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Ferruginous Hawks on the Yakima Training Center

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Summary

Habitat quality for ferruginous hawks (*Buteo regalis*) is largely determined by availability of nest sites and adequate prey base. A limitation of one of these will limit the number of hawks in an area. In general, ferruginous hawks are adaptable to various nesting substrates and will nest in proximity to other closely related sympatric species (e.g., red-tailed hawk, Swainson's hawk). This analysis focused on an assessment of prey base availability and habitat disturbance in the vicinity of historic nest sites and small mammal trap sites on the Yakima Training Center (YTC) in Washington State.

The primary ground-disturbing activities on the YTC are associated with military training, fire, and grazing. In addition to the direct effect these activities can have on ferruginous hawks, indirect effects may result from changes in composition, density, and structure of vegetation that subsequently alter faunal population numbers and species diversity.

The primary small mammal species trapped during June through August 1993 were deer mouse (*Peromyscus maniculatus*), Great Basin pocket mouse (*Perognathus parvus*), and least chipmunk (*Eutamias minimum*). Deer mice and Great Basin pocket mice were nocturnally active, with the majority of individuals trapped between approximately 2000 and 0600 hours. Population estimates of small mammal abundance revealed a majority of small-sized, small mammals (e.g., deer mice, Great Basin pocket mice, sagebrush vole) at the trap sites.

Based on enumeration of frequency of disturbance at each of the seven trap sites, the North Bivouac and Hanson Creek sites on YTC were characterized as least disturbed, whereas the Beller site was the most disturbed. The most frequently occurring type of disturbance at the North Bivouac and Hanson Creek sites was cattle grazing, which, it should be noted, has been curtailed at the North Bivouac site since 1991. The most frequently evidenced type of disturbance at the Beller site was use of wheel and track vehicles and disturbed vegetation (e.g., broken sagebrush). Although the use of track vehicles was noted at a similar frequency at another site (the Silica site), examination of training data indicates that use of track vehicles was 50% more frequent at the Beller site than at the Silica site. This result is of significance when examining the number of small mammals, the diversity of small mammals, and the percent canopy cover of shrubs at these sites. A summary of results for each site is presented in Table S.1.

Examination of ferruginous hawk castings to determine prey selection revealed an increased frequency of occurrence of sagebrush voles (*Lagurus curtatus*), deer mice, and other Cricetids in the diet of a single nesting pair of ferruginous hawks. Because Leporids were not identifiable to species, diet analysis may not reflect true use of this group of mammals by ferruginous hawks. Comparison of small mammal, rabbit, bird, and reptile remains indicates a greater frequency of occurrence of small mammals (51%) and rabbits (31%) in ferruginous hawk castings.

Table S.1. Summary of Results of Small Mammal Trapping, Population Estimation, Vegetative Analysis, and Disturbance Rating at Seven Trap Sites, Yakima Training Center, June through August 1993

	North Bivouac	Training Area 8B	Silica Site	Range 55	Training Area 9B	Hanson Creek	Beller
Northing/ easting coordinates	519189 709586	5167337 720249	5186358 705532	5170437 716406	5171130 705472	5186511 720829	5175799 700612
Species diversity of small mammals(a)	High	High	High	High	Low	Low	Low
Number of small mammals trapped(b)	High	High	Low	Moderate	Low	Low	Low
Population estimates of small mammals(c)	High	High	Moderate	Moderate	Low	Low	Moderate
Predominant size of mammals	Small-Med	Small-Med	Small	Small	Small-Med	Small	Small-Med
Percent of bare ground	25.9	50.4	42.3	57.1	44.5	62.9	48.9
Shrub stem density(d)	High	Low	High	Low	Low	Moderate	High
Species diversity of shrubs(e)	High	Low	Low	Low	Low	Moderate	Moderate
Percent canopy of shrubs(f)	High	High	High	Low	Low	High	Moderate
Primary disturbance	Cattle	Vehicles	Vehicles	Fire	Fire	Cattle	Vehicles
Bunchgrasses(g)	Moderate	Low	Low	High	Moderate	Moderate	Moderate
Graze units	E	--	E	--	--	D	F
Training areas pre-Oct 92	3B	8B	3A	8B	9B	5	1A

(a) Range in number of species captured = 2 to 6 (refer to Table 3.6).
(b) Range in number of small mammals trapped = 145 to 677 (refer to Table 3.5).
(c) Range of total estimated populations = 30.1 to 141.0 (refer to Table 3.5).
(d) Range of stem densities/ 400 m^2 = 3 to 499 (refer to Table 3.10).
(e) Range in number of species recorded at each trap site = 1 to 4 (refer to Table 3.9).
(f) Range in percent canopy cover of shrubs = 0.6 to 22.8 (refer to Table 3.9).
(g) Range in percent canopy cover of bunchgrasses = 19.2 to 62.1 (refer to Table 3.8).

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Several Army and civilian personnel assisted in various aspects of the assessment. The Yakima Training Center (YTC) Range Control officers, Mr. J. H. Hoffman and Mr. J. Reddick, provided logistical support required to work effectively on the YTC. Margaret Taaffe-Pounds, Wildlife Biologist at YTC, contributed to planning and logistical support for this assessment.

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1.0 Introduction

Ferruginous hawks (*Buteo regalis*) are a declining raptor species, and are listed as a "threatened" species in the state of Washington with candidate status for federal listing. Factors which have limited ferruginous hawk population status in the recent past include hawk prey base as a result of habitat degradation from fire, grazing, and cultivation; disturbance associated with human activity; and loss or reduction of nesting habitat. Ferruginous hawks are, generally, intolerant of human activity early in the nesting season (i.e., March-August) and will abandon a nest site or young given a certain level of disturbance.

Egg-laying is initiated between mid-March to mid-April, based on latitudinal location with hatching/rearing in July through August. Ferruginous hawk hatching/rearing success is dependent on abundance and distribution of prey species and ultimately on prey species habitat. Ferruginous hawks are reliant on mammals, primarily on rabbits, jackrabbits, ground squirrels, prairie dogs, and pocket gophers, in varying portions of their range and will switch prey readily based on population densities of prey species. Because of the species' ability to exploit various prey populations, individuals will abandon territories in search of adequate prey base and in response to declines in prey base.

Raptors, as indicators of environmental quality, respond to changes in ecosystem condition by adjusting population distribution or individual productivity. In areas where human disturbance degrades their habitat and reduces their prey population, a species such as the ferruginous hawk may indicate general environmental decline. Howard and Wolfe (1976) concluded that ferruginous hawks consistently fledged more young than other large raptors in favorable areas, but were completely absent from unfavorable habitats. They further speculated that ferruginous hawks dominated their study area because of the presence of highly suitable habitat, which allowed birds to maximize expression of their productivity (Howard and Wolfe 1976).

In an effort to determine the suitability of establishing artificial nest structures for ferruginous hawks on the Yakima Training Center (YTC) in Washington State, researchers from the Pacific Northwest Laboratory,[a] in a project sponsored by the U.S. Department of the Army, assessed the hawks' prey base and characteristics of their prey species habitat (e.g., vegetative composition). Four approaches were used to examine the YTC habitat suitability for ferruginous hawks:

- Five YTC nest sites known to have sustained ferruginous hawks in the past were studied.
- Human disturbance in the vicinity of these nest sites was described.
- An index to abundance of prey species was compiled, vegetation described, and disturbance of prey habitat observed.
- The prey species selected by a pair of nested ferruginous hawks on YTC were determined.

These approaches were drawn from past research that has examined nest distribution (Howard and Wolfe 1976, Gilmer and Stewart 1983, Fitzner and Newell 1989, Schmutz 1987), human disturbance (Sutter and Jones 1981, White and Thurow 1985), food habits and prey species abundance

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE AC06-76RLO 1830.

(Howard and Wolfe 1976, Fitzner et al. 1977, Woffinden and Murphy 1977, Smith and Murphy 1978, Schmutz et al. 1980), and intraspecies interactions (Schmutz et al. 1980, Schmutz 1987, Steenhof et al. 1993).

An additional objective of the study was to provide a literature review of the ferruginous hawk, summarizing existing information on ferruginous hawks applicable to the YTC. Beginning with studies in 1992, this information could provide a basis for the environmental assessment for base realignment activities at Ft. Lewis and the YTC. In addition, the field work was intended to provide basic ecological information on ferruginous hawks on the YTC that can be used to develop management recommendations that minimize the impact of military activities on this species.

Nest distribution of ferruginous hawks may reflect land management activities that have affected habitat suitability. Energy development and other human activities (e.g., agriculture and grazing) have been associated with habitat alteration and disturbance and resultant diminished raptor populations (Sutter and Jones 1981). Clearing or conversion of native vegetation may reduce reproductive success by increasing disturbance, destroying nest sites, and reducing prey populations (Howard and Wolfe 1976). Although reduced prey species abundance is not always an apparent result of human intrusion, prey availability is a primary factor in determining nesting success for all raptors. Raptors may exhibit both numerical or functional responses to reduced prey densities (Phelan and Robertson 1977) by abandoning former nesting habitat or by exhibiting delayed density-dependent responses to reduction in prey base.

Declines in raptor populations have been correlated with declines in prey populations. Woffinden and Murphy (1977) reported a drastic decline in prey population numbers prior to a decline in the raptor population in central Utah. Further, Murphy (1975) observed that the golden eagle population in central Utah exhibited a decline in numbers of nested pairs when populations of its primary prey species (e.g., black-tailed jack rabbits) were reduced. In addition to nest productivity, correlations have been made between changes in prey species abundance and factors such as nest abandonment and mortality, clutch size, and number of nesting attempts (Woffinden and Murphy 1977, Thurow et al. 1980, Smith 1981 et al., Stalmaster 1988). Changes in prey species abundance and diversity, which can be attributed to physical habitat disturbance, should be investigated to establish a baseline with which future monitoring results can be compared.

On the YTC, the primary ground-disturbing activities are associated with military maneuvers, fire, and grazing. Changes in composition, density, and structure of vegetation as a result of these activities can affect changes in faunal populations and, subsequently, in populations of ferruginous hawks. For example, grazing can have a positive effect of opening up habitat to small mammal populations and enhancing raptor foraging opportunities. Alternately, overgrazing can have an effect of reducing plant species that serve as food and cover for small mammals or trampling ground to a point where small mammal nesting is reduced.

Developing a reliable method for assessing prey species habitat or population densities is a necessary prerequisite to raptor population management (Fyfe and Armbruster 1977). Faunal changes associated with varying land uses may be assessed by monthly or annual surveys at active and historic nest sites (Call 1978). This approach has been employed in the Canadian prairie region, where the influence of land-use practices on prey abundance has been used to anticipate effects on raptor density and productivity (Owens and Myers 1973, Hodson 1968). Differences in prey species composition and density contribute to assessment of relative site suitability for ferruginous hawks and other raptor species on the YTC.

Sections 2.0 and 3.0 are each organized according to the four objectives of the study. Section 2.0 discusses the research methods used; Section 3.0 covers results. A general discussion of findings concludes the report in Section 4.0.

2.0 Methods

In Washington, ferruginous hawks nest in the shrub-steppe region of the lower Columbia Basin (Fitzner et al. 1977). Historically, ferruginous hawks were common in localized areas, but were never abundant due to their limited distribution. Recent increases in nesting pairs of ferruginous hawks on the U.S. Department of Energy's Hanford Site, located approximately 50 km southeast of the YTC, is likely related to movement of adult birds from offsite areas. Locations of five ferruginous hawk nesting territories have been reported previously for the YTC (Table 2.1). In the recent past, two nest sites have been active: one nest that was occupied and deserted during 1992 and one nest that was occupied and productive during 1993. The nests were located within 0.5 km of each other and may have been the same pair nesting at the site during 1992 and 1993. The fate of the 1993 nesting attempt was reconstructed from remains of juvenile birds found at the nest proper. There may have been several reasons for failure of the nest, which may have involved abundance and diversity of the prey base on YTC.

The objectives of this analysis were 1) to describe the area surrounding five historic ferruginous hawk nest sites; 2) to describe human disturbance to habitat in the vicinity (i.e., within 1.5 km) of five historic ferruginous hawk nest sites; 3) to develop an index of relative abundance of prey species, describe vegetation, and describe disturbance at small mammal trap sites; and 4) to determine prey species selection of a pair of nested ferruginous hawks on the YTC.

Table 2.1. Historic Locations of Ferruginous Hawk Nests on the Yakima Training Center

Coordinates				
Northing	Easting	Location	Activity	Source
5188931	702719	Squaw Creek	87 Unoccupied 92 Unoccupied	WDFW[a]
5168600	727100	Post 20	87 2 young 88 Occupied 92 Unoccupied	WDFW
5174850	711700	Umtanum Ridge	87 Unoccupied 92 Unoccupied	WDFW
5175493	698221	Selah Creek	88 Unoccupied 92 Unoccupied	WDFW
5175264	697828	Selah Creek	88 Unoccupied 92 Unoccupied	WDFW
5166868	712896	Range 11	92 Occupied	PNL
5166777	713724	Range 11	93 Occupied	PNL

(a) Washington Department of Fish and Wildlife (WDFW), Natural Diversity Database, Yakima, Washington.

2.1 Area Surrounding Five Historic Ferruginous Hawk Nest Sites

The locations of historic nest sites presented in Table 2.1 were surveyed to verify nest locations and determine nest activity during 1993. An ambiguity regarding the exact location of the Umtanum Ridge nest site prohibited further analysis at that site. The Selah Creek nest locations were verified and one site was surveyed for our analysis. Two additional nest sites, one identified as active during 1992 and one identified as active during 1993, were surveyed. Drainages within a 1.5-km radius of the five historic nest sites were systematically searched on foot for the presence of ferruginous hawk nests. A 1.5-km buffer was established, based on Stalmaster's (1988) assumption that alternate nests within 1.0 km of an active nest were in the same territory and that alternate nests outside 1.0 km represented a separate nesting territory. The 1.5-km buffer was surveyed to determine the presence of additional nests within a "territory" and to identify other nests proximal to the active or historic territory.

The area immediately surrounding the nest site (50-m radius), i.e., the nest proper, was characterized by describing the nest structure, elevation, slope, aspect, distance to valley floor, distance to top of canyon, cliff aspect, distance to water, and distance to disturbance. A 50-m radius was chosen as the nest proper to facilitate comparison of vegetation/disturbance data between nest sites and trap sites. Vegetation near the nest proper was characterized by establishing two 100-m line transects that emanated from the center of the nest site. Vegetation species that occurred along each transect were recorded to develop a relative estimate of percent canopy cover for each species. At 10-m intervals along each transect, percent canopy cover of each species was recorded using a 20- x 50-cm modified Daubenmire sampling quadrat. Height, diameter, and species were recorded for all shrubs within three 10- x 10-m quadrats located at equal intervals along the 100-m transects (total n = 4). In addition, the total number of shrub species within these quadrats was tallied to determine shrub density. Lastly, a circular area of approximately 200-m diameter was surveyed around the nest proper to compile an overall species list for the site.

2.2 Human Disturbance in the Vicinity of Historic Ferruginous Hawk Nest Sites

Occurrence of roads, training areas, ranges, grazing allotments, and burned areas within 1.5-km radius of the nest site were recorded. For purposes of assessing impact to ferruginous hawks during the breeding season, the period of April through August was chosen for review of historic grazing and training data. Training activity data for 1988 to 1992 were examined for each of the training areas that occurred within a 1.5-km radius of the nest proper. Vehicle type, number of individuals, and number or vehicles were summarized for the historic nest sites included within our analysis. Training activity was summarized for April through August. In addition, grazing intensity was examined for each Grazing Unit for a period between 1988 and 1992.

2.3 Index of Abundance of Prey Species and Description of Vegetation and Disturbance Within Small Mammal Trap Sites

Prey species occurrence was determined from seven randomly located trapping grids established across the YTC. Location of trap sites is presented in Table 2.2. Live traps were arranged along a 125- x 25-m grid to determine prey species occurrence. The trapping grid was located at site center and became the point at which vegetation transects, disturbance transects, and prey density

Table 2.2. Coordinates of Trap Sites on Yakima Training Center

Trap Site Name	Coordinates Northing	Easting
Beller Drop Zone	5175799	700612
Silica Site	5186358	705532
Training Area 9-B	5171130	705472
North Bivouac	5191894	709586
Hanson Creek	5186511	720829
Training Area 8-B	5167337	720249
Range 55	5170437	716406

transects emanated. Live traps were baited with rolled oats, peanut butter, and carrots. During June, July, and August of 1993, traps were checked twice daily between 0600 and 0900 and between 1700 and 2000 hours. Live trapping was conducted to determine prey species occurrence.

Burrow holes were counted to provide an index to the population density of various sizes of small mammals. The number and size of holes were recorded along an 800-m transect oriented on the site center. Two observers spaced 10 m on either side of the transect recorded the number of small, medium, and large mammal holes and the distance from the center line, effectively sampling an 800- x 20-m (1.5-ha) area.

Burrow holes were classified as small (0-3 cm), medium (3-6 cm), and large (>6 cm) for purposes of developing an index of abundance. A census was used because the small mammal trapping was not designed to sample population numbers and in the absence of the animals this physical feature (i.e., holes) was more accessible and easier to count (Davis 1982). From the census of small mammal holes, an index of abundance on a per unit area basis for each trap site was calculated. This index is based on an assumed use of three holes per individual. The assumption that three holes represented an individual animal was used to generate an index to population density so that the number of animals per unit area was not overestimated. The resulting population densities assume that individuals of each size category of mammals excavate an average of three holes. This assumption has not been validated for the YTC and applies to this study only. The index was used to calculate density using Kelker's method (Cox 1969) and assumed that all objects (e.g., holes) were recorded within the strip of 20-m width:

$$D = \frac{k}{2LA} \tag{2.1}$$

where D = density of the population per unit area
A = width
L = length of the transect
k = total sample size.

Vegetation was sampled as described in Section 2.1, with two 100-m vegetation transects oriented perpendicular to one another at site center. Disturbance was recorded along the same 100-m vegetation transects within five 10- x 10-m quadrats located at equal intervals along each transect (n = 10). Disturbance was classified as evidence of track vehicles, wheel vehicles, human debris (e.g., paper, plastic), disturbed vegetation (e.g., broken sagebrush), cheatgrass/knapweed, grazing (e.g., presence of manure), restored vegetation (i.e., colonizing vegetation), fire, and ordnance.

2.4 Prey Species Selection of a Pair of Nested Ferruginous Hawks

One active ferruginous hawk nest was identified on the YTC during May 1993. Visits to the site were minimized to avoid disturbance to nested birds. During August 1993, the nest site was visited to gather pellets and prey remains to determine prey species selection of this nested pair. Prey species and their frequency of occurrence were derived from dissecting raptor castings collected at and around the nest site. The nest site was inspected for castings, as were potential perches (e.g., rocks in the outcropping sequence and fence posts) within 1 km of the test site. A majority of the pellets was collected near the nest site at four perches and at a fence post 210° southwest of the nest site. The latter location was corroborated by a ferruginous hawk feather collected there. Castings were autoclaved to kill microorganisms and dissected in the laboratory. Skulls, bones, bird feathers, and insect exoskeletons were extracted from the pellets. Small mammals, excluding rabbits, were identified by examining skulls and dentition. Estimates of the number of individual animals were based on the proximity of skull parts to other same-species parts (i.e., an upper whole jaw and a lower whole jaw found in one pellet likely represents an individual, whereas two lower-right jaw bones and a lower-left jaw bone may represent two and possibly three individuals). Because of bone size and fragmentation, it was difficult to isolate intact rabbit skulls in the castings; consequently, a total number of rabbits is not included within results of the dietary analysis.

3.0 Results

Results reported here include the characterization of nest sites and the surrounding areas, human disturbance near nest sites, and the abundance of prey species, vegetation, and disturbance in the areas of trap sites.

3.1 Nest Sites and Surrounding Areas

A comprehensive survey of nests was not complete for the entire installation. Nest searches were conducted within a 1.5-km radius of known historic sites during 1993. Information on historic nest locations including activity was derived from Washington Department of Fish and Wildlife (WDFW) and PNL site records. During 1993, PNL and WDFW staff visited each historic nest site to determine activity. On May 8, 1993, one active nest was located at 713724 E/5166777 N. Subsequent visits to the site were minimized to avoid disturbance to nested ferruginous hawks. Nest searches continued at historic sites (Figure 3.1) between May and August 1993. No additional nests were located.

Elevation at the nest sites ranged between 618 and 945 m. The distance from the nest to the top of the canyon and to the valley floor varied for each site between 2 and 228 m and 10 and 131 m, respectively. With the exception of the one active ferruginous hawk nest, each historic nest site was oriented on a south- to south-east facing aspect. The one active nest was oriented on a west-facing aspect. Slope varied between 30° and 75° ($x = 56$ degrees; $n = 5$). In all cases, the nest bowl was constructed on a rock outcrop that was accessible from above. In most instances, perches in the vicinity of the nest site were not observed. This may be attributed to the age of the nests and general state of deterioration of the nest structures. Three of the historic sites were located within 10 to 100 m of seasonal water (at 10, 82, and 100 m).

Land use in the vicinity of the historic sites included grazing and military training activity. Human use of the area was generally light to moderate, with training or use of training facilities constituting the primary disturbance potential. Although all of the sites were located within 0.75 mile of tertiary roads, these roads receive light to moderate use. Larger, more heavily trafficked roads (e.g., I-82) were located between 0.50 and 1.5 km from the historic nest sites, usually out of the field of view from the site.

Vegetation that occurred consistently within a 200-m radius of the historic sites included balsamroot (e.g., *Balsamorhiza careyana* and *B. hookeri*), tumble mustard (*Sisymbrium altissimum*), cheatgrass (*Bromus tectorum*), bluebunch wheatgrass (*Agropyron spicatum*), Great Basin giant wildrye (*Elymus* spp.), Sandberg's bluegrass (*Poa sandbergii*), big sagebrush (*Artemisia tridentata*), and three-tip sagebrush (*A. tripartita*).

Percent canopy cover of vegetation within the nest proper was recorded along two 100-m transects and calculated according to Daubenmire (1959). The area within the nest proper was largely unvegetated (Table 3.1). Vegetation that occurred consistently within the nest proper included bluebunch wheatgrass, Sandberg's bluegrass, and cheatgrass although no one species dominated the vegetative component of the sites.

The dominant shrub species occurring within the nest proper was big sagebrush. Total number of shrubs occurring within the nest proper ranged between 0 and 3,050 per ha. Shrub diameter

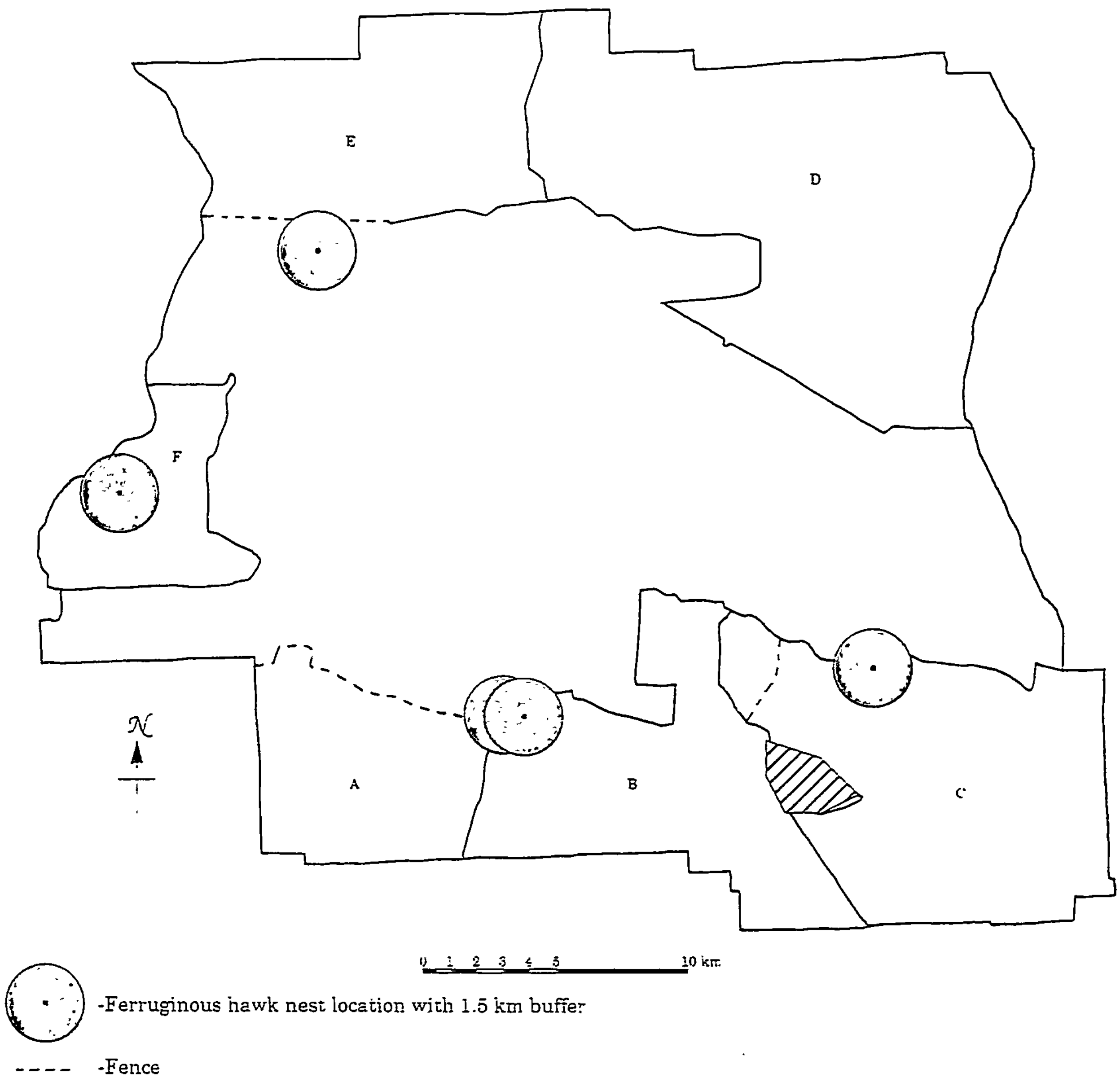


Figure 3.1. Historic Ferruginous Hawk Nest Sites Surveyed During 1993 on the Yakima Training Center

ranged between 34 and 180 cm (Table 3.2). The majority (97%) of shrubs (n = 215) in the 0.2-ha sample area ranged between 34 and 62 cm in diameter. Shrub height ranged between 24 and 98 cm (Table 3.2), with the majority (90%) ranging between 24 and 40 cm (n = 199).

3.2 Human Disturbance Near Nest Sites

Severity of disturbance to ferruginous hawks varies relative to the line of sight of the activity to the birds, security of the nest site, and amount of past disturbance (Snow 1974, Stalmaster 1985).

Table 3.1. Percent Canopy Cover of Frequently Occurring Vegetation Species and Bare Ground of the Nest Proper at Historic Ferruginous Hawk Nest Sites on the Yakima Training Center, June through August 1993

Species	Nest Site, Canopy Cover, % 1	2	3	4	5
Agropyron spicatum	20.9	2.6	6.9	19.1	19.4
Poa sandbergii	10.5	3.5	4.9	4.9	11.4
Bromus tectorum	6.6	11.6	5.5	23.6	0.9
Achillea millefolium	0.1	0.9	0.1	0.9	0.3
Descurainia sophia	0.5	1.9	0.3	1.0	--
Epilobium spp.	0.5	1.1	--	3.8	1.1
Lomatium spp.	8.0	--	2.0	--	1.5
Balsamorhiza careyana	1.5	--	0.8	--	0.1
Sisymbrium altissimum	0.3	1.8	6.1	--	--
Bare ground	43.6	58.6	26.3	46.8	29.4

Table 3.2. Mean Diameter and Height of Shrubs Within the Nest Proper (50-m Radius) at Historic Ferruginous Hawk Nest Sites on the Yakima Training Center, 1993

		Nest Site, cm 1			2			3			4			5		
Species		Diam	Hght	n	Diam	Hght	n	Diam	Hght	n	Diam	Hght	n	Diam	Hght	n
Artemisia	x̄	110	50	1	37	30	111	57	69	15				180	98	3
tridentata	s				24	18		22	25					9	28	
Artemisia	x̄				34	25	5									
ludoviciana	s				7	6										
Purshia	x̄				130	88	2									
tridentata	s				14	11										
Chrysothamnus	x̄				50	40	1									
nauseosus	s															
Chrysothamnus	x̄				50	32	3									
viscidiflorus	s				13	10										
Artemisia	x̄							60	38	42				39	24	17
tripartita	s							30	15					20	9	
Salvia dorrii	x̄													63	26	20
	s													27	11	
Ribes spp.	x̄													35	65	1

x̄ - mean
s - standard error
n - sample size

Disturbance in the vicinity of historic nest sites was described with reference to land use, human use, and roads. The predominant land use and associated disturbance in the vicinity of historic nest sites can be attributed to grazing and military training activities. Because disturbance can be recorded and past disturbance can be corroborated from site conditions (i.e., tire tracks, knapweed, broken plants) or from site records (i.e., training data), we chose to examine disturbance in the vicinity of historic nest sites over the previous 5 years (e.g., 1988-1992). During 1993, human use of these sites was generally light to moderate (ranging from 1 to 3 based on Stalmaster's [1985] criteria for rating human activity), with training or use of training facilities constituting the primary disturbance potential. Stalmaster's (1985) ranking designates human activity intensity scores of 1 for jeep trails, incidental activities, pipelines, and unoccupied buildings; 2 for unimproved roads, powerlines, airstrips; and 3 for light-duty roads, drillholes, oil and gas wells, railroads, and sheep camps. The sites were located within 0.75 miles of tertiary roads; larger, more heavily trafficked roads (e.g., I-82) were located between 0.50 and 1.5 km from several nest sites, usually out of the field of view from the site.

Each of the five historic nest sites occurs within one of six grazing units on the YTC (Figure 3.2). Sites 1 and 5 are located within Grazing Unit B. In 1990, grazing activity within this unit was eliminated, and since then the unit has not been grazed (Figure 3.3). It should be noted that Site 5 was the location of the active ferruginous hawk nest during 1993. Site 2 is located near Grazing Unit E. Grazing activity in this unit has decreased steadily since 1990. During 1992, grazing intensity was greatest during May, accommodating 125 animal units months (AUMs) (see Table 3.3). Site 3 is located within Grazing Unit F. As in units A, C, and E, grazing intensity has decreased steadily since 1990 (see Figure 3.3). During 1992, no grazing activity was reported for Unit F during the period of ferruginous hawk nesting. Site 4 is located within Grazing Unit C, where grazing intensity decreased markedly between 1990 and 1991 and continued to decrease through 1992 (see Figure 3.3).

Each of the historic nest sites occurs in the vicinity of one or several training areas (Figure 3.4). Activity within these areas was summarized for the period of ferruginous hawk activity (e.g., April-August) between 1988 and 1992. Dispatch of military personnel and vehicles in these areas is reported as user days per month. Gaps in 1992 data may suggest lack of a complete data set for that year. Overall training activity has decreased across all training areas on the YTC with periods of peak use generally reported for June.

- Sites 1 and 5 are proximal to Training Areas 10B, 10C, 11A, and 11C. Training activity (e.g., use of wheel/track vehicles and personnel) in these areas has decreased since 1990 (Figure 3.5). Maximum numbers of track and wheel vehicles dispatched in these areas (2,104) was reported for June 1989 and maximum number of user days in these areas was reported for June 1990 (20,292) (see Table 3.4).

- Site 2 is proximal to Training Areas 2A, 3A, 2B, and 3B. Use of track and wheel vehicles generally decreased in this area after 1990, with the period of maximum use reported for June 1989, when 2,759 wheel and 1,228 track vehicle user days were reported for this area. The number of user days has also decreased since 1990, with a maximum number (28,663 user days) reported for June 1990 (see Table 3.4). Training Areas 2A, 2B, 3A, and 3B are more heavily trafficked by vehicles than are the other training areas. Similarly, these training areas report a greater number of user days compared to other training areas. Training Areas 10B, 10C, 11A, and 11C have also received heavy training activity although it appears from the record that the number of vehicles dispatched to these areas has generally been fewer than to Training Areas 2A, 2B, 3A, and 3B.

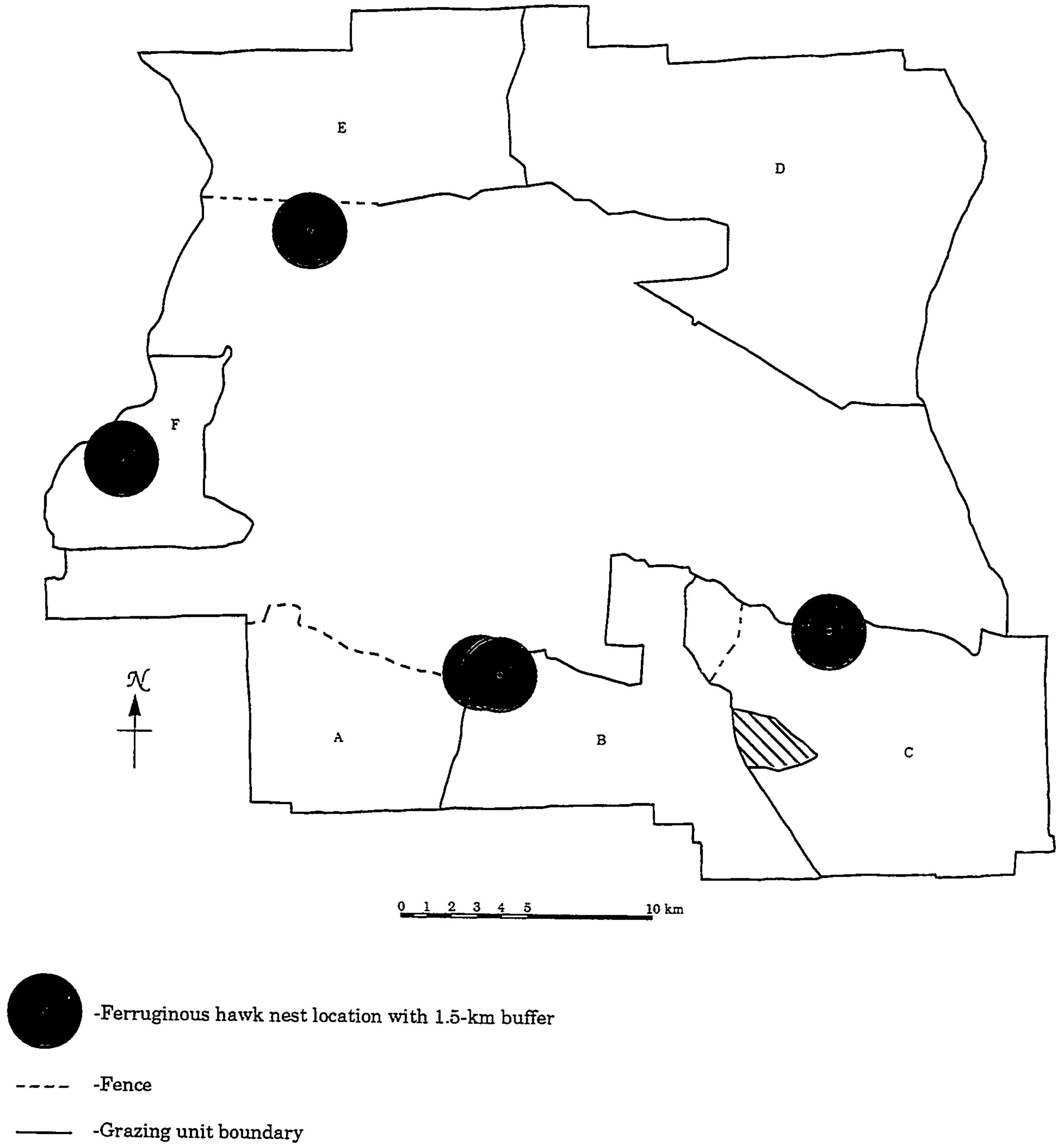
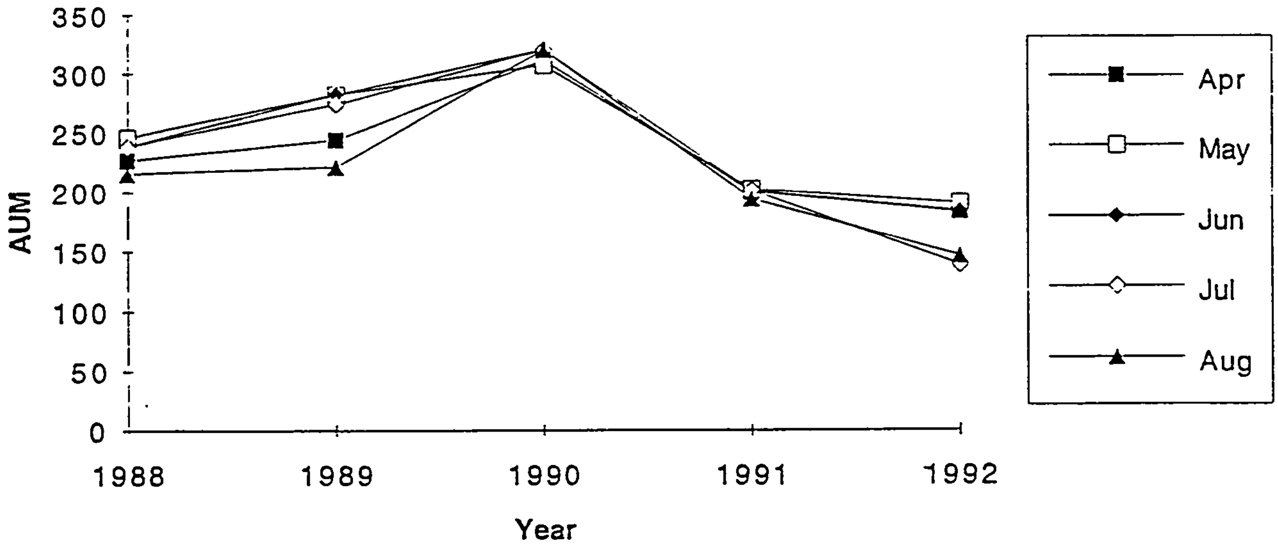


Figure 3.2. 1993 Yakima Training Center Grazing Unit Boundaries
(Blank area in interior is not grazed.)

Unit A 1988-1992



Unit B 1988-1992

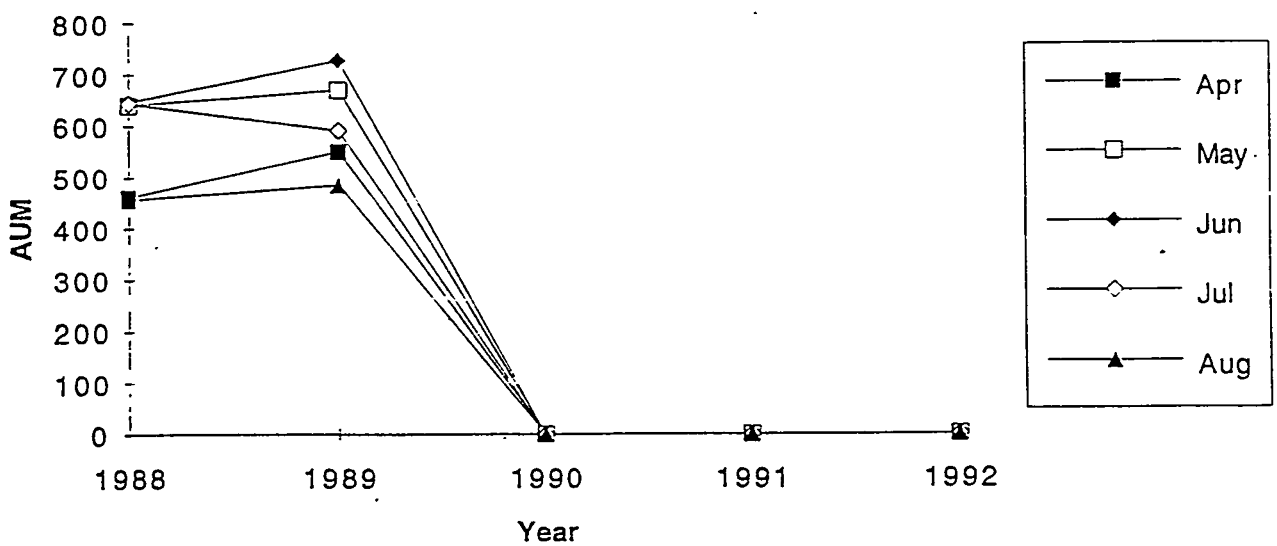
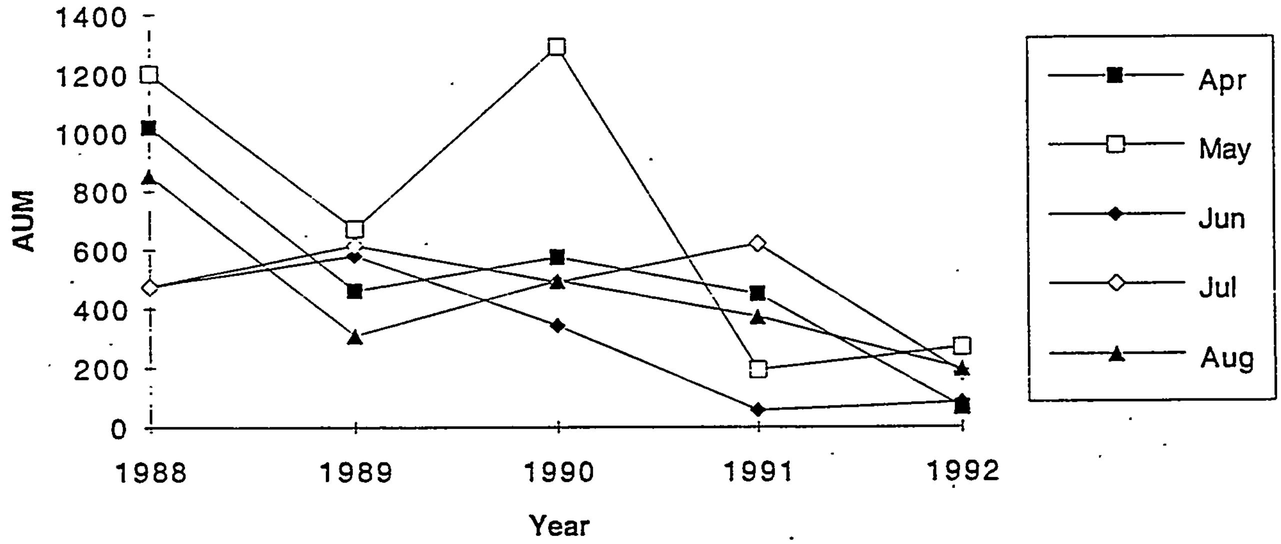


Figure 3.3. Grazing Unit Activity, Yakima Training Center, 1988-1992

Unit C 1988-1992



Unit D 1988-1992

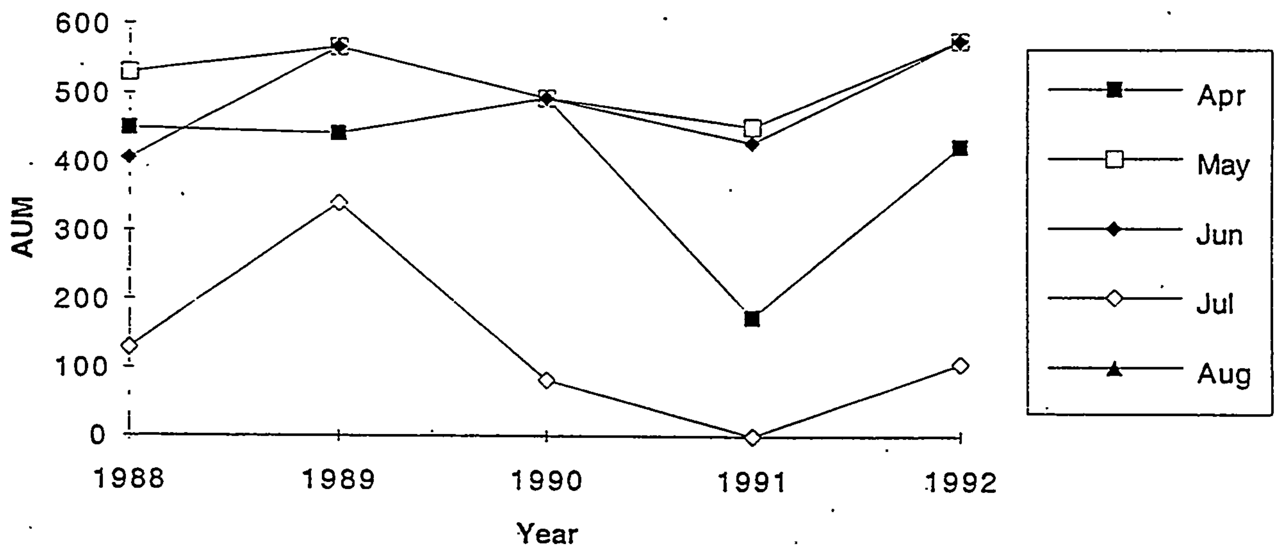
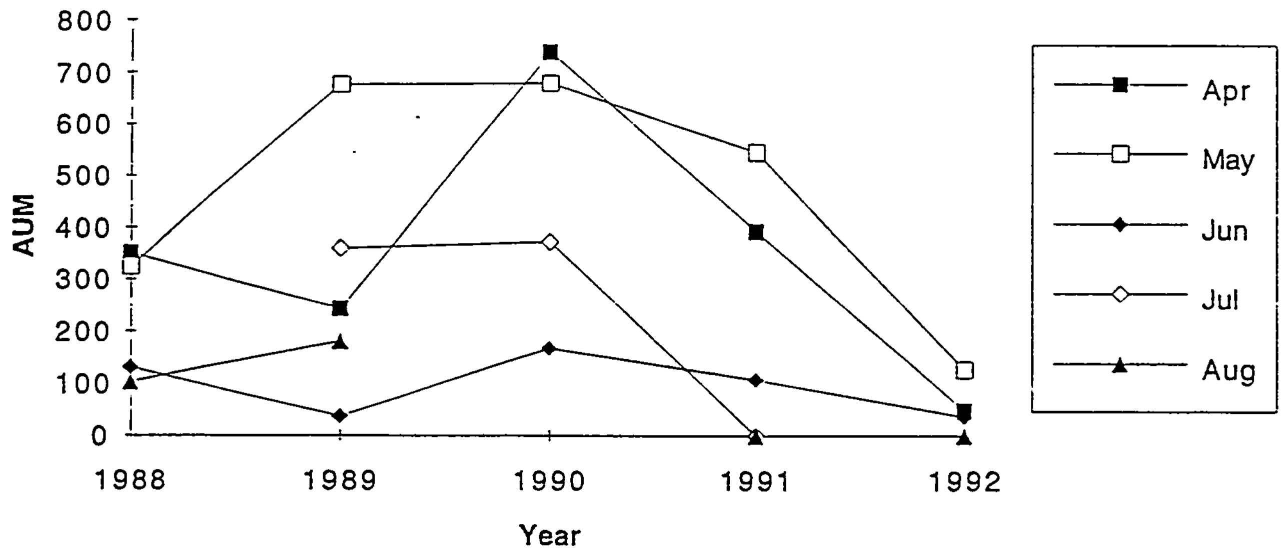


Figure 3.3. (contd)

Unit E 1988-1992



Unit F 1988-1992

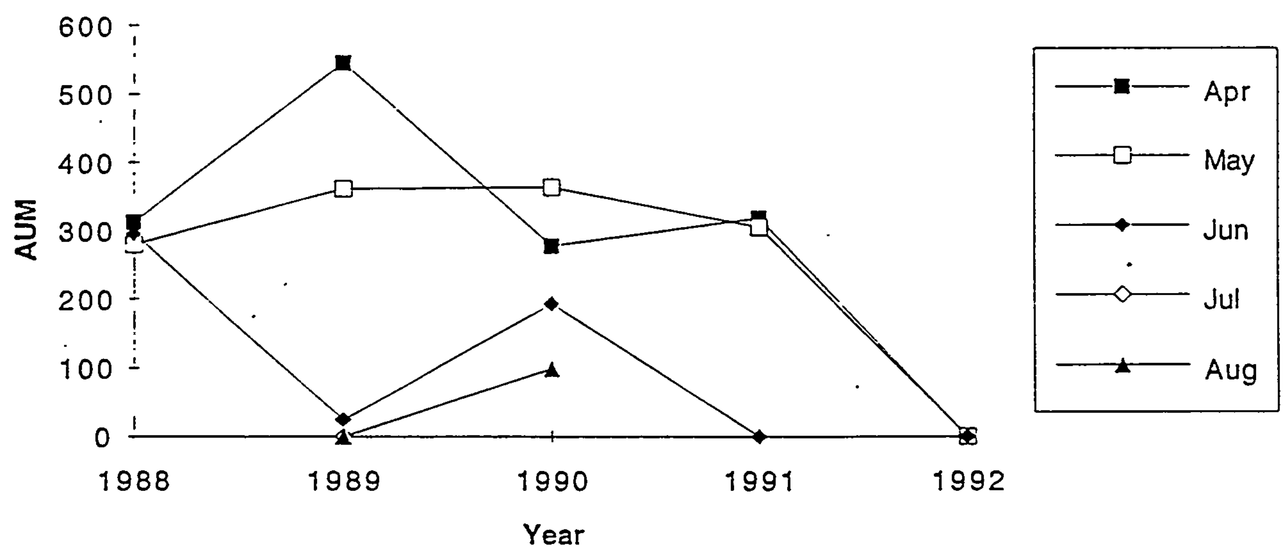


Figure 3.3. (contd)

Table 3.3. Grazing Activity on Grazed Units of Yakima Training Center, 1988-1992

Units and Months	Animal Units				
	1992	1991	1990	1989	1988
Unit A					
Mar					37
Apr	183	200	311	244	227
May	190	202	307	282	246
Jun	183	201	320	282	238
Jul	138	201	320	274	238
Aug	146	194	320	221	216
Sep	148	174	320	221	193
Oct	148	161	238	221	193
Nov	143	171	236	187	160
Dec	43	182	112	175	131
Unit F					
Mar					28
Apr		317	277	545	312
May		304	362	360	279
Jun			193	24	295
Jul					
Aug			99		
Sep					
Oct			379	74	
Nov			204	430	
Dec			204	375	617
Jan	610	204	278	746	730
Feb			56		
Unit B					
Mar					57
Apr				548	461
May				669	640
Jun				726	646
Jul				590	644
Aug				483	456
Sep				483	
Oct					
Nov					
Dec					

Table 3.3. (contd)

Units and Months	Animal Units				
	1992	1991	1990	1989	1988
Unit C					
Mar					155
Apr	66	450	576	462	1018
May	268	192	1294	671	1201
Jun	83	57	342	579	474
Jul	181	620	489	615	474
Aug	196	373	497	309	854
Sep	154	372	458	289	474
Oct	165			289	474
Nov	296				399
Dec	304				
Unit D					
Mar			135		57
Apr	423	174	493	442	450
May	575	452	493	567	530
Jun	575	428	493	567	406
Jul	105		82	340	129
Aug					
Sep					
Oct					
Nov					
Dec			364	538	467
Jan		176	738	394	
Feb			406		
Unit E					
Mar					23
Apr	47	393	739	244	351
May	125	545	679	677	325
Jun	36	106	167	38	131
Jul			372	360	
Aug				180	102
Sep					412
Oct		177			394
Nov		198	229	317	382
Dec		326	914	650	363
Jan	327	756	453	349	298
Feb					48
Total	5858	8306	14949	17037	17435

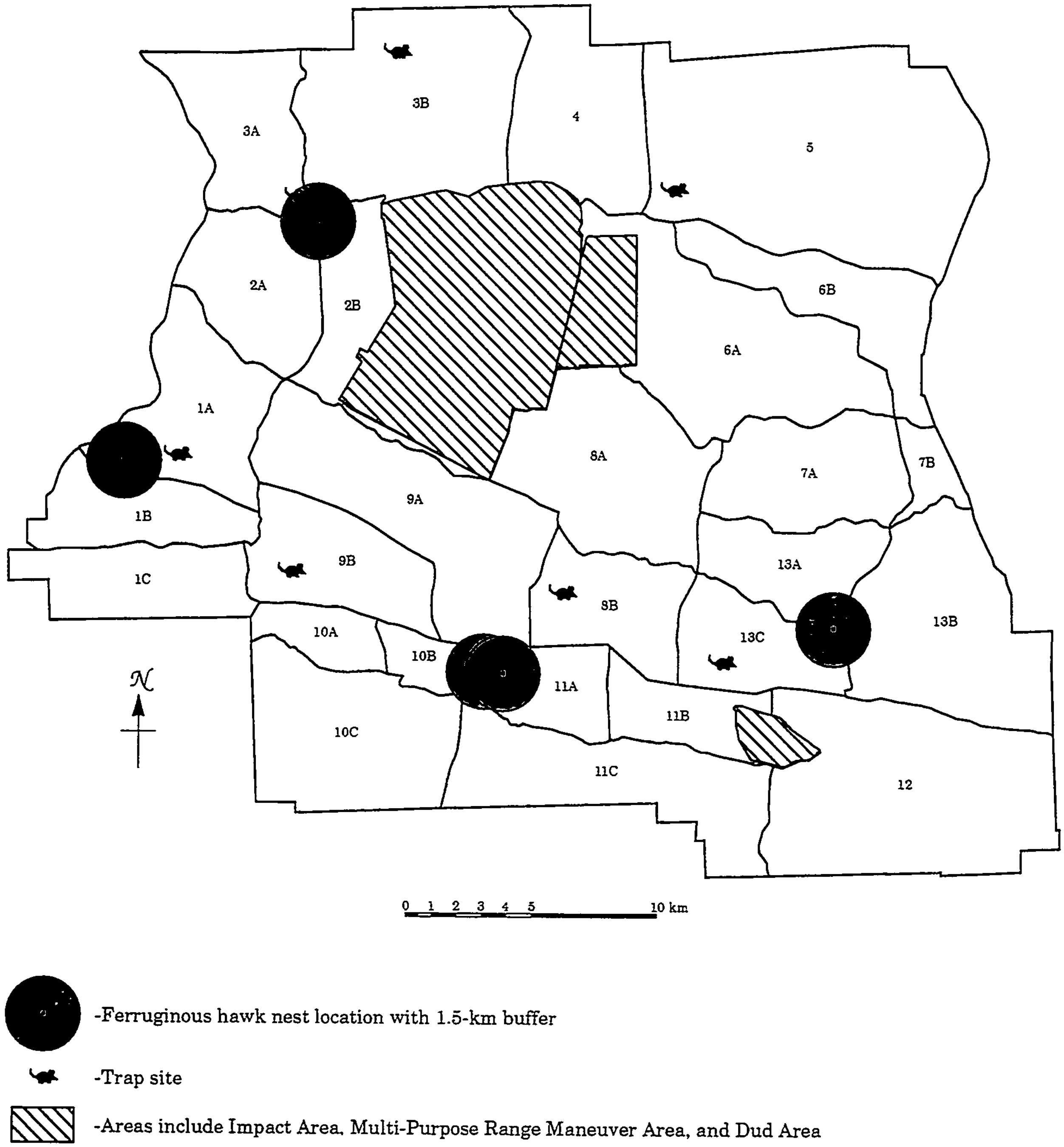
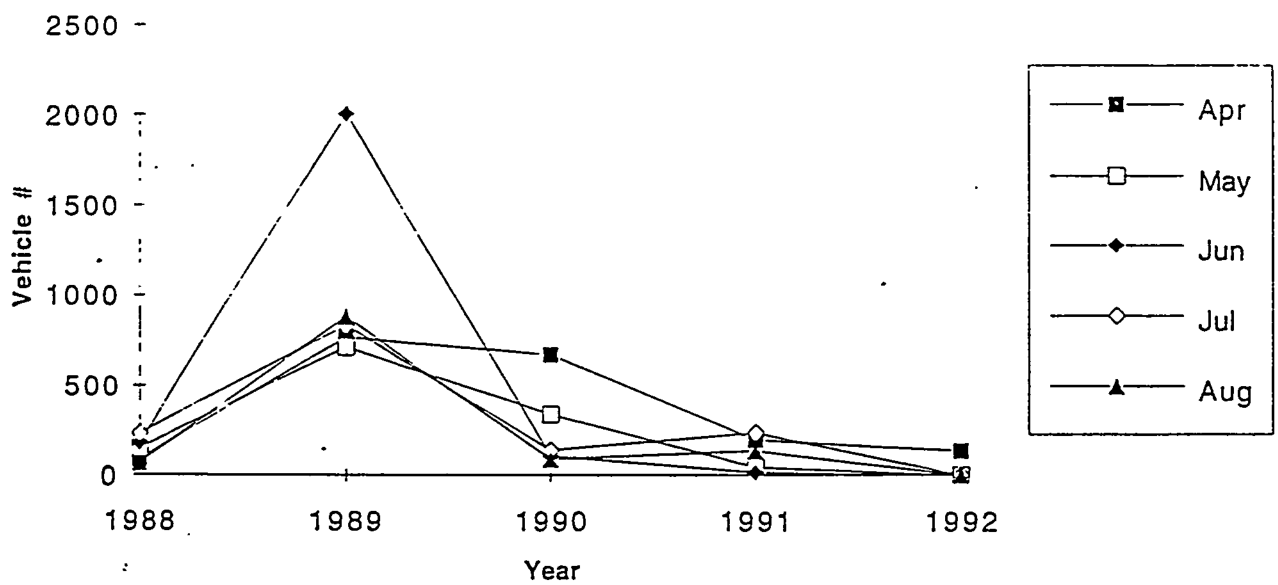


Figure 3.4. Nest Sites and Small Mammal Trap Sites in Relation to Training Areas, Surveyed in 1993

TA 1A/TA 11B

Wheel Vehicle



TA 1A/TA 11B

Track Vehicle

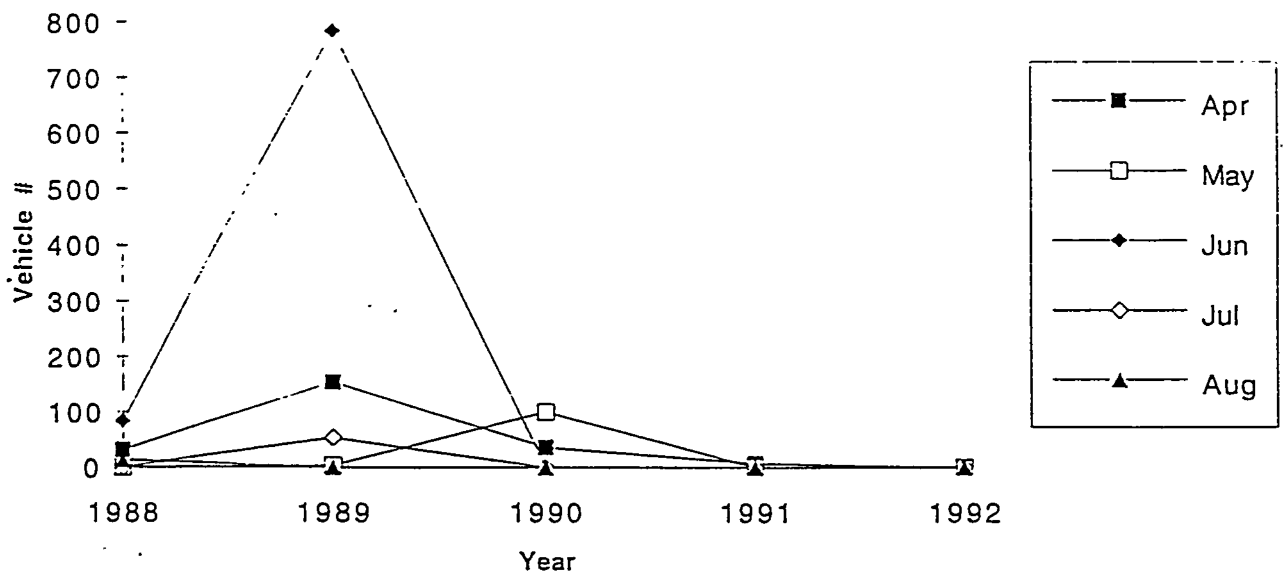
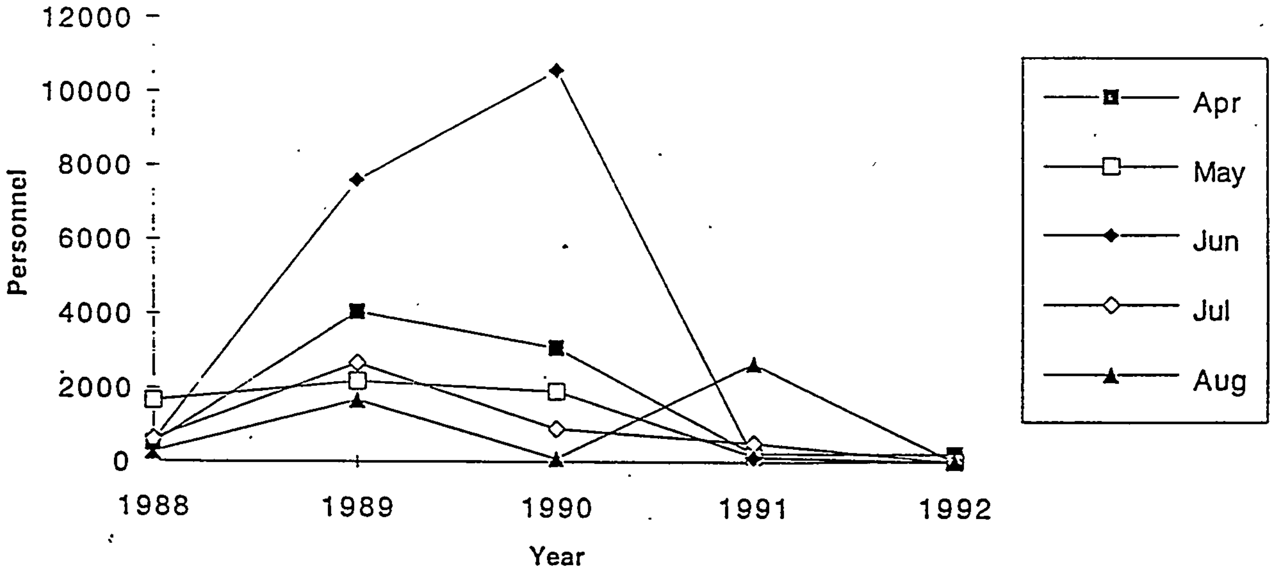


Figure 3.5. Training Activity in Training Areas, Yakima Training Center, 1988-1992

TA 1A/TA 11B

Personnel Dispatch



TA 2A/ TA 2B/ TA 3A/ TA 3B

Wheel Vehicle

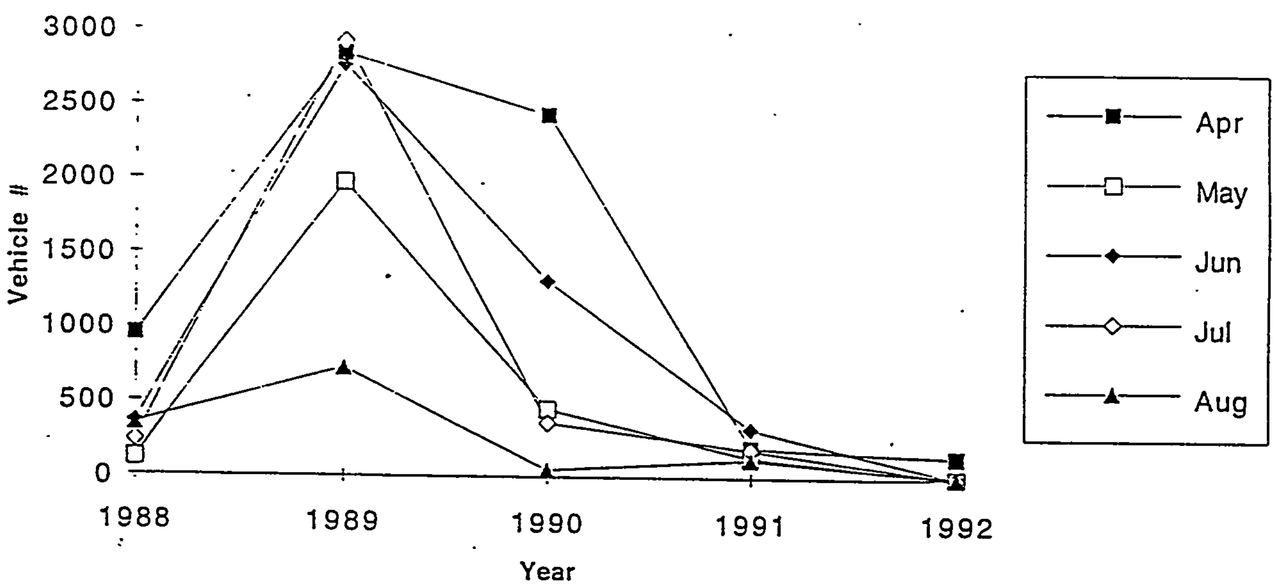
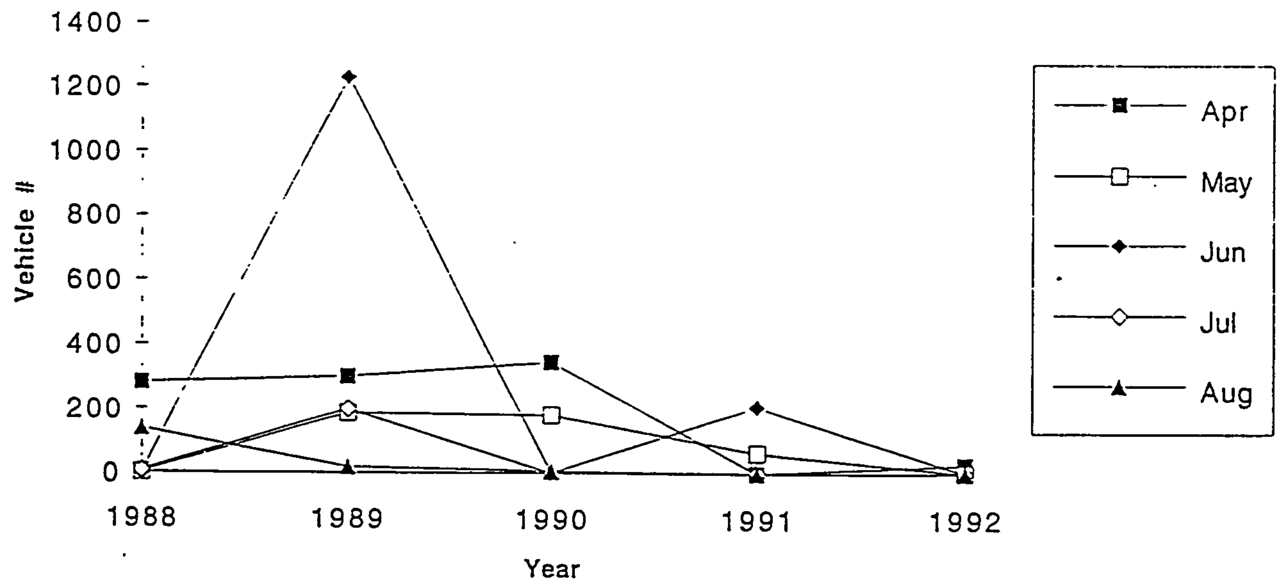


Figure 3.5. (contd)

TA 2A/ TA 2B/ TA 3A/ TA 3B

Track Vehicle



TA 2A/ TA 2B/ TA 3A/ TA 3B

Personnel Dispatch

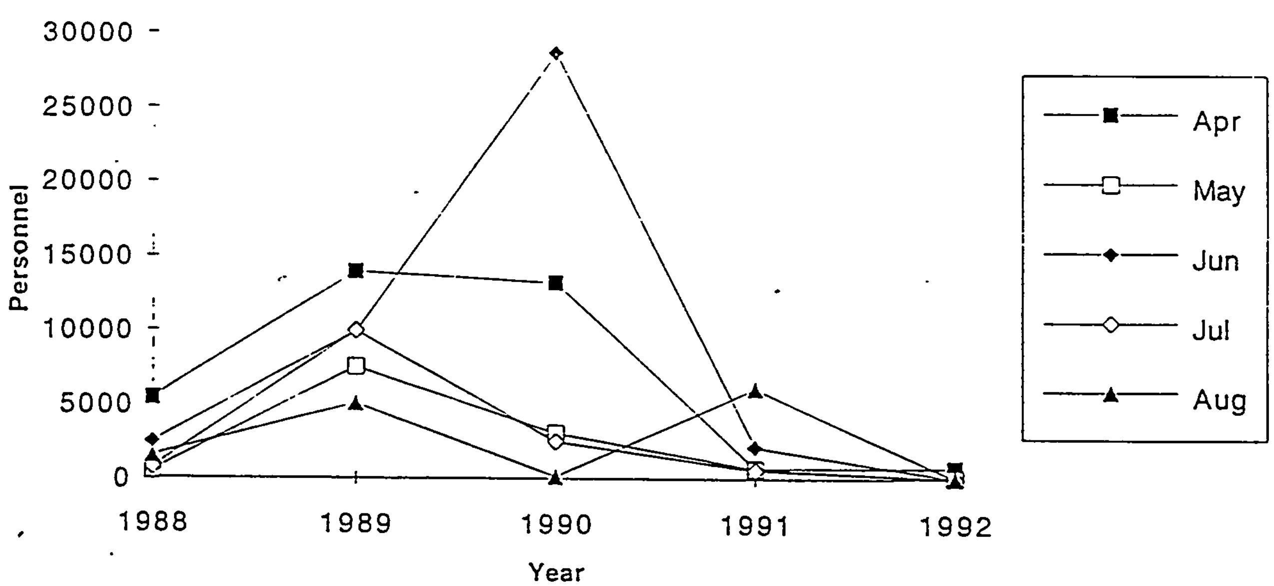
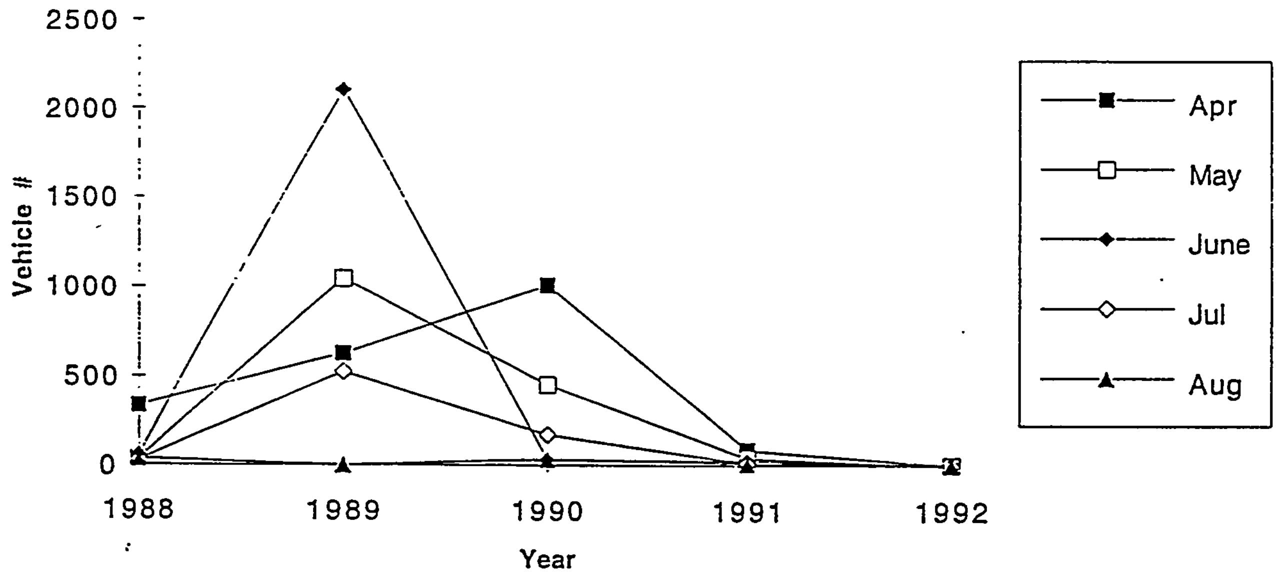


Figure 3.5. (contd)

TA 10B/ TA 10C/ TA 11A/ TA 11C

Wheel Vehicle



TA 10B/ TA 10C/ TA 11A/ TA 11C

Track Vehicle

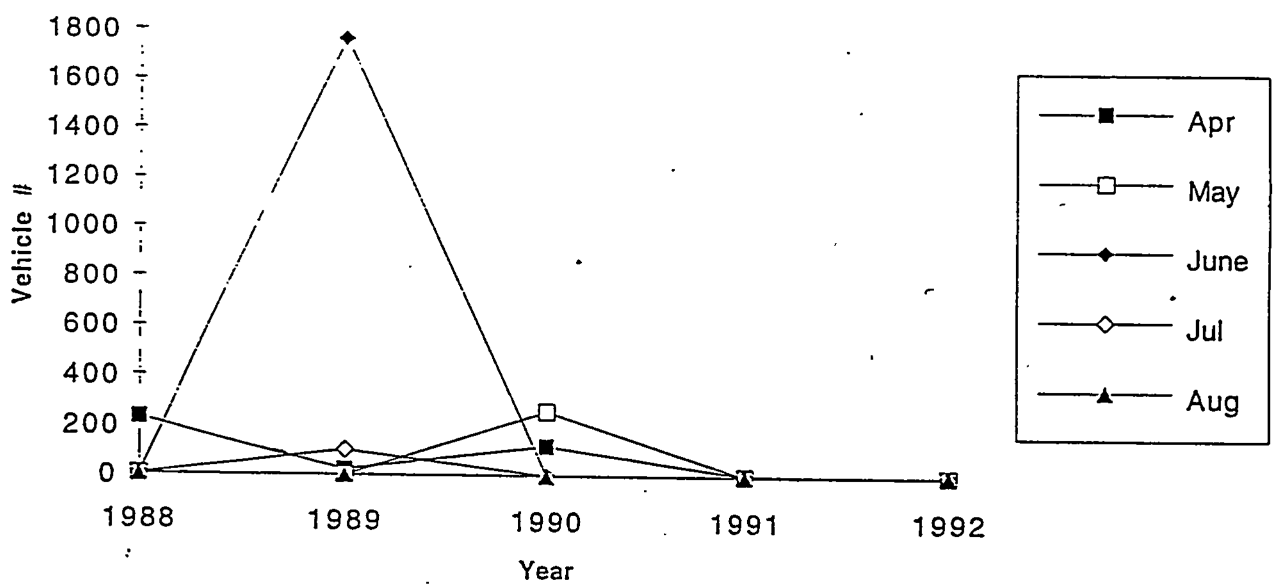
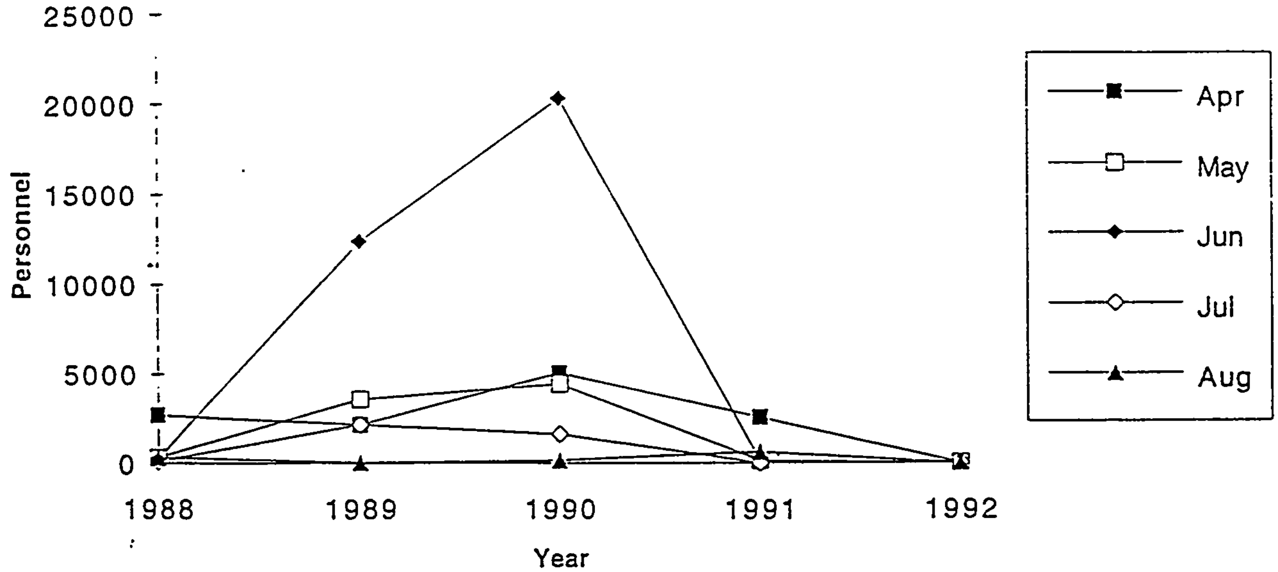


Figure 3.5. (contd)

TA 10B/ TA 10C/ TA 11A/ TA 11C

Personnel Dispatch



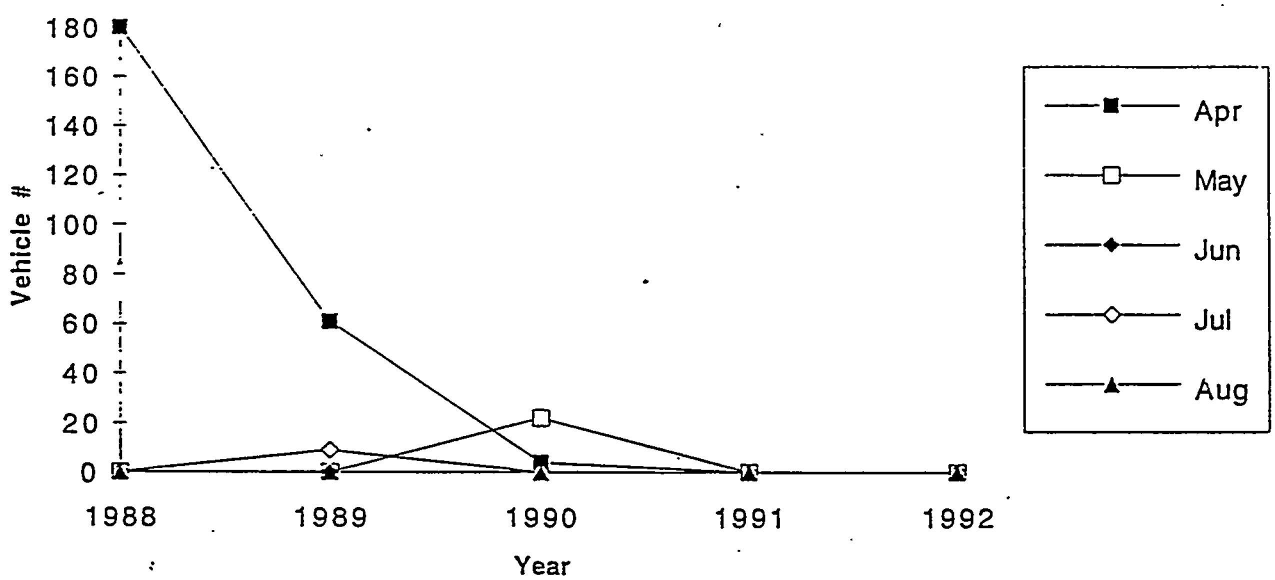
TA 13 A/ TA 13 B/ TA 13C

Wheel Vehicle

Figure 3.5. (contd)

TA 13 A/ TA 13 B/ TA 13C

Track Vehicle



TA 13 A/ TA 13 B/ TA 13C

Personnel Dispatch

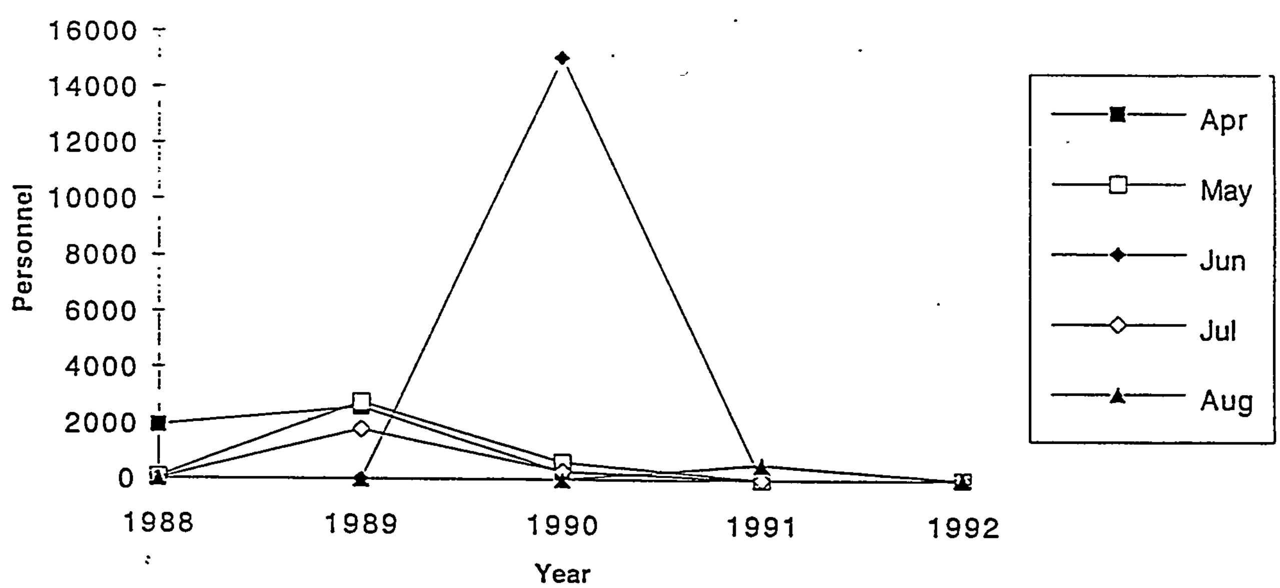


Figure 3.5. (contd)

Table 3.4. Training Activities (wheel vehicles, track vehicles, and personnel) in Training Areas of Yakima Training Center, 1988-1992

Training Areas and Months	1988	1989	1990	1991	1992
		Wheel Vehicles			
TA 1B/TA 1A					
Apr	89	767	669	196	134
May	150	711	337	44	134
Jun	178	2004	107	16	0
Jul	234	832	139	237	0
Aug	68	879	87	135	0
		Track Vehicles			
TA 1B/TA 1A					
Apr	32	154	36	7	0
May	0	4	100	0	0
Jun	84	784	0	0	0
Jul	0	54	0	0	0
Aug	14	0	0	0	0
		Personnel			
TA 1A/TA 1B					
Apr	497	4045	3067	228	213
May	1656	2188	1901	174	0
Jun	539	7595	10556	119	0
Jul	612	2677	902	517	0
Aug	272	1675	90	2654	0
		Wheel Vehicles			
TA 2A/TA 2B TA 3A/TA 3B					
Apr	951	2841	2434	200	141
May	121	1974	455	137	0
Jun	362	2759	1317	328	0
Jul	238	2921	365	189	0
Aug	349	725	49	123	0
		Track Vehicles			
TA 2A/TA 2B TA 3A/TA 3B					
Apr	282	300	345	0	28
May	0	185	179	64	0
Jun	0	1228	0	205	0
Jul	7	197	0	0	0
Aug	139	20	6	0	0
		Personnel			
TA 2A/TA 2B TA 3A/TA 3B					
Apr	5429	13947	13202	696	731
May	514	7502	3055	689	0
Jun	2467	9898	28663	2137	0
Jul	720	9963	2483	575	0
Aug	1540	5066	142	6049	0

Table 3.4. (contd)

Training Areas and Months	1988	1989	1990	1991	1992
		Wheel Vehicles			
TA 10 B/10 C					
TA 11 A/11 C					
Apr	336	625	1007	89	0
May	34	1041	452	41	0
Jun	55	2104	31	26	0
Jul	25	525	171	12	0
Aug	38	2	35	14	0
		Track Vehicles			
TA 10 B/10 C					
TA 11 A/11 C					
Apr	231	24	120	3	0
May	0	0	260	0	0
Jun	0	1762	0	0	0
Jul	0	'103	0	0	0
Aug	1	0	0	0	0
		Personnel			
TA 10 B/10 C					
TA 11 A/11 C					
Apr	2691	2141	5015	2557	0
May	305	3564	4395	165	0
Jun	232	12380	20292	131	0
Jul	91	2159	1604	28	0
Aug	325	55	164	638	0
		Wheel Vehicles			
TA 13 A,B,C					
Apr	228	621	52	0	0
May	17	746	20	0	0
Jun	0	0	0	0	0
Jul	6	604	20	0	0
Aug	0	0	0	0	0
		Track Vehicles			
TA 13 A,B,C					
Apr	180	61	4	0	0
May	0	0	22	0	0
Jun	0	0	0	0	0
Jul	0	9	0	0	0
Aug	0	0	0	0	0
		Personnel			
TA 13 A,B,C					
Apr	1947	2576	294	0	0
May	76	2763	630	0	0
Jun	0	0	15072	0	0
Jul	12	1788	300	0	0
Aug	0	0	0	578	0

- Site 3 is proximal to Training Areas 1A and 1B. Training activity in these areas has, generally, decreased since 1989 (Figure 3.5). Peak use of wheel and track vehicles was reported for 1989 for all months, with the greatest number reported for June (2,004) (Table 3.4). The greatest number of user days was reported for June 1990 (10,556) (Table 3.4).

- Site 4 is proximal to Training Areas 13A, 13B, and 13C. Training activity in these areas has decreased since 1989 (Figure 3.5). Peak use of wheel vehicles for all months was reported for 1989, with a sharp decline following that period. Track vehicle use of these units declined sharply after 1988. The number of user days for these areas is generally low, with peak numbers (15,072) reported for June 1990 (Table 3.4).

3.3 Occurrence and Index to Abundance of Prey Species, Vegetation, and Disturbance Within Small Mammal Trap Sites

3.3.1 Prey Species Occurrence

Locations of small mammal trap sites are listed in Table 2.2 and shown in Figure 3.6. Trap sites were randomly selected from UTM coordinates generated for the YTC. The occurrence of mammal holes and estimated density of animals per site are listed in Table 3.5. Species composition of small mammals and number are reported for each site for June, July, and August 1993 in Table 3.6. Species captured most commonly included deer mouse (*Peromyscus maniculatus*), least chipmunk (*Eutamias minimum*), and Great Basin pocket mouse (*Perognathus parvus*). The North Bivouac and Training Area 8B trap sites were characterized by a greater number of species and number of small mammals (see Table 3.6). This was observed consistently during June through August. Although fewer individuals were captured compared to the North Bivouac and Training Area 8B, the number of species at the Silica site and Range 55 was similarly elevated. Sites where species diversity and number of individuals captured was consistently low included the Beller Drop Zone and Training Area 9B. The Hanson Creek trap site represented an anomaly, where the number of individuals captured was generally similar to the Silica site and Range 55 (moderate) but species diversity was low. Variation among sites in prey species diversity and abundance may be related to disturbance and to vegetative characteristics of the site that will be discussed later.

Traps were checked twice daily between approximately 0600 and 0900 and 1700 and 2000 hours and reset to assess nocturnal and diurnal species occurrence. Of the total captures of deer mice, nearly all (98%; n = 131) were recorded between 0600 and 0900. Similarly, the greatest number of Great Basin pocket mice were recorded between 0600 and 0900 (98%; n = 73), indicating that both this species and deer mice are generally nocturnal. Least chipmunks were collected in greater abundance during 1700 to 2000 hours (see Table 3.7).

3.3.2 Index to Abundance of Small Mammals

Mammal holes were classified as small (0-3 cm), medium (3-6 cm), and large (>6 cm) for purposes of providing an index to abundance of small, medium, and large mammals (see Table 3.5). For purposes of analysis, we assumed that small mammal holes represented use by deer mice, sagebrush voles (*Lagurus curtatus*), and Great Basin pocket mice; medium holes represented use by least chipmunk; and large holes represented use by Townsend's ground squirrel (*Cittellus townsendii*). Hole size is assumed to correspond to the body size of each species identified (Burt and Grosenheider 1976). The index was used to calculate population density on a per-unit-area basis for each trap site.

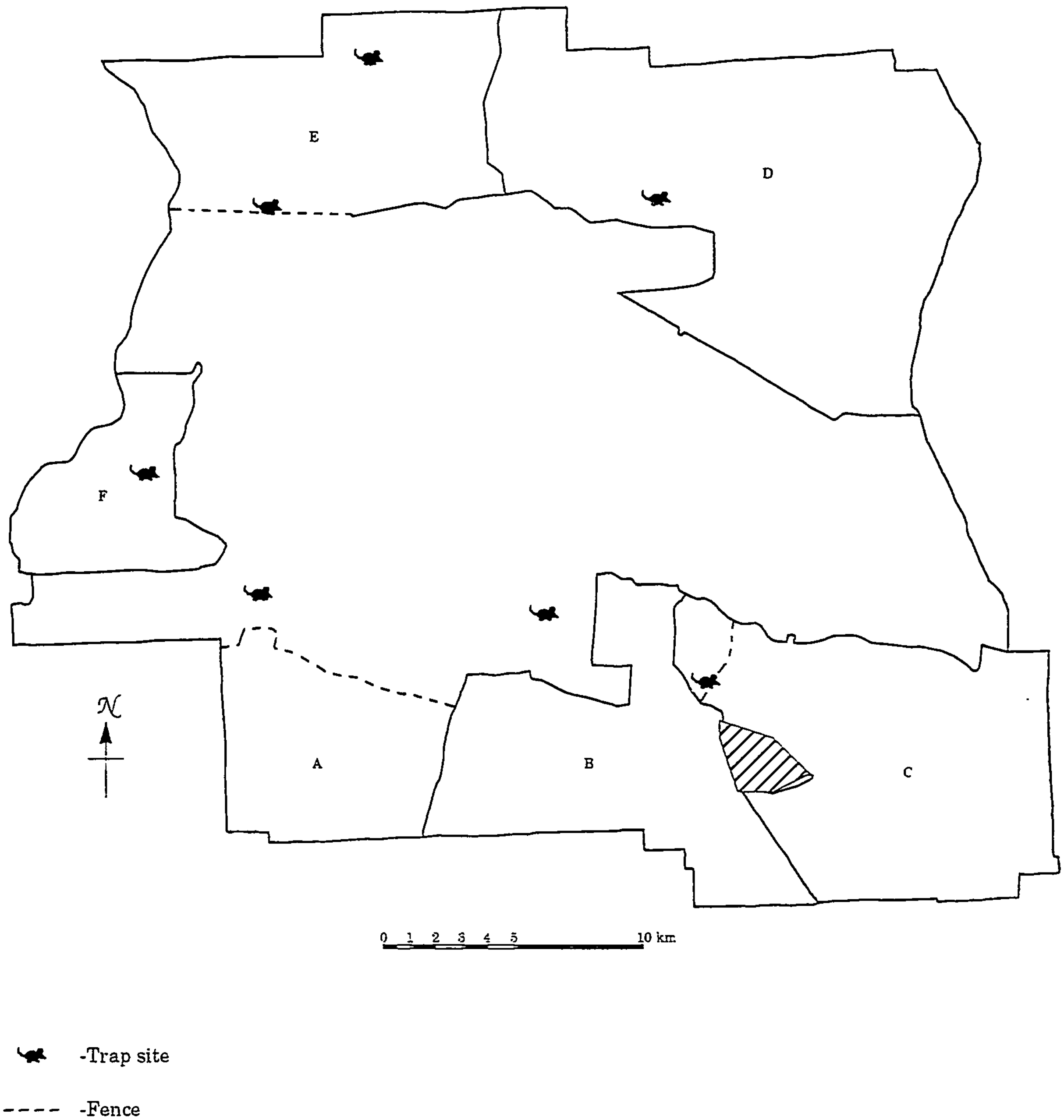


Figure 3.6. Small Mammal Trap Sites in Relation to Grazing Units, Yakima Training Center (Blank area in interior is not grazed.)

Table 3.5. Frequency of Occurrence and Estimated Abundance of Small, Medium, and Large Mammal Holes at Seven Trap Sites, Yakima Training Center, 1993

Trap Site	Northing/Easting Coordinates	Total	Holes/ha	Animals/ha
Beller Drop Zone	5175799 700612			
Small		130	81.3	27.0
Medium		97	60.6	20.2
Large		57	35.6	11.9
Silica Site	5186358 705532			
Small		196	123.0	41.0
Medium		46	29.8	9.6
Large		9	5.6	1.9
Training Area 9B	5171130 705472			
Small		58	36.3	12.0
Medium		60	37.5	12.5
Large		27	16.9	5.6
North Bivouac	5191894 709586			
Small		415	259.4	86.5
Medium		104	65.0	21.7
Large		28	17.5	5.8
Hanson Creek	5186511 720829			
Small		166	103.8	34.6
Medium		31	19.4	6.5
Large		--	--	--
Training Area 8B	5167337 720249			
Small		317	198.1	66.0
Medium		310	193.8	64.6
Large		50	31.3	10.4
Range 55	5170437 716406			
Small		312	195.0	65.0
Medium		40	25.0	8.3
Large		5	3.1	1.0

Table 3.6. Species Diversity of Small Mammals Collected June through August, Yakima Training Center, 1993

Trap Site	Species Captured	Species	June Total	July Total	August Total	Total
Beller	2	*Cittellus townsendii*	1			4
		Peromyscus maniculatus	1		2	
Silica Site	4	*Peromyscus maniculatus*	1	3		
		Eutamias minimum	1	3	5	
		Cittellus townsendii	1			
		Perognathus parvus		5	1	20
Training Area 9B	2	*Peromyscus maniculatus*		1		
		Perognathus parvus			1	2
North Bivouac	5	*Peromyscus maniculatus*	11	28	22	
		Eutamias minimum	8	21	28	
		Cittellus townsendii	3	1		
		Lagurus curtatus	1	6	6	
		Perognathus parvus		2		137
Hanson Creek	2	*Perognathus parvus*		16	31	
		Peromyscus maniculatus			1	48
Training Area 8B	6	*Eutamias minimum*	16	13	27	
		Cittellus townsendii	1	9		
		Peromyscus maniculatus	1	22	25	
		Lagurus curtatus	1	3	3	
		Perognathus parvus		5	4	
		Reithrodontomys megalotis			1	131
Range 55	4	*Peromyscus maniculatus*	1	4	8	
		Lagurus curtatus		2	11	
		Cittellus townsendii		1		
		Perognathus parvus			13	40

Table 3.7. Occurrence of Small Mammals Captured During Diurnal and Nocturnal Trapping Sessions, Yakima Training Center, June through August 1993

Species	Traps checked, 0600-0900 h	Traps checked, 1700-2000 h
Peromyscus maniculatus	123	8
Eutamias minimum	50	72
Perognatus parvus	69	4
Lagurus curtatus	19	14
Cittellus townsendii	4	13

Based on Kelker's method for calculating density and applying our index and the assumption that each individual animal is represented by three holes, it appears that small-sized mammals represent the majority the mammal species on the YTC. Further, it appears that the North Bivouac and Training Area 8B trap sites have a greater population density of mammals than the other sites. Although this result is based on several gross assumptions, it is consistent with trapping success for these sites. The sites do differ, however, in the ratio of small- to medium-sized animals estimated. The North Bivouac site is characterized by a greater percentage of small-sized mammals estimated for the site (76%), whereas Training Area 8B has equal percentages of small- and medium-sized mammals estimated for the site (46% and 47%, respectively). This result is also consistent with trapping success for these sites. Sites where the estimated density was low include Training Area 9B and Hanson Creek (see Table 3.5). Although the number of holes would suggest that an equal ratio of small- to medium-sized mammals (e.g., 40% to 42%, respectively) should occur at Training Area 9B, no medium-sized mammals were captured at that site (see Table 3.6). It should be noted that both of these sites were characterized by low species diversity, with only two species (deer mice and Great Basin pocket mice) captured.

3.3.3 Vegetation Distribution

Primary vegetation species occurring at small mammal trap sites included bluebunch wheatgrass, Sandberg's bluegrass, cheatgrass, and big sagebrush (see Table 3.8). Although big sagebrush was recorded relatively frequently in the Daubenmire plots, the percent cover of big sagebrush recorded using this method should not be construed to be representative of the percent cover for the species, as Daubenmire noted that large erratically distributed plants (e.g., shrubs) are not sampled with a high degree of accuracy using this method. Tumble mustard and bottlebrush squirreltail (*Sitanion hystrix*) were also recorded frequently at the trap sites.

Bluebunch wheatgrass and Sandberg's bluegrass were the dominant species occurring at the trap sites. Training Area 8B and the Silica trap sites had characteristically less canopy cover of bluebunch wheatgrass and Sandberg's bluegrass combined than did the other sites (19.2% and 24.5%, respectively); however, the other sites did have a greater percentage of big sagebrush. This result is consistent with estimates of canopy cover of big sagebrush measured within 10- x 10-m shrub plots at these sites (22.8% and 22.6%, respectively) (see Table 3.9). With exception for the North Bivouac trap site, all sites were characterized by greater than 40% bare ground.

The dominant shrub species occurring among the trap sites included big sagebrush, green rabbitbrush, and gray rabbitbrush (Table 3.10). Total shrub stems ranged between 7 and 499 among the sites. The Beller Drop Zone and North Bivouac trap sites had a greater number of stems relative to the other trap sites; however, the Silica site and Hanson Creek also had a relatively high number of stems (Table 3.10). Further, the North Bivouac trap site had a greater number of shrub species than other sites.

Mean diameter and height for each species recorded at each trap site are included in Table 3.10. Fifty-five percent of shrubs ranged between 52 and 100 cm mean diameter although shrub diameter varied among the sites. Mean shrub height ranged between 17 and 56 cm, the majority of stems (78%) ranging between 17 and 36 cm. Overall, shrub height and diameter suggest that plants are small in stature and possibly young.

Table 3.8. Percent of Canopy Cover of Frequently Occurring Vegetation Species and Bare Ground of Small Mammal Trap Sites on the Yakima Training Center, June through August 1993

Species	Beller	Silica Site	TA 9B	North Bivouac	Hanson Creek	TA 8B	Range 55
Agropyron spicatum	9.6	14.0	21.3	15.6	7.0	4.9	39.3
Poa sandbergii	20.9	10.5	8.4	21.4	24.3	14.3	22.8
Bromus tectorum	1.6	2.1	1.9	0.9	--	2.4	0.5
Artemisia tridentata	6.3	23.0	--	1.5	4.5	13.0	--
Sisymbrium altissimum	0.3	1.0	0.1	--	--	--	3.3
Sitanion hystrix	--	10.6	2.6	3.1	--	--	2.0
Bare ground	48.9	42.3	44.5	25.9	62.9	50.4	57.1

Table 3.9. Percent of Canopy Cover of Shrub Species at Small Mammal Trap Sites, Yakima Training Center, 1993

Species	Beller	Silica Site	TA 9B	North Bivouac	Hanson Creek	TA 8B	Range 55
Artemisia tridentata	6.0	22.6	--	8.0	6.7	22.8	--
Chrysothamnus nauseosus	1.6	--	--	2.9	--	--	0.4
Chrysothamnus vicidiflorus	0.1	0.1	0.4	6.8	--	--	0.2
Artemisia tripartita	--	--	--	0.6	10.4	--	--
Tetradymia canescens	--	--	3.2	--	--	--	--
Grayia spinosa	--	--	--	--	0.6	--	--
Total	7.7	22.7	3.6	18.3	17.7	22.8	0.6

Based on the estimation of Loetsch et al. (1973) of area and our recorded stem density from 10- x 10-m quadrats, the percent cover can be obtained as follows:

$$C = 100\,AD \qquad (3.1)$$

where C = cover (%)
A = mean area per plant (area)
D = density of plants (number per unit area, where the area units are the same as area for A).

Canopy cover was determined for each species at each trap site (see Table 3.9). Because all stems were counted within the 400-m^2 sample area, it is assumed that the sample area represents the general character of each site. Big sagebrush dominated the canopy on all sites where it occurred, with the exception of the Hanson Creek trap site where three-tip sage was the dominant species. Overall, canopy cover was lowest at the Beller Drop Zone, Training Area 9B, and Range 55 trap sites. Training Area 8B and the Silica trap sites had the greatest canopy cover (22.8% and 22.7%, respectively) but were not significantly different from the North Bivouac and Hanson Creek trap sites (18.3% and 17.7%, respectively). Although the greatest total stem density was recorded at the Beller Drop Zone, the percent cover of vegetation, primarily big sagebrush, was generally lower in comparison to the other sites, which suggests that plants are smaller-statured and perhaps young. On the hand, the

Table 3.10. Number of Stems, Diameter (dm), and Height (hgt) (units = cm) Recorded at Small Mammal Trap Sites, Yakima Training Center, June through August 1993

Species		Beller		Silica Site		TA 9B		North Bivouac		Hanson Creek		TA 8B		Range 55	
		dm	hgt	dm	hgt	dm	hgt	dm	hgt	dm	hgt	dm	hgt	dm	hgt
Artemisia	$\bar{x}$	30	29	62	35	–	–	62	47	67	40	95	52	–	–
tridentata	n	352		300		–		108		76		129		–	
Chrysothamnus	$\bar{x}$	25	2	–	–	–	–	93	56	–	–	–	–	100	46
nauseosus	n	133		–		–		17		–		–		2	
Chrysothamnus	$\bar{x}$	23	17	52	35	71	39	43	24	–	–	–	–	96	38
viscidiflorus	n	14		1		4		188		–		–		1	
Artemisia	$\bar{x}$	–	–	–	–	–	–	87	45	56	28	--	–	–	–
tripartita	n							4		169					
Tetradymia	$\bar{x}$	–	–	–	–	69	33	–	–	–	–	–	–	–	–
canescens	n	–		–		34		–		–		–		–	
Grayia	$\bar{x}$	–	–	–	–	–	–	–	–	63	39	--	–	–	–
spinosa	n	–		–		–		–		8		–		–	
Stems/400 m^2		499		301		38		317		253		129		3	

$\bar{x}$ = mean

n = number in sample

Silica and North Bivouac trap sites have relatively high stem densities and percent cover. It should be noted, however, that the North Bivouac trap site has a greater number of species present than the Silica site.

3.3.4 Disturbance

Disturbance at each trap site was measured within five 10- x 10-m quadrats located at equal intervals along each 100-m vegetation transect (n = 10). Disturbance was noted as evidence of track vehicles, wheel vehicles, human debris, disturbed vegetation (e.g., broken sagebrush), cheatgrass/knapweed, cattle grazing, fire, and/or ordnance (see Table 3.11). The predominant types of disturbance (e.g., disturbance that was noted at a majority of the trap sites) evidenced presence of wheel vehicles, track vehicles, human debris, and cattle grazing. Cattle grazing was noted at all of the trap sites and recorded most frequently at Hanson Creek and the North Bivouac trap sites, which were located within Grazing Units D and E, respectively (see Figure 3.2). Since 1988, grazing intensity in Unit D has remained relatively constant at approximately 400 to 500 AUMs (see Table 3.3). However, in Unit E grazing has been curtailed since 1989, the monthly maximum decreasing from

Table 3.11. Type and Frequency of Disturbance (as indicated by "hits") at Small Mammal Trap Sites, Yakima Training Center, 1993

	Training Area 8B	Range 55	Training Area 9B	Beller	Silica	North Bivouac	Hanson Creek
Track vehicles	7	6	4	12	10	0	0
Wheel vehicles	7	4	9	8	0	0	1
Human debris	8	1	5	5	2	0	2
Disturbed vegetation	2	1	0	8	4	0	0
Cheatgrass/ knapweed	0	10	10	0	0	0	0
Cattle grazing	6	3	2	5	6	9	10
Fire	0	1	0	0	0	0	0
Ordnance	0	7	0	0	1	0	0

nearly 700 AUMs in May 1989 to 125 in May 1992. This observation may be of significance relative to vegetation composition and relative abundance of small mammals at these sites. The Hanson Creek trap site has a greater percentage of bare ground than the North Bivouac trap site (62.9% versus 25.9%, respectively); and, as was noted previously, the North Bivouac site is characterized by a greater number and diversity of small mammals than the Hanson Creek site (114 versus 41 animals/ha, respectively).

Evidence of track vehicles was noted more often at the Beller Drop Zone and the Silica site, than at any other site and was the most predominant type of disturbance at these sites. Both sites are located in Training Areas 1A and 3A, respectively. Use of track vehicles in the training areas has declined since 1989, with each area receiving the greatest use during 1989. It should be noted, however, that the number of track vehicles used on Training Area 1A is approximately 50% greater than the number reported for Training Area 3A during 1989 (632 versus 335, respectively). The incidence of broken sagebrush (disturbed vegetation) was noted most frequently at the Beller Drop Zone (see Table 3.11).

Evidence of wheel vehicles was noted most frequently at Training Area 9B and the Beller Drop Zone. Use of wheel vehicles in the Beller Drop Zone has declined sharply since 1989, when use reported was 2,747. Wheel vehicular traffic in Training Area 9B has also declined since 1989, when peak use was reported at 1,451 vehicles. The greatest frequency of occurrence of disturbed vegetation for any of the sites occurred at the Beller Drop Zone (Table 3.11). Although Training Area 9B is a restoration site, regenerated sagebrush was not recorded within randomly sampled plots.

Human debris was noted at all trap sites, with the exception of the North Bivouac, and noted most frequently at Training Area 8B.

If one "hit" was noted each time a type of disturbance was counted at a given trap site, the Hanson Creek and North Bivouac trap sites would represent the "least disturbed" sites, and the Beller site would represent the "most disturbed." Because we did not rank the type of disturbance based on assumptions of potential impact to small mammal habitat, our measure merely provides a relative index of the types and frequency of disturbance evidenced at each trap site.

3.4 Prey Species Selection of Pair of Nested Ferruginous Hawks

We limited visits to the active ferruginous hawk nest to reduce the amount of disturbance to nested birds. Therefore, raptor castings collected at the nest site represent prey species selection for a period that included egg laying, incubation, rearing, and fledging young birds. Small mammal remains were identified in 53% of all raptor castings, with less evidence of birds and insects and no trace of reptiles (Figure 3.7). Deer mice and sagebrush voles composed 72% of the small mammal remains in ferruginous hawk castings collected during 1993. The remaining 28% of small mammal remains included other Cricetid rodents that occur on the YTC, e.g., the montane vole (*Microtus montanus*) and long-tailed vole (*M. longicaudus*); and insectivores, e.g., Merriam's shrew (*Sorex merriami*) (see Table 3.6). Northern pocket gopher (*Thomomys talpoides*) and Townsend's ground squirrel occurred in 16% and 4%, respectively, of raptor castings collected during 1993 (Figure 3.7). Figure 3.8 depicts the relative frequency of prey, including rabbit species, occurring in ferruginous hawk castings. Small mammals occurred with the greatest relative frequency (e.g., 53%), with Leporids occurring in the second greatest frequency (31%).

The relative frequency of small mammals that were identified in ferruginous hawk castings during 1993 is noteworthy in light of results of 1993 small mammal trapping efforts. The number of "large" mammals was reduced in comparison to small- and medium-sized mammals captured during 1993. The Leporidae represent a group of larger-sized mammals, the population density and distribution of which were not recorded during 1993 trapping efforts. Consequently, any estimates of availability of large prey species to ferruginous hawks would be suspect. It should be noted that the 31% frequency of occurrence of remains of this group of larger-sized mammals exceeds that recorded for mammals of slightly smaller size (e.g., Townsend's ground squirrel and northern pocket gopher, which both have a 20% frequency of occurrence).

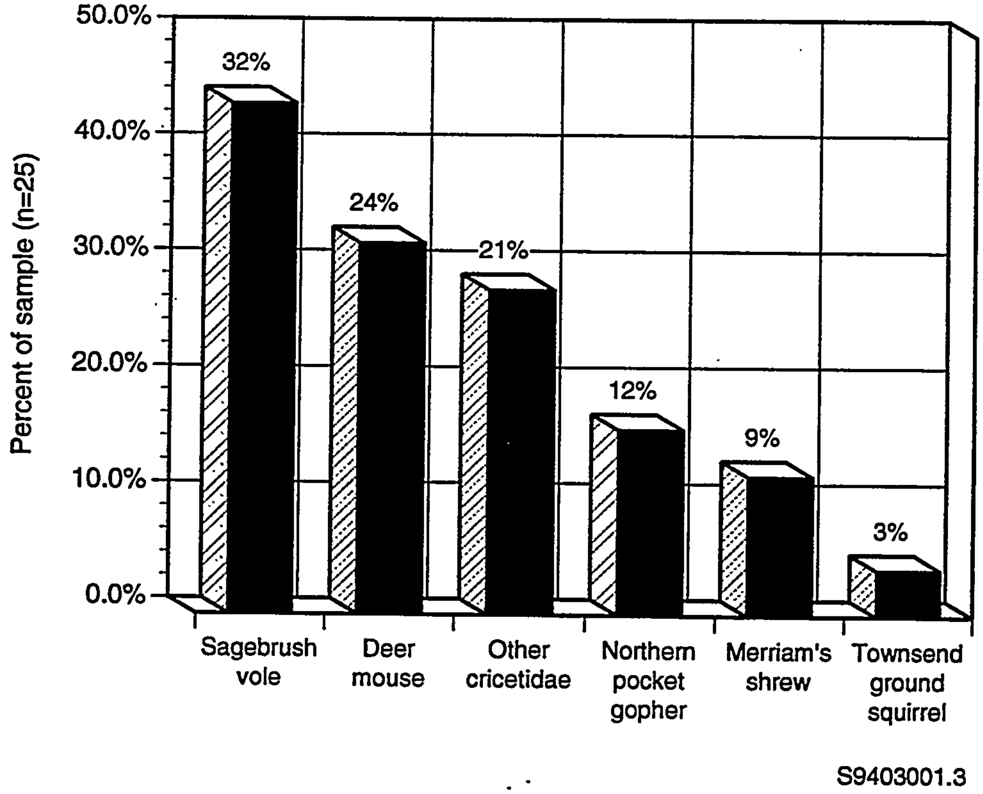


Figure 3.7. Frequency of Occurrence of Small Mammals in Diets of Ferruginous Hawks, Yakima Training Center, 1993

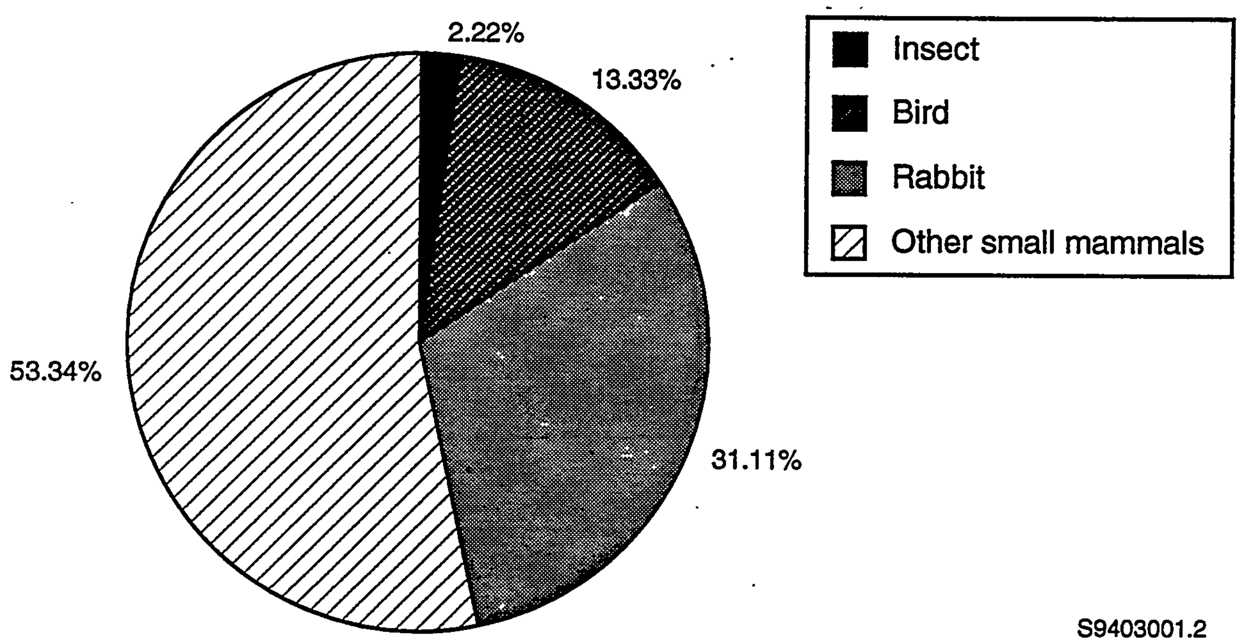


Figure 3.8. Frequency of Occurrence of Mammals, Reptiles, and Birds in Diets of Ferruginous Hawks, Yakima Training Center, 1993

4.0 Discussion and Conclusions

To describe the status of ferruginous hawks on the YTC, the prey base and characteristics of prey species habitat (e.g., vegetative composition and disturbance) were sampled. The results, which are not intended to reflect a relationship between frequency of disturbance and trapping success, suggest that relationships between "types" and "frequency" of disturbance and small mammal and vegetation species distribution may exist. As the degree or type of disturbance affects small mammal populations, ultimately an effect on ferruginous hawks will be realized. Initial proposals to identify suitability of the YTC for placement of nest structures were redefined, as nest site availability did not appear to be a factor limiting ferruginous hawk use of YTC. It was concluded that analysis of prey species abundance and distribution and a general analysis of site disturbance would allow for analysis of ultimate factors that may affect site suitability for ferruginous hawks.

The Washington Department of Fish and Wildlife has maintained a consecutive record of use of YTC by ferruginous hawks for approximately 6 years. Use of YTC by ferruginous hawks has varied during the previous 6 years (see Table 2.1). Direct or indirect effects of disturbance on the species have not been defined. This report presents results of a survey of prey species composition and abundance, vegetation distribution, and disturbance at seven randomly located sites on the YTC. The results can be applied to questions specific to habitat management or restoration potential of YTC for ferruginous hawks or to questions regarding ultimate or proximate factors that may affect ferruginous hawks occurring on the YTC.

Disturbance, manifest as human use or habitat alteration, has been identified as a primary factor affecting ferruginous hawk production (Thurow et al. 1980). Porter and White (1977) concluded that direct human disturbance was the overriding negative factor to which ferruginous hawks did not adapt and that negative effects of human disturbance were augmented when prey availability was reduced. Others speculate that human activity, which may affect nest occupancy or alter nest site location, may not be as significant as habitat alteration, which affects the prey base and production of young (White and Thurow 1985).

Several studies (Thurow et al. 1980, Smith et al. 1981) have demonstrated that ferruginous hawks are strongly dependant on prey availability and closely cycle with fluctuations in populations of small mammals. Stalmaster (1985) observed a significantly high correlation between ferruginous hawk productivity and prey density. Similarly, Smith et al. (1981) demonstrated that decreased prey availability for ferruginous hawks in Utah caused birds to reduce the number of nest attempts, reduce clutch size, fail in attempts to rear young, and reduce hatch success. Because the number of active ferruginous hawk nests on YTC has varied in the recent past, prey species availability and site disturbance were examined.

Although fluctuations in prey species density are related to intrinsic population factors, prey species abundance and distribution has been related to habitat condition and overall suitability of habitat for a species (Woffinden 1975). Baker and Brooks (1981) observed that management of rough-legged hawks was possible by manipulating the vegetative component of the hawks' foraging habitat to reduce numbers of prey species. Raptors responded by decreasing use of the area. Land management activities that alter the density and structure of native vegetation can affect small mammal populations; however, some level of land conversion may be tolerable by prey species populations. Howard and Wolfe (1976) suggested that "ferruginous hawks benefit from areas managed for a high degree of interspersion of vegetation," as may be found in areas subject to some level of disturbance. To date, there are no quantitative assessments of the degree of habitat alteration that will allow ferruginous hawks to persist. Varying degrees of habitat alteration on YTC have resulted from land management for grazing and military maneuvers.

4.1 Effects of Grazing on Yakima Training Center

Overgrazing has been identified as one of the five ultimate causes of ferruginous hawk population decline, affecting the species by changing nest substrate, affecting prey abundance (Phillips 1939, Black and Frischknecht 1971), and affecting prey vulnerability (Kochert et al. 1986). Improper grazing contributes to a reduction of perennial grass species with replacement by annuals and woody species (Black and Frischknecht 1971). The Hanson Creek and North Bivouac sites have been subject to varying degrees of grazing pressure over the previous four years.

The North Bivouac and Hanson Creek sites, which were characterized as "least" disturbed, were typified by disturbance from cattle grazing. In the case of the North Bivouac site, cattle grazing was the only type of disturbance recorded. The Hanson Creek site is located in Grazing Unit D, which has been grazed since 1988 and has received relatively high grazing pressure during the previous 4 years. The North Bivouac site is located in Grazing Unit E, which has also been grazed since 1988. However, the AUMs in this unit were reduced during 1992, to less than 50% of 1991 grazing levels (see Table 3.3). This is of significance relative to vegetation distribution and species composition of small mammals.

The Hanson Creek site was characterized by a low number of species and moderate trapping success (n = 48 captures for 375 trap nights) relative to other trap sites. The species captured at the site included Great Basin pocket mice and one deer mouse. Indices of abundance to small mammals were low at the Hanson Creek site (41 animals/ha) compared to the North Bivouac site. The Hanson Creek site was characterized by 63% bare ground with moderate shrub stem density (253 stems/m^2). Percent canopy cover of shrubs was moderate (18% cover), and shrubs ranged between 28 and 40 cm in height. The dominant vegetative cover at the site was Sandberg's bluegrass (24% cover).

The North Bivouac site, on the other hand, was characterized by a high number of species (n = 5) and high trapping success (n = 137) (see Table 3.6). Species trapped at the site included deer mice, Townsend's ground squirrel, sagebrush vole, Great Basin pocket mouse, and least chipmunk (see Table 3.6). Population estimates derived from indices of abundance were high (114 animals/ha). This site had the lowest percentage of bare ground (26%) and was dominated by herbaceous bluebunch wheatgrass (16% cover) and Sandberg's bluegrass (21% cover) (Table 3.8). Shrub stem density at the site was relatively high (317 shrubs/400 m^2) and included big sagebrush and green rabbitbrush (Table 3.10). Percent canopy cover of shrubs was moderate (18% cover) (Table 3.9) and shrubs ranged between 24 and 56 cm in height (Table 3.10).

The notable difference between the North Bivouac and Hanson Creek sites is the percentage of bare ground (26% versus 63%, respectively) and the species complement of vegetation (Table 3.8). The sites occur within the *A. tridentata/Agropyron spicatum* association (Franklin and Dyrness 1984). The species composition of this association includes shrubs (i.e., *A. tridentata*, *A. tripartita*, *C. nauseosus*, *C. viscidiflorus*, *Grayia spinosa*); grasses dominated by *Agropyron*, *Stipa*, *Poa*, or *Sitanion*; and an understory of *Poa sandbergii*, *Bromus tectorum*, and *Lappula redowskii*. The North Bivouac site retains a significant portion of this complement, including *Agropyron*, *Artemisia*, *Poa*, *Bromus*, *Sitanion*, and *Chrysomthamnus* (see Tables 3.8 and 3.9). The Hanson Creek site, on the other hand, retains remnants of this association including *Agropyron*, *Poa*, *Artemisia*, and *Grayia*. *Poa*, which is not significantly affected by grazing, is distributed similarly across both sites (24% and

21% cover at Hanson Creek and North Bivouac sites, respectively). *Agropyron*, which is affected by grazing, occurs in 7% and 16% cover at the Hanson Creek and the North Bivouac sites, respectively (Table 3.8). Similar variation in occurrence of *Bromus tectorum* was also noted with the species absent from the Hanson Creek site and occurring in 0.9% cover at the North Bivouac site. *Bromus tectorum* generally increases as a result of grazing, the species re-establishing very slowly in this association after grazing has ceased (Franklin and Dyrness 1984).

Grazing was curtailed considerably in Unit E in 1992; conversely, AUMs in Grazing Unit D were increased during 1992 over previous years. This and past grazing management may have affected species composition of vegetation, reducing vegetative diversity at the Hanson Creek site that is located in Grazing Unit E. Species occurrence at the North Bivouac site may suggest that the area is in some stage of recovery or that past grazing practices did not reduce species diversity of the site to the extent noted for Hanson Creek. Results of trapping indicate a similar reduction in number and diversity of small mammal species at the Hanson Creek site. It may be speculated that past practices reduced vegetative diversity and subsequently number and diversity of small mammals at the site.

4.2 Human Disturbance on the Yakima Training Center

In comparison to the grazed sites, the sites characterized by disturbance from human debris and presence of track and wheel vehicles maintained some similarities in number of species and abundance of small mammals. Training Area 8B was similar to the North Bivouac site in terms of number of species encountered (n = 6) and number of individuals captured (n = 131 and 137, respectively). However, an important point about this result is the frequency of occurrence and type of disturbance recorded at Training Area 8B. The primary disturbance at this site was from human debris associated with bivouacs and vehicular traffic from wheel and track vehicles (see Table 3.11). Although small mammal numbers and species abundance were similar for Training Area 8B and the North Bivouac sites, vegetative characteristics of the sites differed.

Training Area 8B was characterized by low stem density (n = 129) and species diversity of shrubs. Big sagebrush was the only shrub species that occurred on the site, accounting for approximately 23% cover. Herbaceous species included *Agropyron* (5%), *Poa* (14%), and *Bromus* (2%). The number of shrub stems varied from the North Bivouac site (i.e., 129 versus 317); however, the percent cover of shrub species did not vary greatly (23% versus 18%). The similarity in number of species and abundance of small mammals at Training Area 8B and the North Bivouac site may be a function of species composition of vegetation as well as shrub canopy cover.

This can be examined further with regard to results for Training Area 8B and the Silica site. Vegetation at the Silica site and Training Area 8B was similar in percent cover of big sagebrush (22.6% versus 22.8%, respectively) and species diversity of shrubs (see Table 3.10) as well as the species complement of herbaceous vegetation. These two sites did differ, however, in percent cover of all vegetation calculated from Daubenmire plots (33% versus 60%). At the Silica site, percent cover of vegetation was greater, with many small-statured shrubs accounting for a large percentage of vegetative cover. Conversely, Training Area 8B was characterized by fewer plants but of larger stature. The difference in success of small mammal captures at these sites was noted not in species diversity but in number of small mammals trapped, which was significantly lower at the Silica site (131 versus 20) (see Table 3.6). In addition to species composition and percent cover of shrubs, vegetation structure may affect abundance of small mammals.

The herbaceous component of the Silica site was similar to the sites that were grazed but did not appear (from soil compaction and rubbing of shrubs) to be overgrazed, and retained high species diversity. Disturbance from wheel and track vehicles at the Silica site may have altered vegetation structure, and recovering plants may not provide adequate habitat for a large number of small mammal species. Studies examining vegetation distribution and occurrence of small mammals (Murphy 1978, Wakeley 1978, Call 1979, Feldhamer 1979, Littlefield et al. 1992, Baker and Brooks 1981), have identified percent cover and structure of vegetation as characteristics that affect habitat use. Hanson Creek, North Bivouac, and Training Area 8B did not differ significantly in species diversity. However, *Lagurus curtatus* was absent from the Silica site. Unlike the North Bivouac and Training Area 8B site, the Silica site was characterized by many small-statured sagebrush (see Table 3.10), and habitat suitability at the site may have been limited for the species. Sagebrush voles occur in loose soils in association with sagebrush, requiring green vegetation of the plant for forage (Burt and Grossenheider 1976). Compacted soils and limited sagebrush may have reduced habitat potential for voles at the silica site.

4.3 Prey Species

Wakely (1978) could not identify a direct relationship between rodent biomass and use of an area by foraging ferruginous hawks, suggesting that diversity of vegetation was more critical in birds' choice of foraging areas than was prey density. A general perception regarding ferruginous hawk prey selection is that if a broad prey base or an alternate prey species are available, birds can inhabit an area. In the absence of this, Woffinden and Murphy (1989) speculate that birds exhibit nomadic behavior and often relocate nesting territories. The results of trapping efforts during June through August 1993 suggest that a diversity of prey species occur on the YTC. Variations in species abundance and distribution are likely associated with the type and duration of disturbance to an area. As duration of disturbance alters vegetative structure and soil type affects capacity for colonization of species, small mammal abundance and distribution may be limited.

Use of small mammals by ferruginous hawks was determined from analysis of pellets collected at the nest site during August 1993. Sagebrush voles and deer mice accounted for 75% of small mammal remains (53% of total individuals) in ferruginous hawk castings. Although the number of individual Leporids could not be corroborated from castings, this group represented 31% of all remains in ferruginous hawk castings, representing the primary forage of birds. The use of rabbits by ferruginous hawks has been well documented (Lokemoen and Duebbert 1976, Thurow et al. 1980, Steenhof 1983, Stalmaster 1988). However, rabbits have been ranked as third in importance as a primary forage species of ferruginous hawks in Washington (Olendorff 1993). Fitzner et al. (1977) identified pocket gophers as the primary prey species of ferruginous hawks in Washington. However, Fitzner et al. (1977) maintained that diet varied relative to the habitat in which birds were nested. Therefore, in the absence of this species, birds adapt to alternate sources of prey. It appears from 1993 results for a nested pair of ferruginous hawks on YTC that pocket gophers occurred significantly less than Leporids (8%) and that other species comprised a greater percentage of the overall diet (i.e., sagebrush voles [23%], deer mice [17%], other Cricetid rodents [15%]). It should be noted that Fitzner et al. (1977) did not observe any remains of pocket gophers in the diets of hawks nested in desert shrub habitat.

Pocket gophers comprised 83% and 91% of small mammal remains in ferruginous hawk pellets collected on the U.S. Department of Energy Hanford Site during 1992 and 1993, respectively. Microtine rodents comprised 6.5% and 2.1% of total individuals identified during these periods, respectively, and all other species accounted for less than 4% of the mammalian portion of the birds' diets (K. Lehmkuhl, personal communication, October 1993). These findings are consistent with the observations of Fitzner et al. (1977) for eastern Washington; therefore, we may suggest that given the availability of pocket gophers, ferruginous hawks would rely on them as their primary forage species.

During 1993, it appeared that the nested pair of ferruginous hawks on YTC used Leporids more often; however, this group did not account for a significant portion of the birds' diet and, in fact, the diet appeared to be quite varied. This variety of groups, including reptiles, birds, and insects was also observed by other researchers in eastern Washington during 1992 and 1993 (K. Lehmkuhl, personal communication, October 1993).

The results of pellet analysis illustrate a reliance by the birds on a variety of prey species. It stands to reason that in the absence of an abundance of pocket gophers, ferruginous hawks would rely on other species. In analysis of prey-switching behavior by ferruginous hawks, Black and Frischknecht (1971) concluded that a reduction in major prey species, which was thought to be limiting the ferruginous hawk population under study, was not indexed according to changes in number of individuals available because diet shifts were not commensurate with prey species declines. Instead, the reduction in prey species was indexed by an overall reduction in reproductive success of the birds. This result may indicate a trend that has influenced ferruginous hawk use of YTC over the previous 6 years. Visits to the nest site were limited during incubation and rearing to minimize disturbance to birds. During August 1993, when it appeared that young had fledged, we conducted a survey of the nest sites and perch sites nearby to collect pellets and remains of prey items that may have been cast during rearing. During the site visit, one carcass of a juvenile ferruginous hawk was collected. From initial observations of the nest, we concluded that the nest was occupied by two juvenile ferruginous hawks and assumed that only one bird survived to fledging. This result is consistent with Stalmaster's findings for Swainson's hawk production on the YTC during 1993. Stalmaster concluded from preliminary observations that nested Swainson's hawks were undernourished and underdeveloped and that average clutch size was reduced (M. Stalmaster, personal communication, August 1993).

5.0 Management Recommendations

Habitat management for ferruginous hawks requires maintenance of nesting substrate, maintenance of prey base, and limitations on direct human disturbance (Olendorff and Fish 1985). In the absence of suitable nest substrate, man-made structures can be provided for birds. It appears that nesting habitat on the YTC is not limited for ferruginous hawks or other raptor species, e.g., Swainson's hawk, prairie falcon, golden eagle (M. Stalmaster, personal communication August 1993); therefore, management recommendations for nest sites are not discussed here. It is likely that effects on ferruginous hawks at the YTC have resulted either directly from human intrusion or indirectly from habitat alteration. Results of small mammal trapping during 1993 would suggest that prey species abundance and distribution may be limiting birds' use of the YTC, and that habitat management may be necessary to restore prey species diversity and population densities of small mammals. Wakely (1978) speculated that raptors may forage in areas where cover conditions render prey more vulnerable; thus, areas that support many concealed individuals may not benefit hawks as well as "open" areas that support fewer individuals. The trap sites surveyed during 1993 fell into Wakeley's "moderate" category of 20% to 75% vegetative cover. In Wakely's analysis, this cover class was used less than expected by foraging ferruginous hawks. This result suggests that not only should some areas of the YTC be managed for prey species enhancement but also for restoration or maintenance of foraging habitat suitability. Management of prey base requires an understanding of varying types of disturbance and the degree of impact imported. The present study provided some information regarding species occurrence (i.e., number and diversity) in areas subject to varying types of disturbance. A first step to managing ferruginous hawks should include verification of trends in prey species distribution in varying habitats across YTC. Once understood, vegetation-disturbing activities should be managed to maintain patch diversity or maximize edge effect.

Habitat suitability index (HSI) criteria for ferruginous hawks (Jasikoff 1982) assume that prey species abundance is related to volume and structure of herbaceous and shrub vegetation. The criteria further assume that dense, tall vegetation will provide abundant prey but poor accessibility of prey for ferruginous hawks. Therefore, an optimum complement of food and vegetation components will be realized when the average height of plants is 15 to 60 cm corresponding with vegetative cover of 60% to 100%. Wakely (1978) observed that ferruginous hawks foraged in areas characterized by bare ground and pasture significantly more than expected and that this behavior was not necessarily associated with abundance of prey species but with accessibility to forage.

Based on HSI criteria and results of 1993 surveys, the YTC provided a suitability rating between approximately 0.01 and 0.51 (on a scale of 0.0 to 1.0) (Jasikoff 1982). Range 55 and Training Area 8B were the least and the greatest, respectively, for optimal production. Verification of these results would take into account the abundance of small mammals in related types of habitat throughout the site:

- The HSI model criteria, which are based on physical attributes of the habitat, warrant extensive small mammal trapping and vegetation surveys throughout the ferruginous hawk nesting season.

- Sampling across large blocks or habitat types on YTC and verification of cover type and percentage of each type across the site should be incorporated into a stratified random sample of small mammal abundance and distribution on YTC.

Habitat management that would accommodate site activities and contribute to overall management for the species should follow these guidelines:

- In patches of sagebrush, manage fires so as not to alter large tracts (i.e., >600 m) of habitat, thus creating large monocultures, reducing structural diversity within patches, and increasing the potential for invasion of noxious weeds.

- Based on success of current rehabilitation efforts, continue habitat restoration with plantings of native shrubs and seeding with native grasses.

- Manage grazing to minimize soil compaction, erosion, and decreased capacity for establishment of noxious or undesirable species (Olendorff 1993).

- Restrict off-road vehicle travel in mature sagebrush stands to avoid destruction of individual plants. Conduct walk-through surveys and, if necessary, relocate bivouacs to avoid use of mature sagebrush stands and eliminate trampling of individual plants.

Ferruginous hawks' ability to acclimate to constant disturbance has been established (Olendorff and Stoddart 1974, Gilmer and Stewart 1993). However, limitations on distance or line of sight of activities must have restrictions. Management of training activities that will contribute to species maintenance activities should follow these guidelines:

- Post known active nest or perch sites with "No Trespassing" or "Alert" signs to reduce the incidence of "random" visitation to nests. Post areas at 450 m (minimum) and 800 m (maximum) from nest (Olendorff and Fish 1985, Sutter and Jones 1981).

- Limit use of training areas and ranges in the vicinity (i.e., within 800 m) of known active nests during March through August.

- Restrict use of live rounds on ranges adjoining (i.e., within 800 m) known active nests during March through August.

- Impose road closures, foot traffic, and prolonged activities (i.e., one-half hour to several days) within 800 m of known active nests during March through August.

- Limit use of helicopters or fixed-wing aircraft within 500 m of known active nests to survey and/or monitoring activities during March through August.

6.0 References

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