monitoring program at other wind energy site locations during 1989 season. The banded prairie falcon was recovered near Billings, Montana several months after banding.

Table 8. Summary of Nesting Activity for Dyer and Midway Study Sites, Altamont Pass, CA.

Location	Nests	Young [in nest]	Roosting [# observed]	Banded	Young
Dyer					
Great Horned Owl	2	2	3		
Common Barn Owl	5	1	2		
Red-tailed Hawk	5	3	-	1	(3)
American Kestrel	1				
Golden Eagle	2	1		1	(2)
Prairie Falcon	1	1			
Common Raven	3				2 on towers
Western Screech Owl			1		
Mallard			in stockpond		
Midway					
Burrowing Owl	1				
Common Barn Owl			1		
Common Raven	6				5 on towers

DISCUSSION

From September 1988 to August 1989 this study examined the relationship of bird abundance and activity to mortality from collisions with wind turbines. The average activity of raptors observed in the Altamont Pass was lower annually than expected from reports by bird watchers such as Richmond (1985). Activity rates were lower than the rates observed in the Montezuma Hills, Solano County (Howell et al. 1988). This was due in part to a difference in observation periods between sites. Altamont observations were recorded year round while the Montezuma Hills observations were only recorded during the fall and winter when greater numbers of wintering birds could be expected. Even with this bias, the relative bird activity rates and number of species was lower in the Altamont Pass. The primary difference between Altamont Pass and Montezuma Hills was the greater abundance of golden eagles in the Altamont Pass area. This difference can be attributed to the difference in abundance of nesting and foraging habitat in Altamont Pass and the Montezuma Hills. In addition the abundance of ground squirrels will contribute to attracting eagles and red-tailed hawks into the area of Altamont Pass. Intensive disking for wheat farming has reduced the quantity and quality of foraging habitat by reducing ground squirrels in the Montezuma Hills.

Site differences between Dyer and Midway contributed some of the more interesting results of this study. Based on nest counts Dyer had more nests, almost 3 fold, than Midway, yet the mortality rate between them was not different. Familiarity with the area may favor residents and reduce mortality among them. Although the turbine towers are readily utilized as perches and nest platforms, predominantly raven, towers may contribute to mortality by being an attractant. No banded young were recovered as turbine strike mortalities. Turbine string length was moderately correlated with mortality at Dyer but not correlated with string length at Midway. Midway and Dyer had similar topographic relief. This may well be a result of small sample size.

Further evaluation of towers that had strikes indicated that some individual locations had multiple strikes both at Midway and Dyer. Based on inspection of topographic maps and the distribution of turbine strings, the locations of multiple strikes tended to occurred at swales and on shoulders of hills (Figures 15 and 16). Combined data for the Dyer and Midway study sites from U.S. Windpower and this study showed 28 strikes at turbine string ends (3 terminal towers) and 58 strikes at interior turbine string locations.

Scavenging observed in this study was a high estimate. The density of game hens was much higher in the study plots than the density of dead birds along the turbine strings. Additional game hen carcasses may have been discovered as a result of an initial discovery of one in a plot. Plucked carcasses are also more visible than the cryptic plumage of naturally occurring birds. In addition, based on field observations of coyote, fox, ground squirrels, common ravens, and turkey vultures the number of scavengers is much higher in the Altamont Pass. In the Montezuma Hills baited track stations resulted only in house cat tracks. Body size is another factor affecting removal rates, with larger birds not being removed as rapidly. This prediction is supported by the degree of decomposition observed when large birds are recovered. Removal will be less of a factor in determining eagle and large raptor mortality rates. The bias from scavenging will be greater for smaller birds which could result in under estimates of mortality rates.

For 359 turbines sampled, 42 birds and 1 mammal were recovered in a 12 month period. Since this is only one year of observation, it is difficult to extrapolate these values to long term trends. No variance in the mortality rate can be established. Orders of magnitude may be approximated, but without an understanding of variation this could be misleading. A single estimate would probably be high. During the 4 years of U.S. Windpower's self monitoring and this study 42 golden eagles were recovered resulting in an expected mortality of approximately 10 golden eagles per year for the entire facility. This order of magnitude is most likely correct with numbers of mortalities varying around 10 and depending upon the annual variation of the golden eagle population.

It is important to point out that this estimate of the number of raptors, especially golden eagles found in the area by U.S. Windpower and this study, amounts to a significant number of mortalities when examined in light of the most recent statewide (Thelander 1974, Schlorff 1986) and local (Lenihan and DiDonato 1987) surveys of nesting golden eagles and other raptors. This rate of loss from mortality, in addition to 1) natural and other human caused mortality and 2) the loss of historical nesting and foraging habitat, could affect the local recruitment of golden eagles.

CONCLUSION

Lack of sufficient information about avian mortality from collisions with wind turbines at large wind energy facilities led to this study. Although most of the prior studies concluded that losses represent a small fraction of the population, it has become apparent that some species, such as golden eagles may be more vulnerable to impacts from wind turbines, and in fact their populations may be impacted on a higher relative scale than other species experiencing this type of mortality.

Based on our observations that carcasses were located down wind near the turbines and multiple strikes occurred in swales or shoulders of hills, we think the majority of strikes occurred among birds in transit. That is they were moving with the wind or sheering across the wind at an acute angle to the rotation of the turbine blades. Birds would have increased velocity and be in a position to have difficulty seeing the rapidly moving turbine blade along its narrow axis. Turkey vultures with their relatively slow soaring flight encountered no mortality during this study and extremely low mortality during the U.S. Windpower self monitoring program. Increased contrast of the turning blades might help reduce mortality by alerting birds in time for them to alter their flight path.

It would be difficult at this stage to determine if weather is a contributing factor. The raptors were active in all kinds of weather, but because collisions are very low probability events determining exact time and weather condition for a specific collision is extremely difficult if not impossible.

Recent literature reporting field trials of acoustic deterrents for birds found that they were ineffective for starlings (Bomford 1990). Because of problems with habituation to noise and the unremarkable hearing of birds, acoustic devices will probably not be effective in reducing collision mortality in the near future. Extensive research will be required to examine behavioral responses to these devices and to different types of sound. Hypotheses about the relationship of visibility, topography and mortality should be tested to evaluate methods to reduce avian mortality.

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LITERATURE CITED

Anderson, W. 1978. Waterfowl Collisions with Power Lines at a Coal-Fired Power Plant. Wildl. Soc. Bull., 6:77-83.

Avery, M., P. Springer, and N. Dailey. 1980. Avian Mortality at Man-made Structures: An Annotated Bibliography (Revised). U.S. Fish Wildl. Serv. Biological Services Program, National Power Plant Team, FWS/OBS-80/54. 152 pp.

Binford, L. 1979. Fall Migration of Diurnal Raptors at Pt. Diablo, California. West. Birds, 10:1-16.

Bissell & Kern, Inc. 1986. Project Description Montezuma Hills Windpower, Solano Co. CA. Wind Generation Parks, Inc. Sausalito, CA. 36 pp.

Bloom, P. 1985. Raptor movements in California. Pages 313-323. in. Harwood, M.(ed.). Proceedings of Hawk Migration Conference IV. H.M.A.N.A. Hawk Mountain, PA. 393 pp.

Bomford, M. 1990. Ineffectiveness of a sonic device for deterring starlings. Wildl. Soc. Bull. 18:151-156.

Clark, W. and B. Wheeler. 1987. A Field Guide to Hawks North America. Houghton Mifflin Co. Boston. 198 pp.

Cogswell, H. 1977. Water Birds of California. University of California Press. Berkeley. 399 pp.

Day, R. and G. Quinn. 1989. Comparisons of treatments after an analysis of variance in ecology. Ecological Monographs 59:433-463.

Faanes, C. 1987. Bird Behavior and Mortality in Relation to Power Lines in Prairie Habitats. U.S. Fish Wildl. Serv., Fish Wildl. Tech. Rep. 7. 24 pp.

Harwood, M.(Ed.). 1985. Proceedings of Hawk Migration Conference IV. Hawk Migration Assoc. of N. Am. 393 pp.

Hoffman, S. 1985. Raptor movements in inland Western North America: a Synthesis. Pages 325-338. in. Harwood, M.(ed.). Proceedings of Hawk Migration Conference IV. H.M.A.N.A. Hawk Mountain, PA. 393 pp.

Howell, J.A. 1990a. Summary of site differences between Montezuma Hills and Altamont Pass, California, for raptors. Solano Co. Dept. Environ. Manage. Fairfield, CA. 4 pp.

Howell, J.A. 1990b. Experimental design to reduce avian collision mortality with wind turbines. Alameda County Planning Dept. Oakland, CA. 2 pp.

Howell, J.A. and J. DiDonato. 1989a. Project expansion avian use monitoring related to wind turbine siting, Montezuma Hills, Solano County, California. Solano Co. Dept. Environmental Manage. Fairfield, CA. 5 pp.

Howell, J.A. and J. DiDonato. 1989b. Farnsworth property, avian use monitoring related to wind turbine siting, Montezuma Hills, Solano County, California. Solano Co. Dept. Environmental Manage. Fairfield, CA. 5 pp.

Howell, J.A., J. Keane and J. DiDonato. 1988. Avian use monitoring related to wind turbine siting, Montezuma Hills, Solano County, California, Fall 1987 to Spring 1988. Solano Co. Dept. Environmental Manage. Fairfield, CA. 23 pp. + Appendices.

Howell, J.A. and J. DiDonato. 1988a. Crepuscular avian use monitoring related to wind turbine siting, Montezuma Hills, Solano County, California, Spring 1988. Solano Co. Dept. Environmental Manage. Fairfield, CA. 20 pp. + Appendices.

Howell, J.A. and J. DiDonato. 1988b. Raptor nesting survey related to wind turbine siting, Montezuma Hills, Solano County, California, Spring 1988. Solano Co. Dept. 12 pp. + Appendix.

Johnson, B. and E. Cheslak. 1985. Raptor abundance and distribution in relation to a large wind turbine generator (Draft). P.G.& E. San Ramon, CA. 16 pp.

Jones & Stokes Assoc., Inc. 1987. Bird Abundance and Movements at the Potrero Hills Wind Turbine Site, Solano County, California: Preproject Monitoring Results. Sacramento, CA 34 pp.

Lehmann, E. 1975. Nonparametrics. Holden-Day, Inc. San Francisco, CA. 457 pp.

Leitner, P. 1982. Potential WTG Effects on Wildlife. Appendix D:188-193. in Environmental Science Associate, Inc. Cordelia Hills WTG Project, Final Environmental Impact Report. City of Fairfield, CA.

Lenihan, C. and J. DiDonato. 1987. Raptor populations of southern Alameda County. Predatory Bird Research Group U.C. Santa Cruz. 30 pp.

McCrary, M., R. McKernan, R. Landry, W. Wagner, and R. Schreiber. 1983. Nocturnal Avian Migration Assessment of the San Gregorio Wind Resource Study Area, Spring 1982. S. CA Edison Co. Rosemead, CA. 121 pp.

McCrary M., R. McKernan, R. Schreiber, W. Wagner, and T. Sciarrotta. 1986. Avian Mortality at a Solar Energy Power Plant. J. Field Ornithol., 57:135-141.

Newton, I. 1979. Population Ecology of Raptors. Buteo Books. Vermillion, SD. 399 pp.

Norusis, M. 1988. SPSS/PC+ V2.0. SPSS Inc., Chicago. 324 pp.

Olendorff, R. and R. Lehman. 1986. Raptor Collisions with Utility Lines: an Analysis Using Subjective Field Observations. P.G.& E. San Ramon, CA 73 pp.

Olendorff, R., A. Miller, and R. Lehman. 1981. Suggested Practices for Raptor Protection on Power Lines. Raptor Research Foundation, Inc. Dept. Veterinary Biology, Univ. Minnesota, St. Paul. 111 pp.

Richmond, J. 1985. Birding Northern California. Mt. Diablo Audubon Society, Walnut Creek, CA. 142 pp.

Rogers, S., B. Cornaby, C. Rodman, P. Sticksel, and D. Tolle. 1977. Environmental Studies Related to the Operation of Wind Energy Conversion Systems. U.S. Dept. Energy. Nat. Tech. Inform. Ser. 108 pp.

Rusz, P., H. Prince, R. Rusz, and G. Dawson. 1986. Bird Collisions with Transmission Lines Near a Power Plant Cooling Pond. Wildl. Soc. Bull., 14:441-444.

Schlorff, R. 1986. Golden eagle status review. Calif. Dept. Fish and Game. Wildlife Mgmt. Branch. Job Report II-17. 11 pp.

Steel, R. and J. Torrie. 1960. Principles and Procedures of Statistics with Special Reference to the Biological Sciences. McGraw-Hill, Inc., New York. 481 pp.

Thelander, C. 1974. Nesting territory utilization by golden eagles (Aquila chrysaetos) in California during 1974. Calif. Dept. Fish and Game. Wildlife Mgmt. Branch. Admin. Report No. 74-7. 19 pp.

Wagstaff and Brady. 1985. Solano County Wind Turbine Siting Plan and Environmental Impact Report. Solano Co. Dept. of Environmental Mgmt. Fairfield, CA. 156 + 58 pp.

Zar, J. 1974. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, NJ. 620 pp.

APPENDIX A

Physical Parameter Scales

Methods
Mortality Transect Procedures
Scavenging Plot Procedures

Physical Parameter Scales

To tally the passage of birds, first identify the species as best you can. Second, if there are more than one individual place the count in brackets (n), such as a flight of 70 mallards would be recorded (70). For raptors that can be aged, identify the tally with an A for adult and an I for immature.

Estimate distance using the standardized scale. Distances are approximate and designed to provide relative orders of magnitude. Distance categories are:

1. $d \leq 75ft$
2. $75ft < d < 150ft$
3. $150ft < d < 250ft$
4. $250ft < d < 350ft$
5. $d > 350ft$

Compass Rose

1. NE	5. SW
2. E	6. W
3. SE	7. NW
4. S	8. N

Angle is derived similarly

0.5	Below Horizon
0	Horizon
1	22.5^{o}
2	45^{o}
3	67.5^{o}
4	90^{o}

Relationship to Turbine

0	Ground
1	Between Ground & Turbine Blade
2	Turbine Blade Diameter (TBD)
3	One TBD Above Turbine
4	Above

DISTANCE SCALE CONVERSION
(Approximate Values)

	Duck (2ftW)	RTHA (4ftW)	Eagle (6.5ftW)
100ft	0.05in	1.00in	1.50in
200ft	0.25in	0.50in	0.75in
300ft	0.16in	0.32in	0.50in

MIDWAY SITE: TURBINE STRINGS WALKED

757-784	(27 turbines active, one turbine dismantled)	all year
801-843	(39 turbines present, 4 missing)	" "
844-859	(15 turbines active, one turbine dismantled)	" "
1052-63	(all 12 active)	
1080-87	(all 8 active)	
1110-22	(all 13 active)	
1203-24	(all 22 active)	

ORDER OF TRANSECTS:MIDWAY

1203-24 (08 mins.)
control (08 mins.)
1110-22 (07 mins., split up)
1012-51 (12 mins.)
control (12 mins., one person)
1052-63 (04 mins.;
1080-87 (05 mins., one person)
757-784 (09 mins.)
control (09 mins.)
844-859 (08 mins.)
836-844 (04 mins.)
801-835 (13 mins.)
control (13 mins.)

1) Enter from North Flynn Rd. Gate to the 1200 Ridge.
- you may be asked to notify operations of the next intended string. This will allow them to prepare the machines in advance.

2) Proceed to 1110-22. One person walks from one end and partner drives around to the other end, parking and walking in towards the other.

3) Both do 1012-51 and 1052-63. Then separate, one person walking the control of 1012-51 and the other person walking over to 1080-87. (Coordination of clearance for this last string should be timed to allow minimum amount of shut-down time and maximum amount of safety). That person who walks back to vehicle via 1012-51 will drive to 1080 and pick up second person.

4) Proceed to other towers together. From there the only change will occur at towers 844-859. One person is dropped off at 859 and walks downstring(descending numbers) towards the other who has driven around to 844 and proceeds upstring.

5) Note: Unless otherwise specified the "control" is the upwind side of the towers (that side from which the roads approach). Please notify Operations when you are clear of the towers so they can activate them.

DYER SITE: TURBINE STRINGS WALKED

2059-74
2137-42
2152-74 (one nacelle gone)(during whole year?)
2220-47
2274-93
2476-88
2514-18
2519-28
2529-36
2672-85
2686-2719 (3 nacelles gone)(time period?)
2747-56

ORDER OF TURBINE TRANSECTS:

2687-2719	(20 mins.)
control	(11 mins.)
2672-86	(11 mins.)
2152-74	(09 mins.)
control	(08 mins.)
2137-42	(07 mins.)
2747-56	(06 mins.)
2059-74	(19 mins.)
2220-47	(16 mins.)
2274-93	(17 mins.)
control	(08 mins.)
2476-88	(08 mins.)
2514-18	(03 mins.)
2519-28	(06 mins.)
2529-36	(06 mins.)

1) On string 2220-47, one person is dropped off at 2247 and walks upstring and the other person drives to 2230, parks and walks to 2220 and back. Both parties meet at the vehicle.

2) A similar procedure to the one above occurs at 2476-88. Person #1 is dropped off at 2488 and person #2 drives to 2480 and walks the lower end of the string. Meet at the vehicle.

3) Get clearance for 2514-28 and divide these strings between the two parties. Each person does one string and again meets at the vehicle. The last string is done together, half each.

Note: In an effort to conserve your energy and to assure USW produces theirs, please advise Operations when you are clear of machines(or are in the control area). Asking for clearance while enroute to a string is acceptable as long as you arrive before or simultaneous with the clearance permission.

Altamont Pass Scavenging Plots 1988

Eight scavenging plots were set up in the study area. Four plots were in the Midway and four in the Dyer study area. Twelve half chicken carcasses were randomly placed in each for a total of 96. Four plots, each a 200ft x 50ft grid, were set up intersecting the turbine strands at right angles and four similar control plots were erected nearby but away from the turbine strings.
Chicken carcasses were tagged with individual and plot numbers to aid in identification. Plots were checked once a day for two weeks or until all carcasses were gone.

Results:

All chickens were removed or eaten completely by the end of eight days with one plot empty as early as Day two. The average was 4.87 days removal time for all plots with only five individual chickens remaining past Day six.

	MIDWAY		DYER
Plot #	last day of predation	Plot #	last day of predation
1	Day 5	1	Day 5
2	" 3	2	" 5
3	" 8	3	" 2
4	" 7	4	" 4

At each station plots 1 and 3 were intersecting the turbine lines and plots 2 and 4 were used as a control.

We found no significant difference in the amount or rate of scavenging when comparing the sites under the turbines with those away from the machines. The majority of the carcasses were removed by ravens, but some mammal activity, including raccoons, foxes and badgers, was evident. It seemed obvious that once a plot was discovered, it was revisited frequently.

PREDATION ON SCAVENGING PLOT CARCASSES (SUMMARY)

(A) Percent carcasses totally removed from plot

2/32 * 100 = 6.02 %

(B) Percent predated (> 50 % of carcass eaten or removed Includes (A))

8/32 * 100 = 25 %

(C) Percent predated to any degree (Includes A and B)

16/32 * 100 = 50 %

The difference in the amount of predation in relation to the height of the vegetation in each plot is as follows : Plot 1 had the highest length (Up to 2 ') and experienced 25 % predation, Plot 2 had the second highest length (up to 18in) and experienced the largest amount of scavenging (75 %).

Plots 3 and 4, located in a newly planted field, were equal in their vegetation heights (up to 9in) and experienced 62.5 % and 37.5 % respectively, which may have led to discovery by perching birds and mammalian scavengers who frequent the area, possibly having been previously rewarded by line kills.

APPENDIX B

Species Status/Abundance
California
(From: Cogswell 1977, Clark and Wheeler 1987)

Species Status/Abundance

RAPTORS:

1) TURKEY VULTURE (*Cathartes aura*)
   - abundant
   - subsists on carrion
   - social and gregarious (roosting, feeding, perching)
   - roost sites are often on radio towers
   - soars at moderate heights in search of food

2) BLACK-SHOULDERED KITE (*Elanus caeruleus*)
   - uncommon (usually in open grassland, savannah, marsh and wetland areas)
   - hunts by hovering but also from exposed perches
   - prey is mainly rodents and small birds
   - generally non-migratory

3) BALD EAGLE (*Haliaeetus leucocephalus*)
   - uncommon to rare
   - found near water; wetlands, marshes, rivers and lakes
   - observed inland during migration
   - feeds on fish, waterfowl, mammals and carrion
   - hunts from air or exposed perch

4) NORTHERN HARRIER (*Circus cyaneus*)
   - common (in open fields, marsh/wetlands)
   - hunts by flying low to the ground
   - preys on rodents, small birds and occasionally waterfowl
   - perches on fenceposts and on ground, nests on ground

5) SHARP-SHINNED HAWK (*Accipiter striatus*)
   - uncommon, except in migration
   - preys on small to medium sized birds
   - usually found in moderate to dense woodland, chaparral and riparian areas

6) COOPER'S HAWK (*Accipiter cooperii*)
   - uncommon, even during migration
   - preys on medium to large sized birds, occasionally on mammals
   - usually found in moderate to dense woodland, chaparral and riparian areas

7) RED-SHOULDERED HAWK (*Buteo lineatus*)
   - uncommon
   - found in moist woodlands, riparian
   - hunts small mammals, birds, amphibians and reptiles
   - hunts by soaring and from exposed perch

8) BROAD-WINGED HAWK (Buteo platypterus)
- rare even in migration
- found in moist woodlands, riparian
- hunts small mammals, birds, amphibians and reptiles
- hunts by soaring and from exposed perch

9) SWAINSON'S HAWK (Buteo swainsoni)
- uncommon (common inland especially during migration)
- preys on small mammals
- found in open grassland, woodland and savannah

10) RED-TAILED HAWK (Buteo jamaicensis)
- abundant, resident
- found in open fields, savannah and mixed woodlands
- hunts by soaring or from exposed perches
- commonly found perched on man-made structures including power poles
- feeds on mammals, birds, reptiles and carrion
- known to nest on towers

11) FERRUGINOUS HAWK (Buteo regalis)
- uncommon winter migrant
- found in open fields, savannah
- hunts by soaring, hovering and from exposed perches
- feeds on mammals (jackrabbits and ground squirrels)

12) ROUGH-LEGGED HAWK (Buteo lagopus)
- uncommon winter migrant
- found in open areas (savannah, grasslands)
- perches on ground, fenceposts
- feeds on small mammals

13) GOLDEN EAGLE (Aquila chrysaetos)
- uncommon, resident
- found in open grassland, savannah and woodland
- hunts by soaring and from high perches
- known to nest on power towers
- feeds on medium to large sized mammals, birds and carrion

14) AMERICAN KESTREL (Falco sparverius)
- abundant, resident
- found in open grassland, farmland
- hunts by hovering and from exposed perches
- feeds on insects, small mammals and birds
- usually cavity nests

15) PEREGRINE FALCON (Falco peregrinus)
- rare to uncommon migrant
- feeds on birds, waterfowl
- hunts by rapid pursuit and by aerial stoops
- found in marsh/wetlands, cliffs and occasionally on skyscrapers in city

16) PRAIRIE FALCON (_Falco mexicanus_)
- uncommon, resident
- hunts by rapid pursuit and from exposed perches
- perches regularly on power towers
- feeds on birds, mammals and reptiles

APPENDIX C
Raptor Nest Summary
Banding Summary

Dyer

G-1 Great Horned Owl(GHOW) nest on cliff face above ranchette, former Common Raven (CORA) nest, at least two young, 2-3 weeks old, both parents present, fledged 6-21-89

G-2 GHOW nest in old eagle nest in rocky outcrops, past supply yard where Chuck and I separated to check nests, female incubating (340 N of TWR's 2916, 335 of TWR 2935)

G-3 GHOW (1) roosting in drainage near CBOW 3

G-4 GHOW roosting in drainage near CBOW 2

G-5 GHOW roosting in drainage past RTHA (R-3), in rocky area

BO-1 Common Barn Owl(CBOW) (2) roosting near the above GHOW 2 nest, rock outcrops

BO-2 CBOW 1 roosting on cliff in gully (right turn at Jackson Barn), cliffs visible from twr 2174, downhill

BO-3 CBOW in cavity near prfa nest in rock outcrop, flew from hole when I threw a rock, near GHOW 3

BO-4 CBOW in barn with small pond, Jackson Barn

BO-5 CBOW nest in PRFA rock, one dead egg, one broken, one dead adult 100 feet from rock, cause unknown (6-7-89)

BO-6 CBOW nest with > _ 2 young, in cavity 8' from GHOW nest 1 (6-21-89)

BO-7 CBOW in Jackson Barn, section 5B

R-1 Red-Tailed Hawk (RTHA) nest in eucalyptus tree at first ranchette on right, entering Dyer, Female incubating, nest failed

R-2 RTHA nest with 3 young (3-4 weeks) in oak with ants, down from twr 2514, banded young

R-3 RTHA nest, active, pair screaming at us, near the big white wash Aerie, past supply yard, first nest failed, second nest in Oak (directly N of twr 2077 @ 400-500') has two young @ 3 weeks old (6-21-89)

R-4 RTHA with one fledgling in brushy peak, Chuck found, food begging

R-5 RTHA pair with old nest in gully downhill from twr 2174 not nesting this year, one nest good, one falling apart, at bend in dirt road (230 from twr 2927, 100' from road)

A-1 American Kestrel (AMKE) in rocky outcrop near GHOW 2, adults entering cavity

GE-1 Golden Eagle (GOEA) nest with two young in it about 3-4 weeks old, adults feeding, large nest in oak tree near Dyer office, banded young.

GE-2 GOEA pair near old nest area and GHOW 2 nest

P-1 Prairie Falcon (PRFA) nest, adults present, male incubating, female screaming at me, rock outcrop near GOEA 1, one young, two dead eggs

C-1 Common Raven (CORA) nest on cliff behind ranch house near Dyer office

C-2 CORA nest on twr 2201

C-3 CORA nest on twr 2082 (6-21-89) reported by FM crew, not verified

W-1 Western Screech Owl roosting near GHOW 2 and GOEA 2 area (5-18-89)

W-1 Mallard female with young at forest Barn and pond enroute to observation point

MIDWAY

B-1 Burrowing Owl (BUOW) nest near Midway Station, bird often perched on line

BO-8 CBOW roosting in palm tree on ranchette near Midway Gate

C-4 CORA nest on twr 1007

C-5 " " " " 1201

C-6 " " " " 547

C-7 " " " " 5419

C-8 " " " " 1522

C-9 " " " PG&E platform outside area near Sub-Station

RAPTOR NEST SUMMARY

Great Horned Owl (Bubo virginianus)

CORRESPONDING MAP LETTER G-1

DATE LOCATED 5-5-89

UTM COORDINATE 418120 N 61638 E

SUBSTRATE rock outcrop

HEIGHT ABOVE GROUND 15'

NEST MATERIAL sticks

NUMBER OF EGGS/ YOUNG 2-3 young @ 3 weeks old; fledged

ADULT BEHAVIOR female incubating, male perched in oak

SURROUNDING HABITAT grassland, oak trees, rock outcrops

DISTANCE FROM NEAREST TURBINE 150'

COMMENT located 8' from CBOW nest

Great Horned Owl (Bubo virginianus)

CORRESPONDING MAP LETTER G-2

DATE LOCATED 4-25-89

UTM COORDINATE 418444 N 61558 E

SUBSTRATE rock outcrop

HEIGHT ABOVE GROUND 35'

NEST MATERIAL sticks

NUMBER OF EGGS/YOUNG undetermined

ADULT BEHAVIOR incubating

SURROUNDING HABITAT rock outcrops, grassland, oaks

DISTANCE FROM NEAREST TURBINE 1500'

COMMENT nesting in old stick nest (probable GOEA's)

RAPTOR NEST SUMMARY

COMMON BARN OWL (Tyto alba)

CORRESPONDING MAP LETTER C-5

DATE LOCATED 6-7-89

UTM COORDINATE 418086 N 61527 E

SUBSTRATE cavity

HEIGHT ABOVE GROUND 25'

NEST MATERIAL N/A

NUMBER OF EGGS/YOUNG 2 dead eggs

ADULT BEHAVIOR dead near nest

SURROUNDING HABITAT grassland, oak trees, rock outcrops

DISTANCE FROM NEAREST TURBINE 350'

COMMENT one adult found dead 150' from cliff, reasons unknown

Common BARN OWL Tyto alba)

CORRESPONDING MAP LETTER C-6

DATE LOCATED 6-21-89

UTM COORDINATE 418121 N 61638 E

SUBSTRATE cavity

HEIGHT ABOVE GROUND 12'

NEST MATERIAL N/A

SURROUNDING HABITAT grassland, oak trees, rock outcrops

DISTANCE FROM NEAREST TURBINE 150'

COMMENT located in same rock as GHOW nest (G-1)

RAPTOR NEST SUMMARY

RED TAILED HAWK (*Buteo jamaicensis*)

CORRESPONDING MAP LETTER R-1

DATE LOCATED 4-25-89

UTM COORDINATE 418040 N 61601 E

SUBSTRATE Eucalyptus tree

HEIGHT ABOVE GROUND 15'

NEST MATERIAL sticks, leaves

NUMBER OF EGGS/YOUNG undetermined, failed

ADULT BEHAVIOR incubating

SURROUNDING HABITAT eucalyptus grove, rock outcrops

DISTANCE FROM NEAREST TURBINE 500'

COMMENT located near ranchette, historical nest

RED-TAILED HAWK (*Buteo jamaicensis*)

CORRESPONDING MAP LETTER R-2

DATE LOCATED 3-01-89

UTM COORDINATE 418371 N 61170 E

SUBSTRATE Valley Oak

HEIGHT ABOVE GROUND 15'

NEST MATERIAL sticks

NUMBER OF EGGS/YOUNG 3 young, fledged

ADULT BEHAVIOR defensive

SURROUNDING HABITAT grassland

DISTANCE FROM TURBINE 400'

COMMENT banded in nest; nest is downhill from tower 2519

ACTIVITY CODES:

CF - CARRYING FOOD (TO NEST, MATE, YOUNG)
CO - COPULATION
DF - DISPLAY FLIGHT
FL - FLEDGLING(S) PRESENT
FY - FEEDING YOUNG
IN - INCUBATING
NE - ACTIVE NEST FOUND (SHOW LOCATION ON MAP)
ON - OLD NEST FOUND (SHOW LOCATION ON MAP)
PA - ADULT PAIR PRESENT/TOGETHER
PE - PERCHED NEAR NEST
TA - TERRITORIAL DEFENSE (INTRASPECIFIC)
TE - TERRITORIAL DEFENSE (INTERSPECIFIC)
VA - VOCALIZING (AGGRESSIVE)
VE - VOCALIZING (NON-AGGRESSIVE)
YP - YOUNG PRESENT (IN NEST)

HABITAT CODES:

1 - DEVELOPED/RESIDENTIAL
2 - GRASSLAND(NON-AGRICULTURAL,PASTURE)
3 - CROPLAND
4 - EMERGENT CROP
5 - FALLOW/DISCED
6 - EUCALYPTUS GROVE
7 - RIPARIAN DRAINAGE
8 - RIVER RIPARIAN
9 - OTHER (EXPLAIN)

BAND NUMBERS, ALTAMONT PROJECT 1989

Band Number	Species	Leg	Area	Date
0877-97204	RtHa	L	Dyer	5-25-89
0987-93501	RtHa	L	Dyer	5-25-89
0987-93502	RtHa	L	Dyer	5-25-89
0629-08655	GoEa	L	Dyer	5-26-89
0629-08657	GoEa	L	Dyer	5-26-89
0816-71551	PrFa	L	Dyer	6-07-89

BAND NUMBERS, SOLANO PROJECT 1989

Band Number	Species	Leg	Area	Date
0608-66576	GhOw	R	Site 5	5-25-89
1443-31801	AmKe/M	R	T. Stewarts	5-25-89
1443-31802	AmKe/M	R	T. Stewarts	5-25-89
1443-31803	AmKe/M	R	T. Stewarts	5-25-89
1443-31805	AmKe/M	R	T. Stewarts	5-25-89

All birds were banded in the nest by J. DiDonato using Judd Howell's bands except the GoEa. They were banded by Phil Detrich.

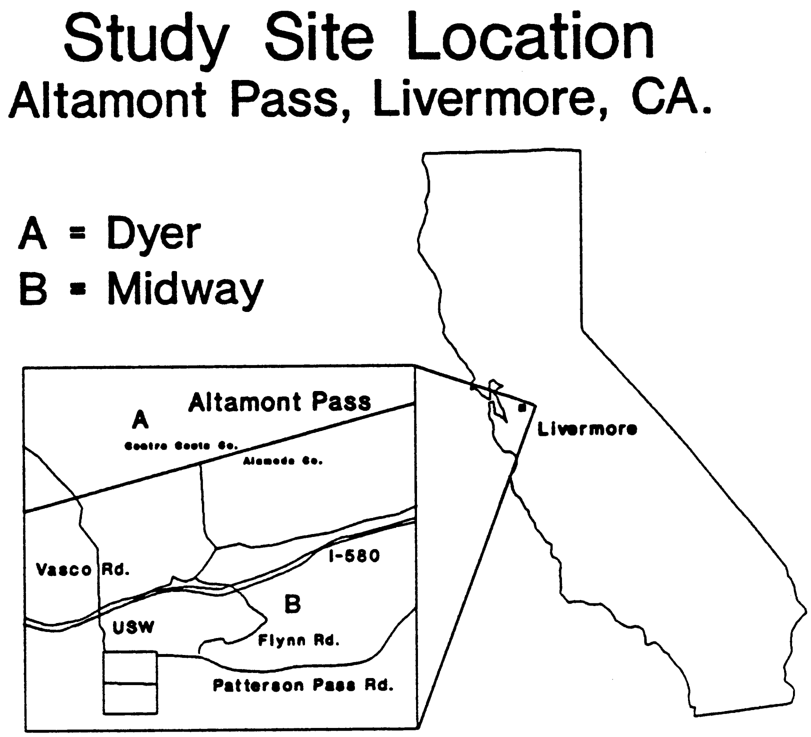

Figure 1. Study Site Location, Altamont Pass, Livermore, CA.

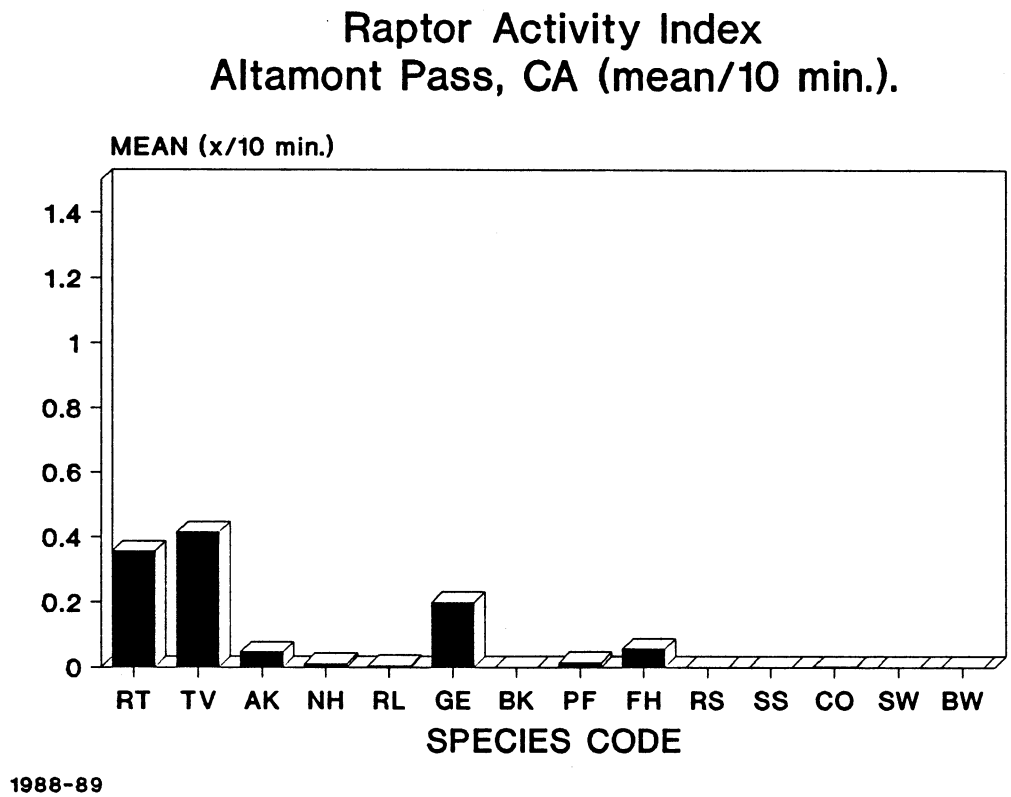

Figure 2. Raptor Activity Index, Altamont Pass, CA (mean/10 min.). RT--Red-tailed Hawk, TV--Turkey Vulture, AK--American Kestrel, NH--Northern Harrier, RL--Rough-legged Hawk, GE--Golden Eagle, BK--Black-shouldered Kite, PF--Prairie Falcon, FH--Ferruginous Hawk, RS--Red-shouldered Hawk, SS--Sharp-shinned Hawk, CO--Cooper's Hawk, SW--Swainson's Hawk, BW--Broad-winged Hawk.

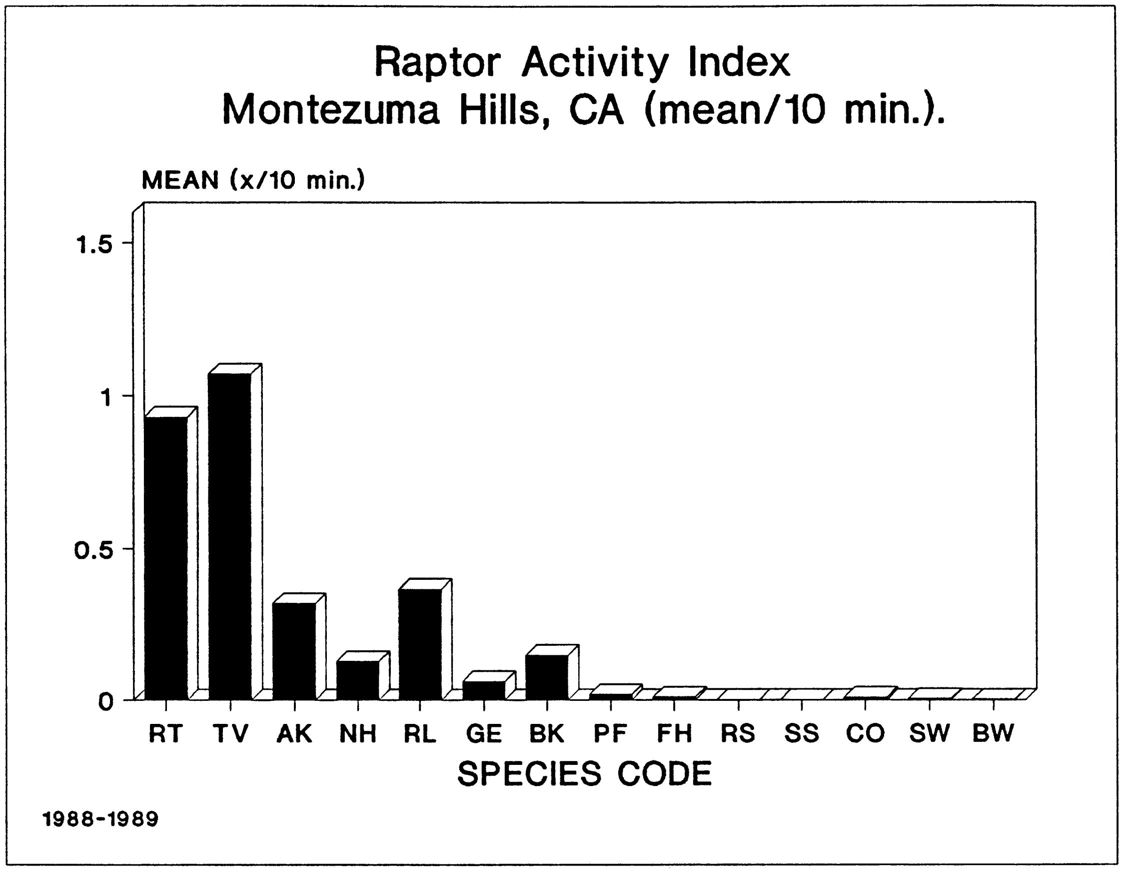

Figure 3. Raptor Activity Index, Montezuma Hills, CA (mean/10 min.). RT--Red-tailed Hawk, TV--Turkey Vulture, AK--American Kestrel, NH--Northern Harrier, RL--Rough-legged Hawk, GE--Golden Eagle, BK--Black-shouldered Kite, PF--Prairie Falcon, FH--Ferruginous Hawk, RS--Red-shouldered Hawk, SS--Sharp-shinned Hawk, CO--Cooper's Hawk, SW--Swainson's Hawk, BW--Broad-winged Hawk.

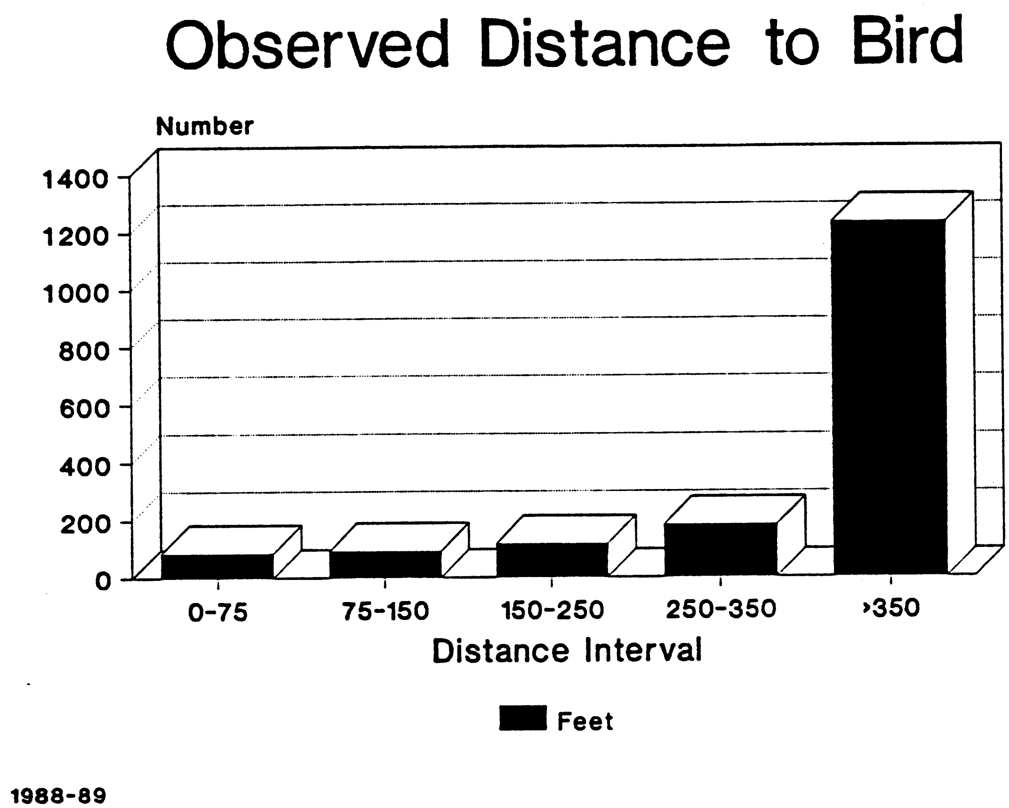

Figure 4. Bird Observation Distance from Observer.

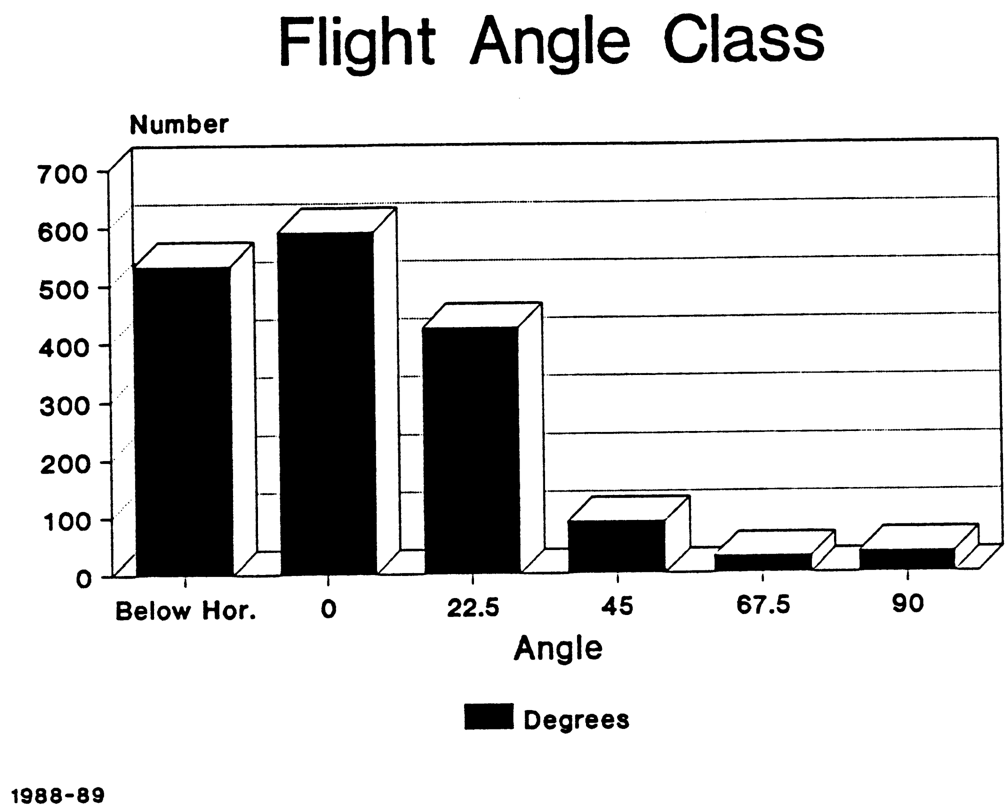

Figure 5. Flight Angle Class, Altamont Pass, CA.

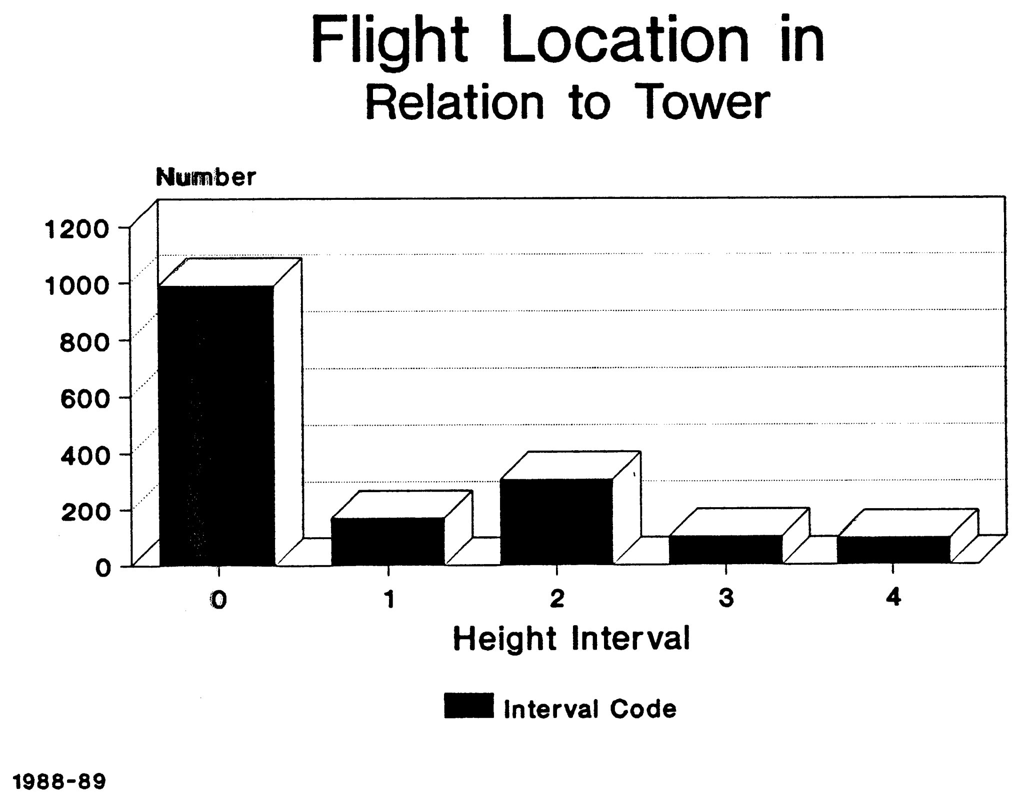

Figure 6. Flight Height in Relation to Wind Turbine and Tower, Altamont Pass, CA. 0= on the ground, 1= between ground and turbine blade, 2= turbine blade diameter, 3= one turbine blade diameter above the turbine, and 4= above.

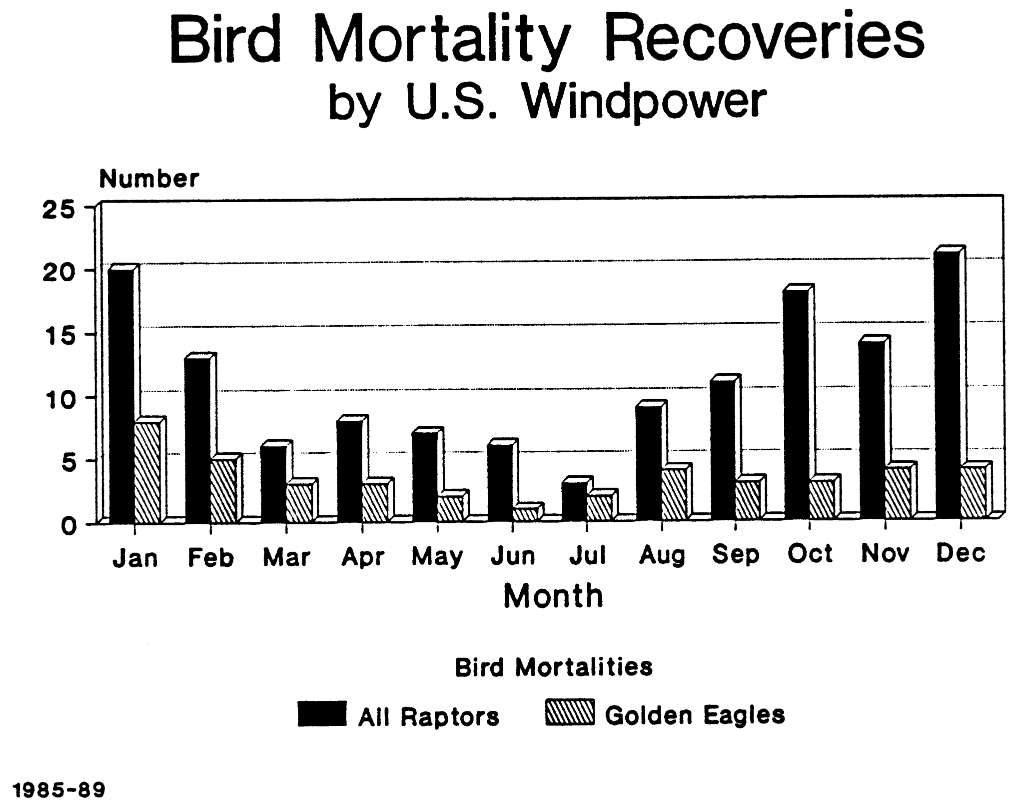

Figure 7. Bird Recoveries by U.S. Windpower from 1985-1989, Altamont Pass, CA.

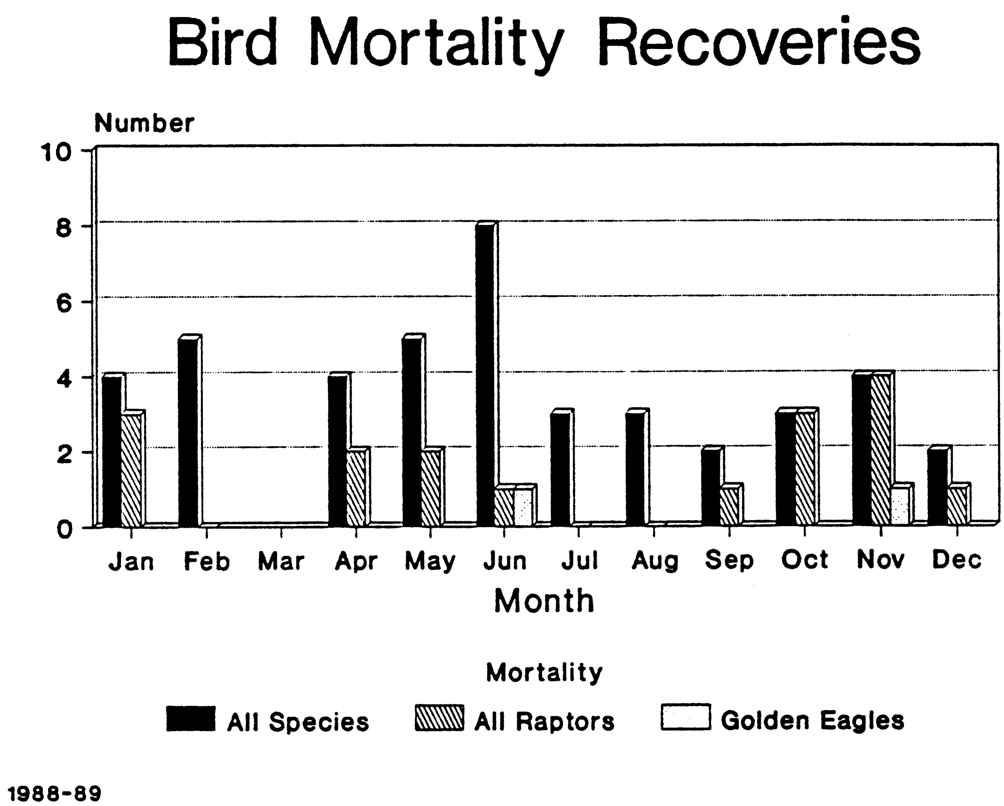

Figure 8. Bird Recoveries at U.S. Windpower Facility, 1988-1989, Altamont Pass, CA.

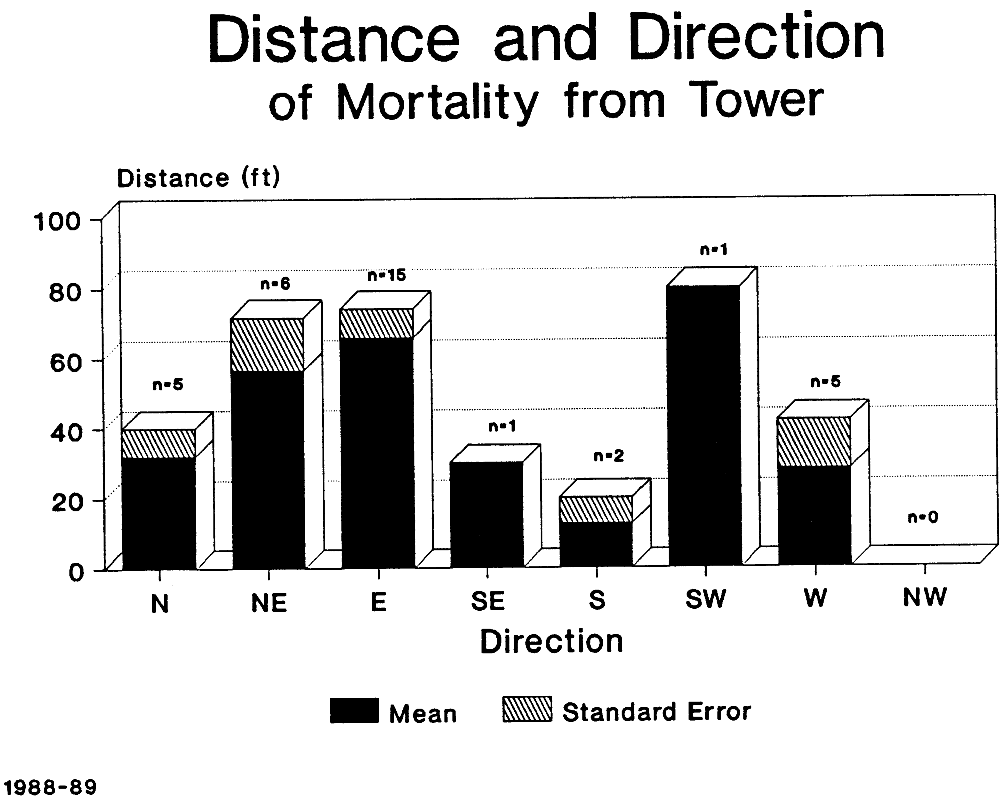

Figure 9. Average Distance and Direction of Bird Carcasses' Location from Tower, Altamont Pass, CA.

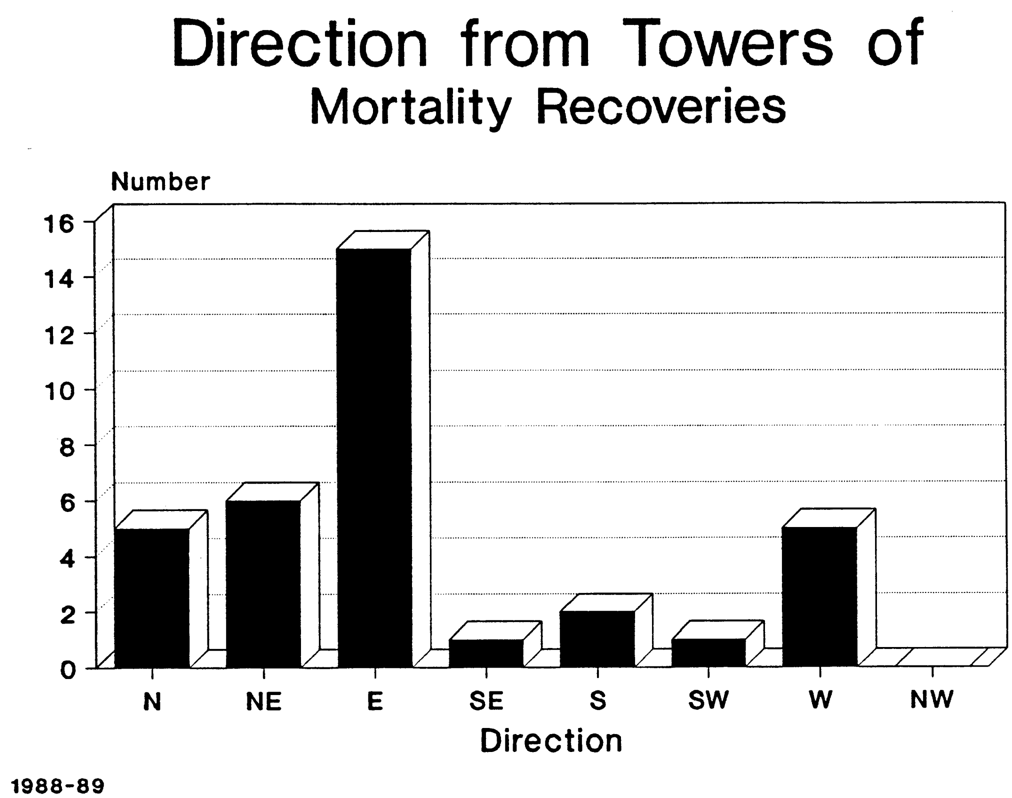

Figure 10. Direction for Recoveries, Total Number of Birds, Altamont Pass, CA.

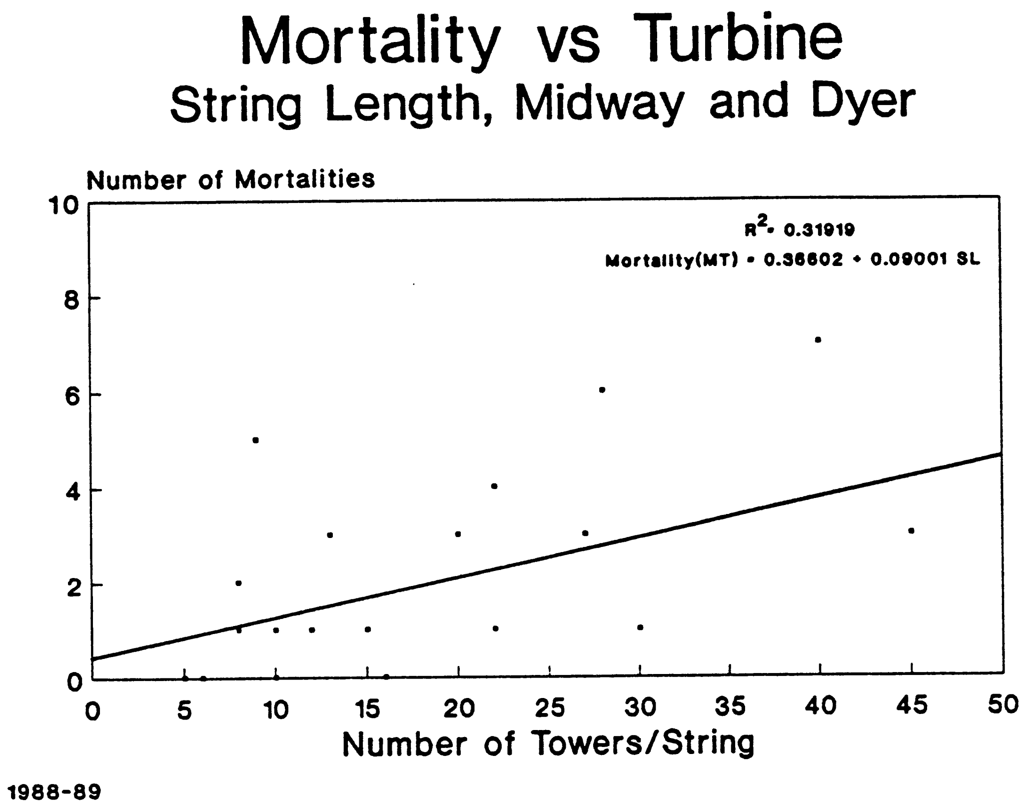

Figure 11. Mortality versus Turbine String Length, Midway and Dyer, Altamont Pass, CA.

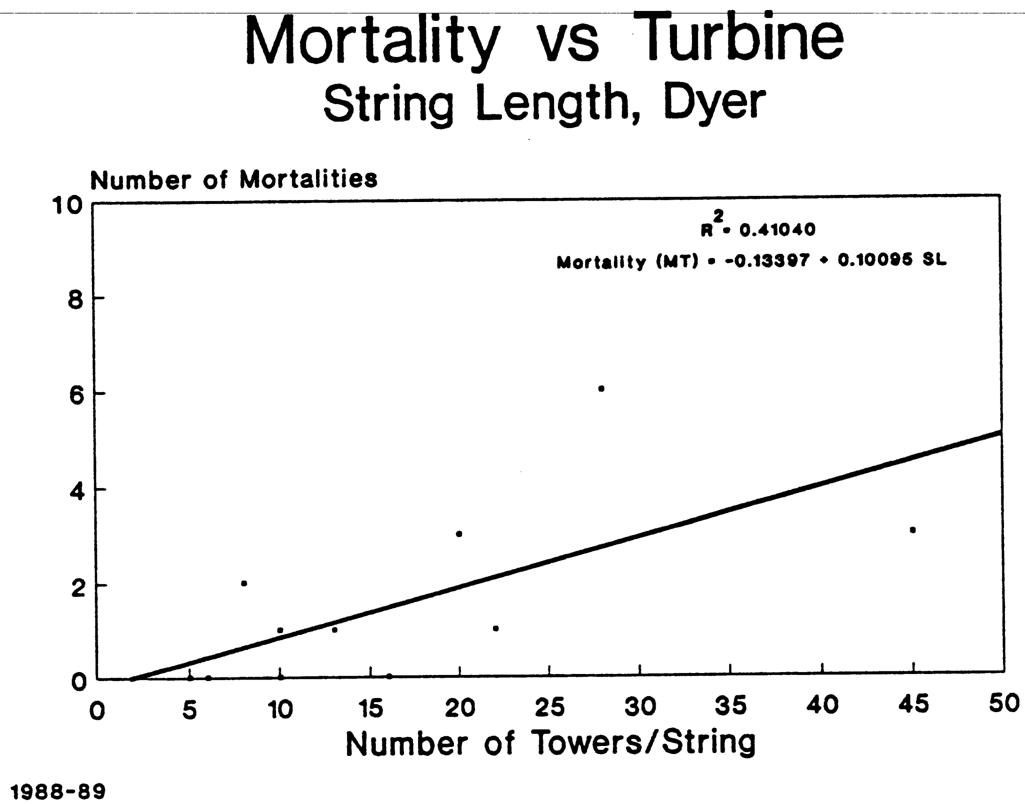

Figure 12. Mortality versus Turbine String Length, Dyer, Altamont Pass, CA.

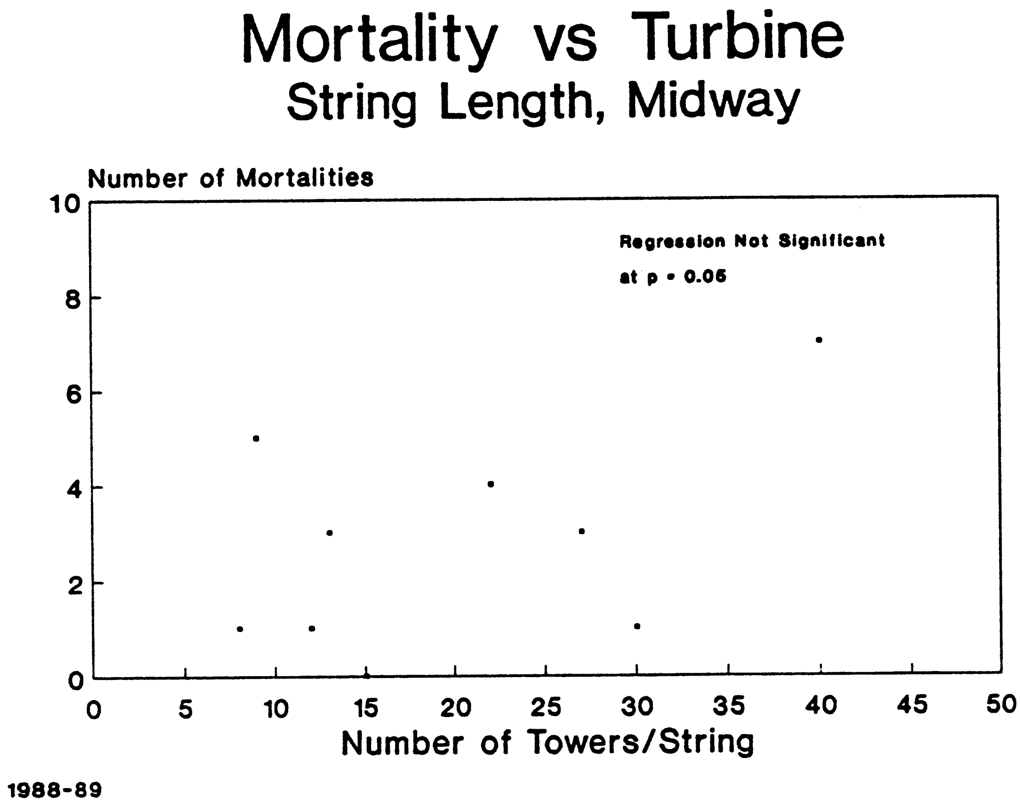

Figure 13. Mortality versus Turbine String Length, Midway, Altamont Pass, CA.

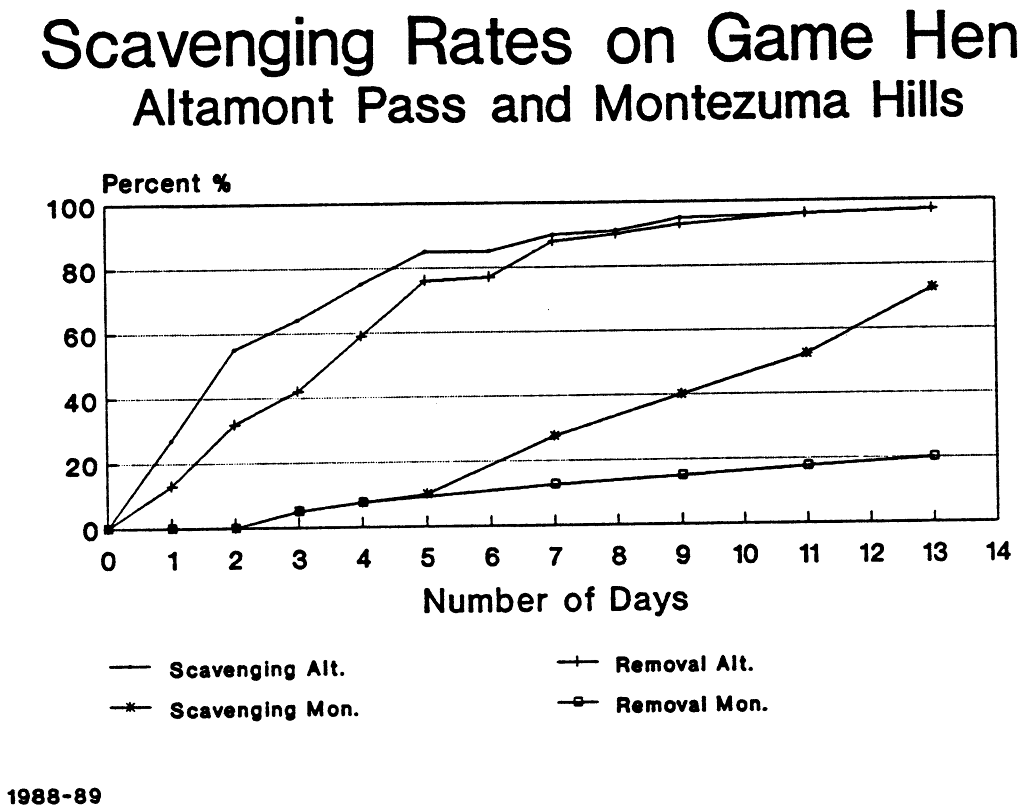

Figure 14. Scavenging Rates of Game Hen Carcasses, Altamont Pass and Montezuma Hills, CA.

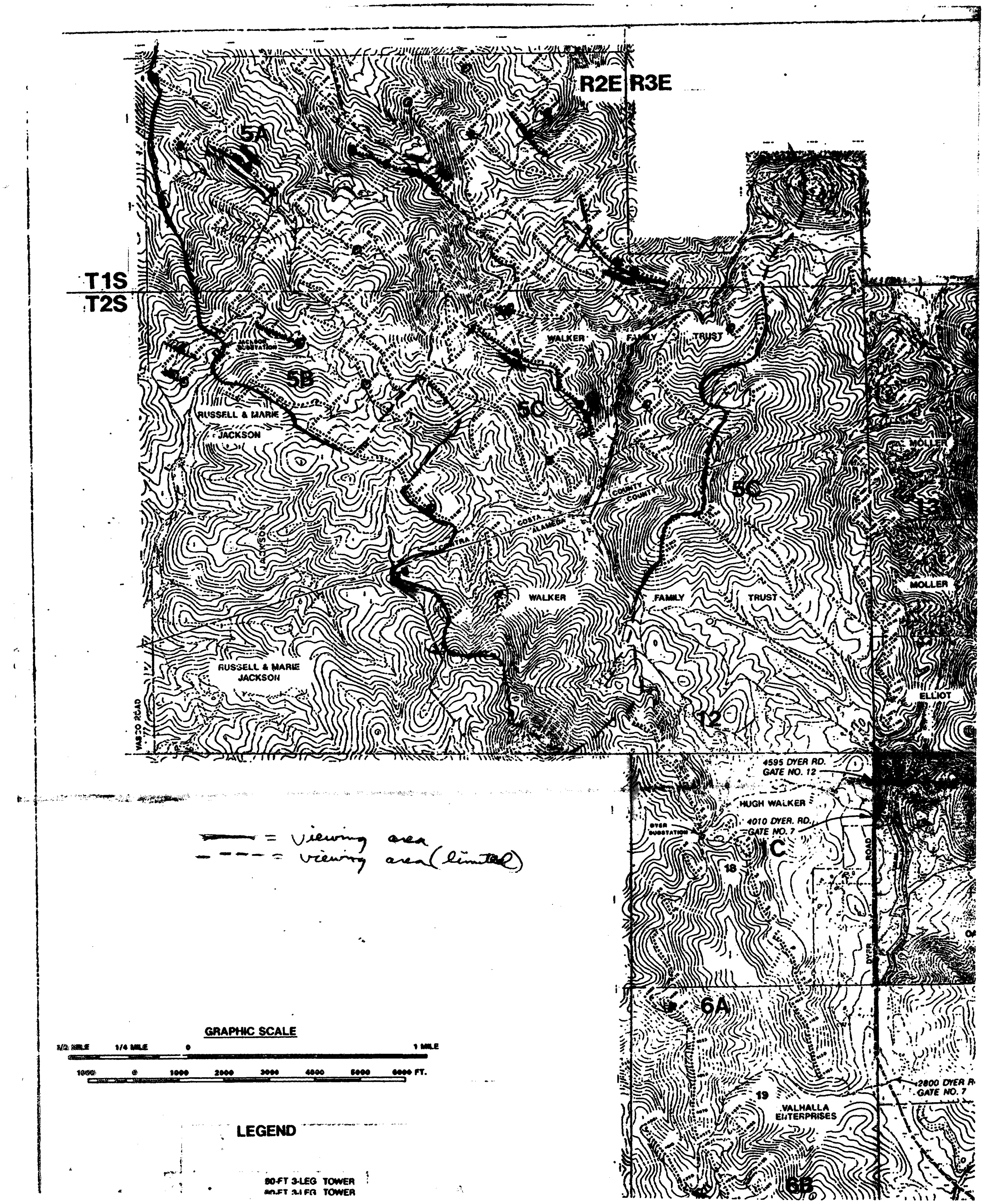

Figure 15. Distribution of Avian Collisions at Dyer Study Site Altamont Pass, Contra Costa County, California. (Red circles represent one mortality, hash marks represent multiple mortalities at that location)

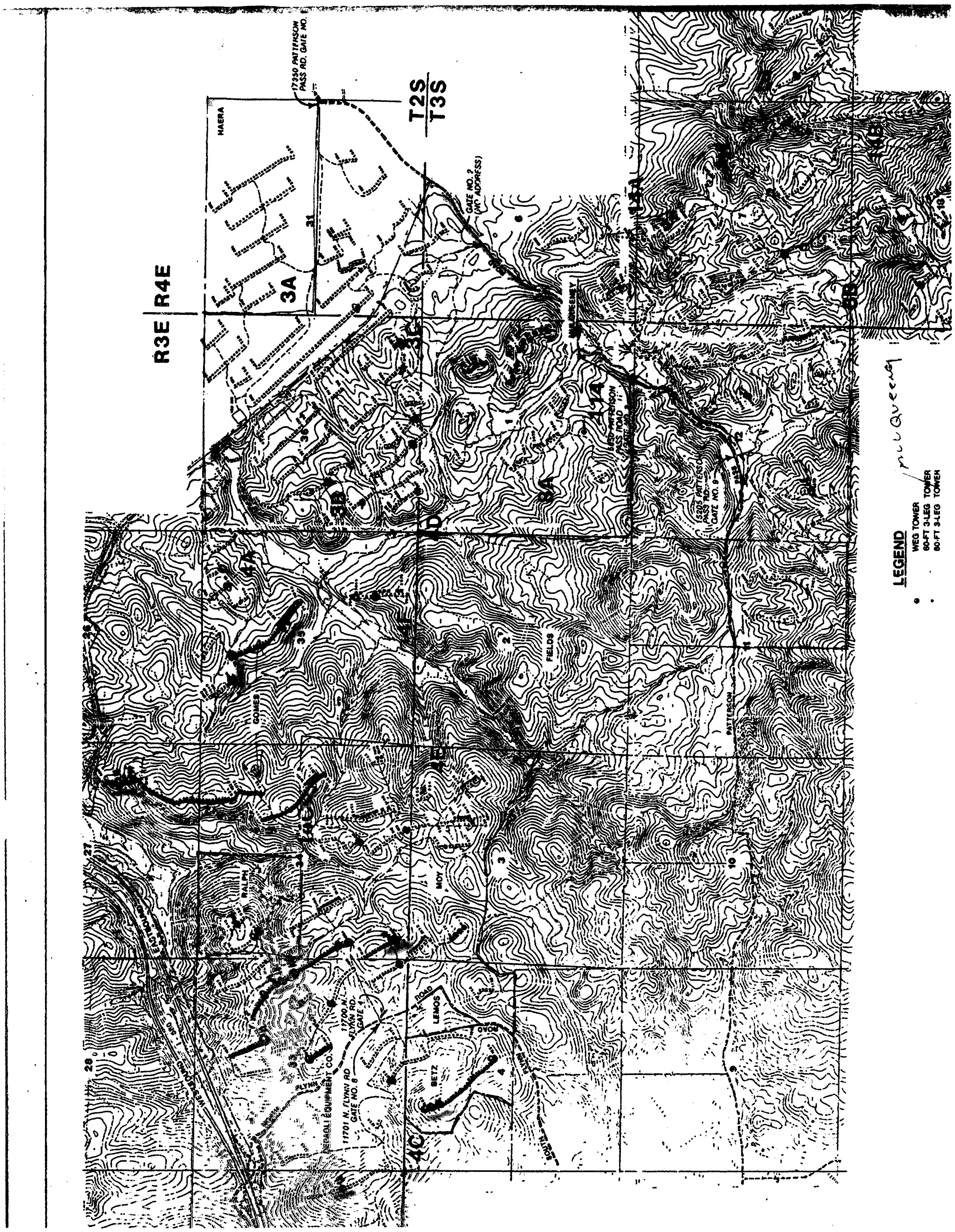

Figure 16. Distribution of Avian Collisions at Midway Study Site Altamont Pass, Alameda County, California. (Red circles represent one mortality, hash marks represent multiple mortalities at that location)