Ecology and Productivity of Two Interstate Deer Herds in the Eastern Sierra Nevada

East Walker and Mono Lake Deer Herd Study
Hill Bill Contract # 7027

November 1991

Prepared by:

Timothy Taylor
Consulting Wildlife Biologist
P.O. Box 191
June Lake, CA 93529

Prepared for:

California Department of Fish and Game
407 West Line Street
Bishop, CA 93514

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Rocky Mountain mule deer (Odocoileus hemionus hemionus) from two interstate deer herds, the East Walker (EW) and Mono Lake (ML) herds, were studied from January 1988-June 1991 under contract with the California Department of Fish and Game (DFG). A total of 162 animals were captured and marked; 61 were fitted with radio-telemetry collars for monitoring of movements. Radio-collared deer were located a total of 3872 times from March 1988-June 1991. Deer leave western Nevada winter ranges in late March and early April and move to holding areas located at intermediate elevations along the east slope of the Sierra Nevada mountains in eastern California. There was a significant year-by-herd difference in the timing of spring migration from the winter range. Deer from the EW herd delayed spring migration on irrigated pasturelands located on secondary winter range adjacent to the East Walker River. Mean straight line distances between winter and summer ranges of EW and ML deer were 35 and 65 km, respectively.

Deer displayed strong fidelity to individual summer and winter ranges; only one radio-equipped doe used more than a single summer home range during the study. Marked deer from different winter ranges were found to occupy summer ranges of close proximity. Conversely, marked deer from the same winter range were found to disperse to opposite ends of the summer range. Summer home range size of adult does averaged 21.4 ha. There was a significant difference ($P \leq 0.025$) in the summer home range sizes of adult does which occupied grazed versus ungrazed habitats. The average size of summer home ranges grazed by livestock was 2.5 times larger (25.87 ha) than those that were not grazed (10.23 ha). The summer home ranges of 38 randomly selected adult does were examined by the investigator; 33 (87%) were grazed by livestock to varying intensities.

Browse dominated the yearlong diets of the subject herds, receiving the highest use in December (99%) and the lowest use in August (61%). In March, grasses comprised 33% and 20% of EW and ML deer diets, respectively. Fecal analysis indicates that Artemisia was most frequent in the winter, fall and early spring diets of EW and ML deer. The heavy use of sagebrush may indicate suboptimal herd condition, at least during the winter. Purshia was the most frequent shrub in the summer diets and comprised 24.9% and 29.2% of July and August diets, respectively. Artemisia and Purshia comprised most (62-85%) of winter-long diets, but Purshia declined steadily through the winter months, reaching

a March low of 1.3% and 3.9% of the EW and ML diets, respectively. Though shrubs declined somewhat in late winter diets, they were still common (≥66%), while grasses became more common in diets during this period. Grasses and forbs made up >30% of March and August diets. Fecal crude protein (CP), fecal nitrogen (FN) and fecal diaminopeimelic acid, (DAPA), indicators of diet quality, were high in the spring and summer and low in the fall and winter.

Reproductive potential (pregnancy rates and fetal rates) was high among does collected from both herds despite relatively low mean kidney fat (KFI) and femur marrow fat (FMF) measures. The CONINDEX method, a relatively objective method of rating deer physical condition through combining KFI and FMF measures, revealed no significant difference in condition of the two herds. Nearly half of the yearlings collected during the study were pregnant, suggesting a higher than expected level of nutrition during the dry 1989-1990 winter. Pregnancy rates and fetal rates among does 6 years and older were 100% and 2.00 fetuses/doe, respectively, indicating a high reproductive potential and an adequate nutritional plane among older age classes.

Principal causes of mortality identified in this study were predation, hunting, highway kills, and causes related to malnutrition. Thirteen of 61 (21%) radio-collared deer were killed by mountain lions during the course of this investigation, suggesting a relatively high take of adults (and presumably young animals) by this predator. An estimated 700 deer from both herds were killed by vehicles in 1990. Five radio-collared bucks were shot and killed by hunters during the 1988-1990 California and Nevada hunting seasons. Three of these were crippled and lost and subsequently found through radio monitoring.

Continued high demand for livestock grazing and increased demand for multiple commercial, residential, and recreational uses of public and private lands, currently pose the greatest long-term threats to these herds. This report describes some specific key habitats used by the EW and ML herds and the importance of obtaining site specific information on deer use patterns of habitats proposed for development. Recommendations for habitat evaluations and improvements are provided, including measures to reduce impacts of highway expansions, mining projects, livestock grazing and human disturbance.

ACKNOWLEDGMENTS

Over the last three years, many individuals and several organizations have provided support for this endeavor. The East Walker and Mono Lake deer herd study was made possible by the collective efforts of the California Department of Fish and Game (DFG). Special acknowledgment must be given to Ron Thomas, DFG wildlife biologist for the Mono unit, for his guidance and technical support during this entire investigation. I am also grateful to DFG biologists Tom Blankinship, Jim Davis and Vern Bleich for their help, both administratively and in the field. Many Department employees assisted with deer trapping and collections including Al Lapp, Rocky Thompson, Dave Jessup, Dave Hunter, Dick Padgett, Denyse Racine and Les Coombs, their help is greatly appreciated. Biologists Tina Mark of the United States Forest Service (USFS), Craig Mortimore, Greg Tanner and Walt Mandeville of the Nevada Department of Wildlife (NDOW), and Tom Dayak of the California Department of Transportation (Caltrans), also assisted in deer trapping and collections. Bureau of Land Management biologists (BLM) Terry Russi and Steve Nelson assisted in data analysis. Also, many local volunteers helped with the deer trapping including Wally Crittenden and Fred Bear from the Inyo and Mono Counties Fish and Game Fines Committee; and Don Rake and Bill Reed from the Mono County Board of Supervisors.

CHAPTER 1. INTRODUCTION

The Rocky Mountain mule deer (<u>Odocoileus hemionus</u>) is the most adaptive and widespread western wild ungulate (Poole 1976). However, in recent decades, there has been a general decline in the population of western mule deer (Julander and Low 1976). A general statewide decline of California's deer herds has been occurring since the 1950's (Bertram and Remple 1977, Dasmann 1981). This is particularly evident in migratory mule deer herds of the Sierra Nevada Mountains (Bertram 1984). According to Bertram and Remple (1977) and Longhurst et al. (1976), this decline can be attributed to a number of factors which have ultimately eliminated deer and reduced productivity and fawn survival. Some of these factors include: habitat problems resulting from overgrazing; changes in logging methods and reforestation techniques; elimination of range by roads; recreational developments such as campgrounds; subdivisions; construction of reservoirs; and predation.

The long term decline of deer numbers in California prompted the California Department of Fish and Game (DFG) in 1975 to formulate a general plan to restore and maintain healthy deer herds at levels compatible with their habitat, to increase the quantity and quality of deer habitats, and to provide for diversified recreational use of deer (Thomas 1985a).

In 1977, DFG was mandated by the legislature to develop management plans for each geographical unit of deer range. Consequently, herd management plans were formulated in 1985 for the East Walker (EW) and Mono Lake (ML) herds, the two eastern Sierra mule deer herds which are the subject of this investigation.

The EW and ML herds, which are each comprised of approximately 3,000 deer, occupy adjacent winter ranges in Mineral and Lyon Counties, Nevada, and share summer range primarily on the east slope of the Sierra Nevada mountain range in northwestern Mono County, California. Since most of the herd range is largely public lands, high demands for commercial, residential and recreational uses exist. Consequently, several major concerns regarding potential impacts of these land uses on the EW and ML herds have recently been identified in DFG herd management plans. These concerns specifically include: (i) the high demand for multiple resource use of the range especially for grazing, recreation, and housing; (ii) increased demands for hydropower and geothermal development and exploratory mining; and (iii) long term habitat reduction and deterioration (Thomas 1985a, Thomas 1985b). Because of these concerns, DFG initiated the present investigation of the EW and ML deer herds so that all critical habitats used by these herds, which may be subject to alteration, be delineated. To effectively manage migratory mule deer in the Sierra it is crucial that migration routes and all seasonal habitats be delineated (Bertram and Remple 1977).

The major objectives of this investigation, which began in January 1988, are those outlined in the EW and ML deer herd management plans. These objectives are (i) to delineate all critical habitats used by the EW and ML deer herds; (ii) to analyze the quality and quantity of all critical habitats defined; (iii) to assess the impacts of land uses, existing and proposed, on critical habitats; (iv) to identify habitat factors limiting the herd; and (v) to formulate recommendations to reduce the impacts of these factors.

This report provides information based on data collected from January 1988-June 1991.

CHAPTER 2. STUDY AREA

The EW deer herd occupies approximately 600 sq. km primarily east of the Sierra Nevada crest in Mono County, California, and Mineral and Lyon Counties, Nevada. The Sierra Nevada range is oriented in a generally north-south direction and extends some 600 km, from Mt. Lassen in the north to Walker Pass, east of Kernville, in the south (Storer and Usinger 1968).

The herd winter range is located some 32 km north of the Bridgeport Valley on the Toiyabe National Forest (TNF), just north of the California-Nevada state line in Mineral and Lyon counties, Nevada (Figure 2-1). The winter range encompasses approximately 140 sq. km and is bounded by the Bodie Hills to the south, the Pine Grove Hills and Bald Mountain (2900 m) to the north, and the Sweetwater Mountains to the west (3550 m). Topography to the east of the winter range is not well defined and is characterized by steep, rugged, uplifted ridges capped by rock outcrops. A number of creeks drain north from the Bodie Hills and east from the Sweetwater range into the East Walker River, which runs north through the center of the winter range from the east slope of the Sierra Nevada. At the south end of the winter range, the East Walker River is bordered by a narrow strip of irrigated pastureland which is used primarily for cattle grazing. Access to Bald Mountain is limited to a few 4-wheel drive

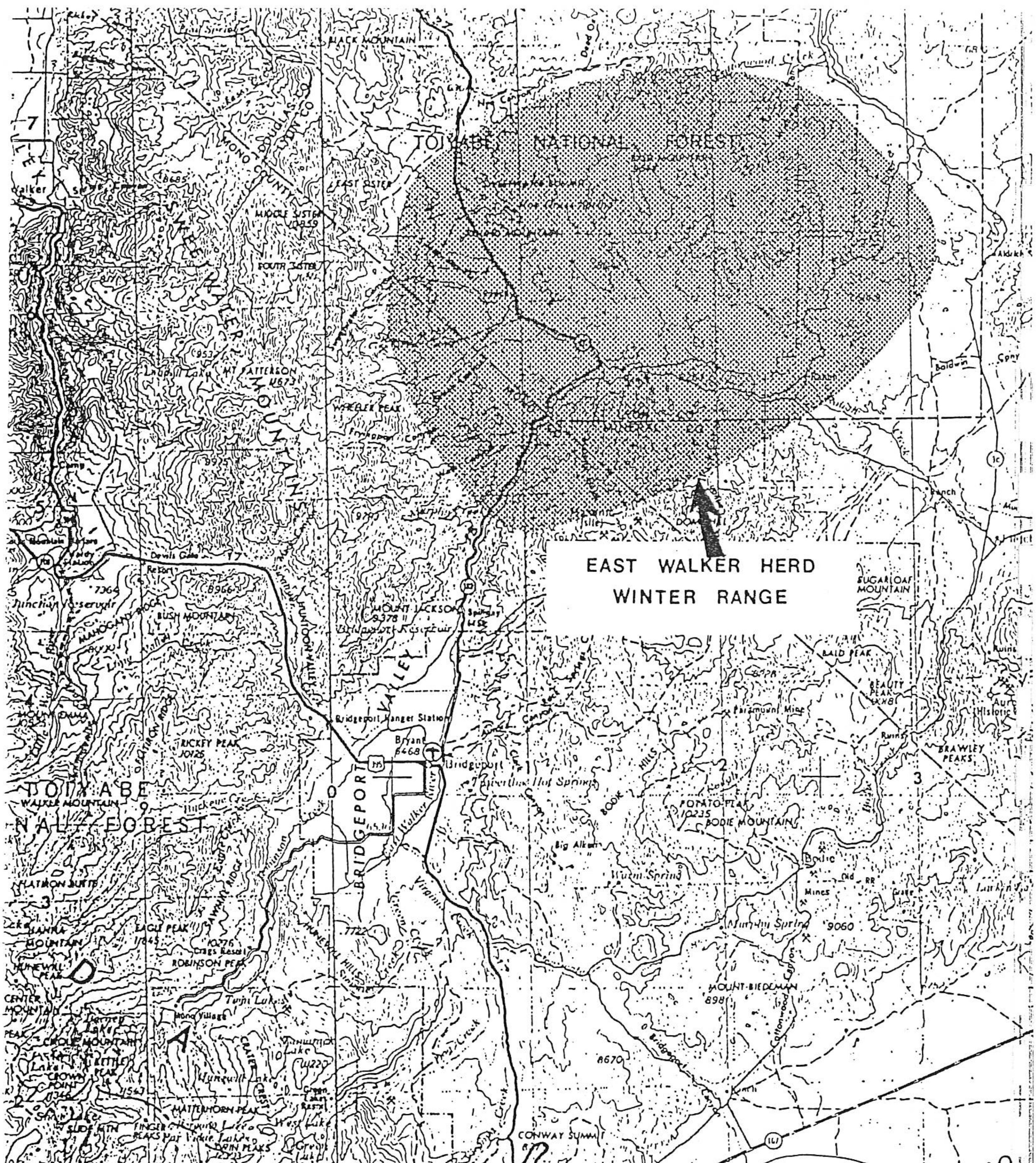

Figure 2-1. Location of the East Walker deer herd winter range in Mineral and Lyon Counties, Nevada.

roads, all of which enter the area from the west. Soils on the winter range are shallow to moderately deep (25-100 cm) and generally have a sandy loam texture (Thomas 1985a).

Vegetation on the winter range is Great Basin sagebrush scrub type (Munz and Keck 1959). Shrubs, big sagebrush (Artemisia tridentata), saltbush (Atriplex spp.), Mormon tea (Ephedra nevadaensis) and rabbitbrush (Chrysothamnus spp.) dominate vegetation along the lower rolling foothills of the Bodie Hills and the Pine Grove Hills at elevations below 1900 m. Singleleaf pinyon pine (Pinus monophylla)-western juniper (Juniperus occidentalis) woodland is the dominate vegetation type above 1900 m. Associated understory vegetation includes big sagebrush, bitterbrush (Purshia tridentata) and rabbitbrush. The most common grass species occurring on the winter range include bromegrass (Bromus spp.), blue grass (Poa spp.), Indian rice grass (Oryzopsis hymenoides), squirreltail (Sitanion hystrix), and needle and thread grass (Stipa comata). Common forbs include lupine (Lupinus spp.), mustard (Brassica spp.), storksbill fillaree (Erodium cicutarium) and phlox (Phlox spp.).

The ML deer herd occupies approximately 2000 sq. km primarily in Mono County, California and Mineral County, Nevada. The herd winter range encompasses some 250 sq. km on the TNF in Mineral County, Nevada, between 12 and 35 miles south of Hawthorne, Nevada, in the Excelsior and Wassuk mountain ranges (Figure 2-2). The Excelsior and Wassuk mountains are adjacent ranges which originate from the Anchorite Hills approximately 20 km north of Mono Lake. The two ranges are oriented in a north-south direction and are divided by a large sandy flat, Whiskey Flat, which extends from Anchorite Pass, north toward Hawthorne and Walker Lake. California Route 167 and Nevada Route 359, which traverse the west side of Whiskey Flat, is the main vehicular route in the area, connecting the east slope of the Sierra Nevada with Hawthorne, Nevada.

The Wassuk Range is approximately 30 km long and extends from Walker Lake, just north of Hawthorne, Nevada, to the Anchorite Hills. The range gradually increases in elevation from south to north and includes several high peaks including Powell Mountain (2905 m), Buller Mountain (2879 m) and Corey Peak (3206 m). Winter range boundaries are recognized as Lucky Boy Pass to the north, the Anchorite Hills to the south, Nine Mile Flat to the west and Whiskey Flat to the east. Numerous steep canyons drain east and west from the Wassuk Range, several of which contain 4-wheel drive roads that provide access to the interior portion of the range.

The Excelsior Mountains are located directly east of the Wassuk Range on the east side of Whiskey Flat. This mountain range extends nearly 60 km from the Anchorite Hills to the south and Nevada Route 95 to the north. The winter range is

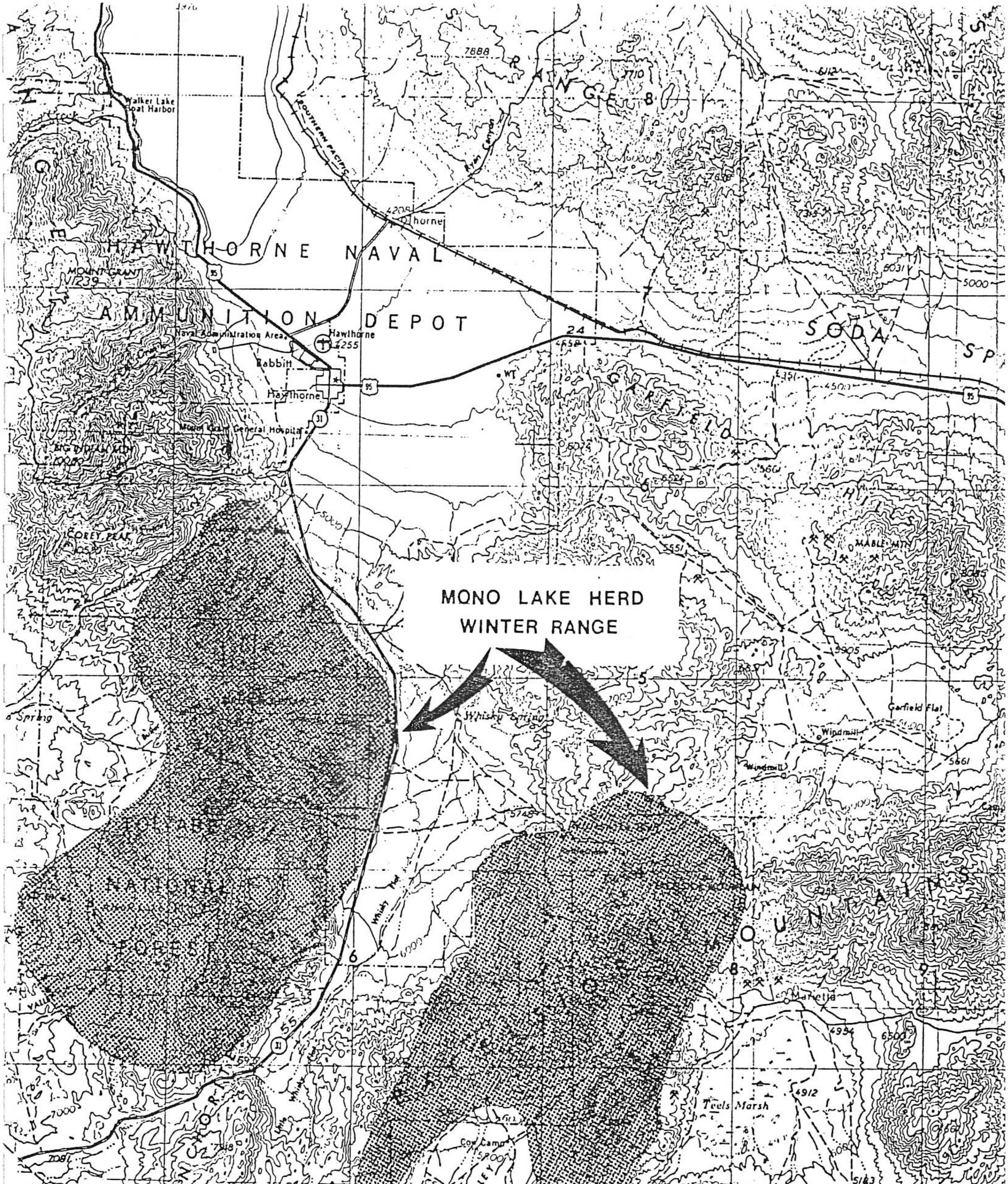

Figure 2-2. Location of the Mono Lake deer herd winter range in Mineral County, Nevada.

located in the southern half of the Excelsior Mountains and is bounded by the Anchorite Hills to the south, Excelsior Mountain to the north, Huntoon Valley to the east and Whiskey Flat to the west. Elevation on the Excelsior winter range varies from 1900 m at Whiskey Flat to 2400 m near Excelsior Mountain, the upper end of winter deer use. Both the Excelsior and Wassuk mountain ranges are dominated by singleleaf pinyon pine-western juniper woodland. Understory vegetation is Great Basin sagebrush scrub type consisting primarily of big sagebrush, bitterbrush, Mormon tea, and rabbitbrush (Munz and Keck, 1959). The lower western slopes of the Excelsior Mountains are gently sloping and open and are dominated by big sagebrush with a grassy understory consisting primarily of Indian rice grass, squirreltail, and needle and thread grass. Vehicular access to the Excelsior winter range is provided by a single 4-wheel drive dirt road which enters the area from Nevada Route 359 through Whiskey Flat. Soils on the winter range are mainly an admixture of sandy loams which are generally shallow and rocky (Thomas 1984b).

Deer from the EW and ML winter ranges share approximately 2000 sq. km of summer range on the TNF, primarily along the east slope of the Sierra Nevada range. Portions of the Stanislaus National Forest (SNF) in Tuolumne county on the west side of the Sierra Nevada are also used to a limited extent by summering deer. Nine plant communities (USDA 1981) varying in elevation from 2130-2950 m, have been identified on summer ranges used by radio-collared deer.

Great Basin Sagebrush Scrub.----This type generally occurs on dry slopes and plains east of the Sierra crest, primarily in the Bodie Hills, the Hunewill Hills, the Conway Summit area and the west side of the Sweetwater Mountain range. This type is most often found in association with Jeffrey pine (*Pinus jeffreyi*) forest and pinyon-juniper woodland.

Single-leaf pinyon pine-western juniper woodland.----This type occurs mainly on dry south and east facing slopes of the Sierra Nevada, the Sweetwater mountain range, and the Bodie Hills. Where this type occurs, singleleaf-pinyon pine is the dominate conifer species between approximately 2070-2600 m, with curlleaf mountain mahogany (*Cercocarpus ledifolius*), big sagebrush, and bitterbrush occurring as codominates.

Jeffrey Pine.----This type is open Jeffrey pine forest which occurs in scattered stands between elevations of approximately 2200-2450 m. This habitat type is most prevalent to the west of California Route 395, from the Twin Lakes drainage north to around Pickle Meadows. Associated understory species include sagebrush, bitterbrush, gooseberry (*Ribes* spp.), and mountain snowberry (*Symphoricarpos vaccinioides*).

Quaking Aspen Riparian.----This dense cover type occurs within a few meters of most stream channels on the east slope of the Sierra Nevada, in the Bodie Hills, and in the Sweetwater mountain range. Quaking aspen (*Populus tremuloides*) and willow (*Salix* spp.) dominate vegetation, with wild rose (*Rosa woodsii*), gooseberry, snowberry, and cornlily (*Veratrum californicum*) occurring as understory species.

Mixed Conifer.----The codominates of this vegetation type, which occur mainly on the east slope of the Sierra Nevada between 2400-2600 m, include Jeffrey pine, white fir (*Abies concolor*), lodgepole pine (*Pinus contorta*), and western white pine (*Pinus monticola*). At higher elevations of the Mixed Conifer type, red fir (*Abies magnifica*) is an occasional associated species with white fir often occurring in pure stands at lower elevations.

Lodgepole Pine Forest.----This forest type is found above the Mixed Conifer type primarily on the east slope of the Sierra Nevada and the west slope of the Sweetwater Mountains at elevations between 2600-3000 m. It is composed of lodgepole pine which often occurs in large dense, homogeneous stands. Within the lodgepole pine forest perennial grasses and forbs (needle-and-thread grass, bluegrass, bromegrass, lupine, and pussy paws (*Calyptridium caudiciferum*)), dominate openings of poorly developed, dryer soils.

Montane Chaparral.----This type occurs on open flats and rocky ridges from 2135-3050 m in the Sweetwater Mountain and the lower foothills of the Sierra Nevada mountains. Greenleaf manzanita (*Arctostaphylos patula*), mountain whitethorne (*Ceanothus cordulatus*), chinquapin (*Castanopsis sempervirens*), and tobacco brush (*Ceanothus velutinus*) occur as codominates. This type is often found in association with big sagebrush.

Whitebark Pine.----This forest type, dominated by whitebark pine (*Pinus albicaulis*), occurs on high windswept ridges at treeline on the east slope of the Sierra Nevada.

CHAPTER 3. POPULATION CHARACTERISTICS

Historical Abundance and Trend

Before settlement by European man, deer were scarce in the eastern Sierra. According to early reports by explorers Walker in 1834, Fremont in 1844 and Von Schmidt in 1856, the eastern Sierra supported sparse populations of big game, primarily bighorn sheep (Ovis canadensis) and American pronghorn antelope (Antilocapra americana) (Thomas 1985a).

In the 1860's the mining industry stimulated development in the region and as a result a grazing economy was established in order to supply the mining settlements of Bodie and Aurora. Large bands of domestic sheep were grazed beginning in the 1870's and by 1877 approximately 180,000 sheep roamed freely in Sierra mountain meadows (Moore 1981). Sheep herdsman also set fire to the range to protect sheep from predators.

At about the same time, market hunters invaded the region, supplying whatever game they could shoot to miners. Market hunting in combination with overgrazing of the bunch grass community by domestic sheep combined to virtually eliminate bighorn sheep and antelope. As a result, bunchgrass ranges were slowly converted to brush, mainly bitterbrush and sagebrush, which provided increased deer browse and prompted a gradual increase in deer numbers until the 1930's.

In addition to meat and wool, the demand for lumber also increased throughout the eastern Sierra in the 1860's. Jeffrey pine (*Pinus jeffreyi*) trees, from forests located south of Mono Lake and on Sawmill Ridge, supplied mining towns such as Bodie, Masonic and Aurora with firewood and buildable lumber. Early logging practices often consisted of clearcuts, which ultimately provided early succession conditions favorable for deer.

Deer tags were first issued by DFG in 1927; only 36 deer were reported taken in Mono County in that year (Thomas 1985a). During the 1940's and 1950's the number of deer in Mono County increased to an estimated 25,000 animals (Britton 1970), which was clearly beyond carrying capacity of most winter ranges. As a result, intensive antlerless hunts were held in Mono County in 1955 and then again in the mid-sixties for the purpose of reducing excessive deer numbers (Thomas 1984). Both antlerless hunts and the severe winter of 1969, which was 259% of the average annual snow fall (Department of Water Resources 1969), combined to reduce pressure on the range (Thomas 1985a, 1985b).

METHODS

Winter and early spring composition counts were conducted on winter ranges in January and March, respectively, using a Bell Jet Ranger III helicopter. Spring composition counts were also conducted from a vehicle and on foot in more accessible portions of the winter range.

Small sample sizes classified on the EW and ML winter ranges precluded the use of mark-recapture methods for estimating possible differences in population size between these herds. Therefore, buck harvest data and early and late winter fawn-doe ratios were used in a model provided by Dasmann (1952) to derive combined autumn population estimates for the EW and ML deer herds from 1988-90. This model incorporates the use of a table that, after inserting the appropriate buck-doe and doe-fawn ratios, permits the number of deer left for each buck killed to be read directly (Connolly 1981).

Dasmann's (1952) method contains several potential sources of error (Connolly 1981). The method assumes that nonhunting loss rates are equal for fawns, does and bucks; that fawns survive to yearling age in about an equal sex ratio; and that no change in sex ratio occurs from immigration or emigration. For these reasons and the fact that this method is based on the true reported buck kill, it is likely to underestimate the true population size.

RESULTS

Recent Population Trends

Population Size.--Combined autumn population estimates for the EW and ML herds indicate that the population was relatively stable from 1987-1990. Estimated numbers of deer on the EW and ML herd winter ranges was 5320 in 1987-88, 5829 in 1989-90, and 5544 in 1990-91.

These estimates are likely to be low for the reasons described above and the fact that in some years both autumn buck ratios and early and late winter fawn ratios were well below the lowest ratios provided in Dasmann's table. Nonetheless, these estimates approximate those most recently provided by DFG.

Population Structure.--Over the last 6 years (1984-1990) fawn to adult ratios based on winter (January) and early spring (March) classifications, suggest that fawn production and survival is moderately low overall and has been declining since 1987 (Table 3-1). For the ML herd, post-season (January) ratios have declined from 52 fawns per 100 does in 1985-86 to 29 fawns per 100 does in 1990-91. EW deer have followed a similar trend, with post-season fall fawn ratios declining from 44 fawns per 100 does in 1985-86 to 19 fawns per 100 does in 1989-90.

Table 3-1. Post-season fawn to doe (fawns/100 does) ratios and buck to doe (bucks/100 does) ratios and spring fawn to adult (fawns/100 adults) ratios for the East Walker and Mono Lake deer herds. 1985-1990.

Year	Post-season bucks/100dd	Post-season fawns/100dd	Spring Fawns	Fall Sample	Spring Sample
		East Walker Herd Composition			
1985-86	15	44	26	456	469
1986-87	11	48	35	170	573
1987-88	22	37	21	239	234
1988-89	9	20	17	227	333
1989-90	19	19	15	231	340
1990-91	19	30	--	263	---
		Mono Lake Herd Composition			
1985-86	6	52	20	257	272
1986-87					
1987-88	17	41	35	317	285
1988-89	22	31	--	250	---
1989-90	12	26	16	388	350
1990-91	14	29	--	238	---

Sex ratios determined from helicopter classifications in January 1988-1990, indicated 9, 19 and 19 males per 100 females, respectively, for the EW herd, and 22, 12, and 14 males, respectively, for the ML herd. Relatively low male to female ratios were also indicated by sex ratios of deer captured in drive netting operations in 1988; 20 males per 100 females in the EW sample and 17 males per 100 females in the ML sample.

Age structure data gathered from drive netting operations indicated that yearlings and fawns comprised 37% of 38 animals trapped on the EW winter range in 1988 and 41% of animals trapped in 1989 (Figure 3-1). In 1988, the only year in which deer were captured with drive nets on the ML range, fawns and yearlings constituted 33% of animals trapped; the 3.5 and 4.5 year classes made up 19% and 24% of the sample, respectively (Figure 3-2).

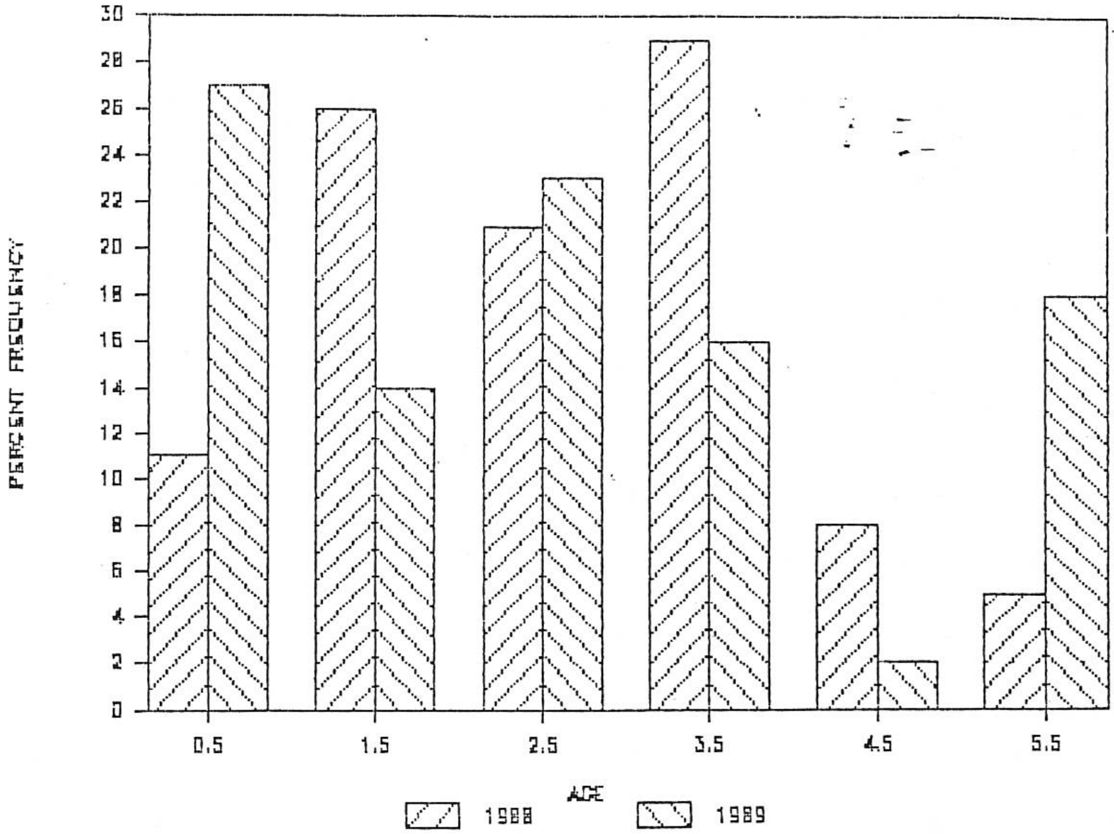

Figure 3-1. Age distribution of mule deer examined during trapping operations on the East Walker deer herd winter range. 1988-1989.

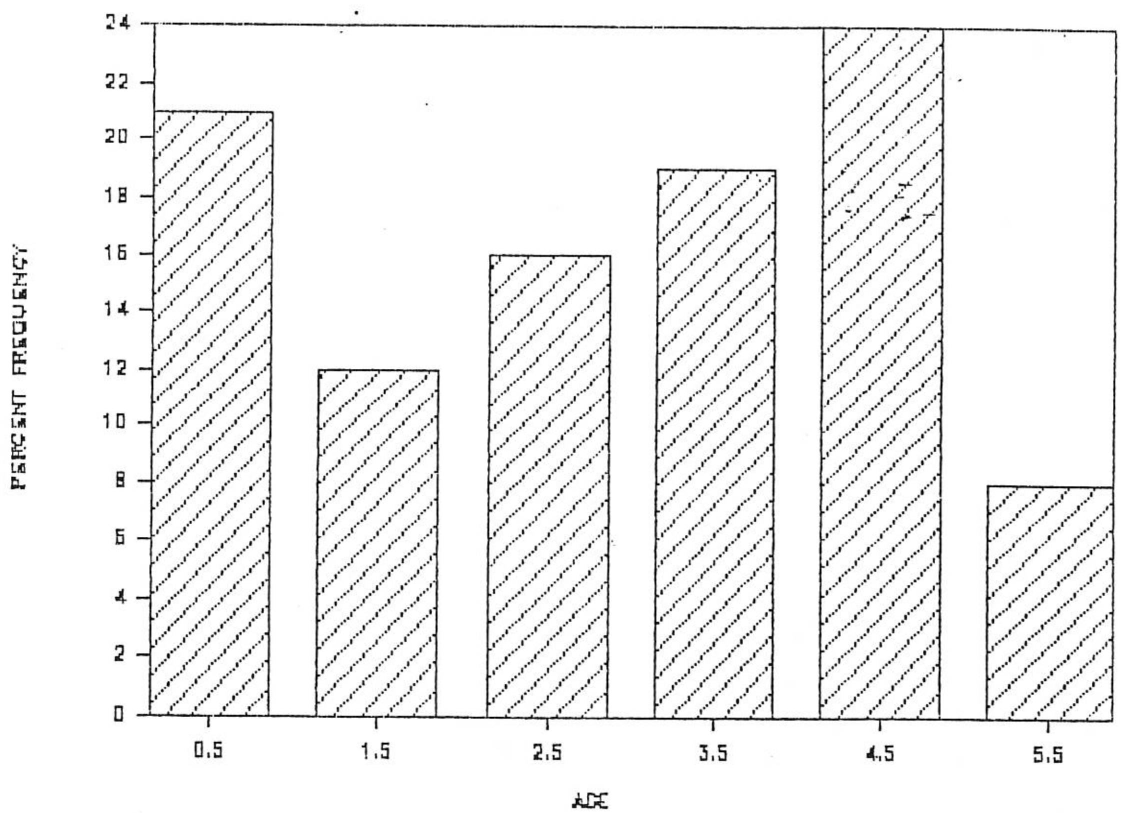

Figure 3-2. Age distribution of mule deer examined during trapping operations on the Mono Lake deer herd winter range. 1988.

CHAPTER 4. MIGRATION AND DISTRIBUTION

Mule deer from the EW and ML herds are migratory, spending the cold winter months at lower elevations in Nevada and the hot summer months at upper elevations along the east slope of the Sierra Nevada mountain range in California. A small number of deer are year-round residents on the winter range, occupying the cooler canyons and drainages in the summer months and the upper elevation Pinyon-Juniper Woodlands during the winter.

Within the last decade, critical habitats used by both herds have been subject to increased demands for multiple commercial, residential and recreational use. However, prior to this investigation, the DFG had obtained very little specific information on the locations and distributions of these critical habitats. This was mostly due to manpower constraints and alternative priorities which precluded the acquisition of such herd specific data. Apart from its scientific value, detailed information on seasonal ranges and migration routes can provide guidance to land management agencies and local governments when making resource allocations that will ultimately dictate the future of the EW and ML herds. To this end, and in order to fill other information gaps concerning the ecology of the EW and ML deer herds, the present investigation was initiated in January of 1988.

METHODS

The East Walker-Mono Lake deer herd study began in January of 1988 and continued with varying intensity through June of 1991.

Deer were captured on the EW and ML deer herd winter ranges from 1 March-4 March 1988 and 22 and 23 March 1989 using a drive net (Beasom et al. 1980) and a Bell Jet Ranger III helicopter. Deer were hazed slowly by helicopter into the net which is 2.4 m high and consists of 15-30 each 15 m panels. The panels were oriented end to end in an appropriate size and configuration and propped up by light weight poles at necessary intervals along the entire length. Net size and configuration were based on terrain and the deer's anticipated flight path. Net sites were preselected by the capture team through aerial reconnaissance and usually employed natural escape routes such as ravines or the mouths of small canyons. Anywhere from 1-10 deer were captured on successive drives until desired numbers were obtained for each wintering area. A small number of deer were individually captured on remote areas of both winter ranges using a helicopter and a hand-held net gun (Coda Enterprises, Mesa, Ariz.).

All deer caught in drive nets or with the net gun were physically restrained and marked with large, plastic, consecutively numbered cattle ear tags (7.5 x 11.5 cm;

Allflex Tag Systems, Harbor City, Calif.), color coded to wintering area. Forty-seven adult females were fitted with radio-collars. In addition, 14 adult males were instrumented with radio transmitters mounted on expandable collars to allow for neck swell during the rut.

Adult radio-collars (159.150-159.470 MHz; Telonics, Inc., Mesa, Ariz.), weighed 260-270 g and had an operational life of 24-36 months at 35-75 pulses per minute. All units were equipped with mortality sensing circuitry which causes the transmitter to double its pulse rate when the animal is stationary for 3-5 hours.

Radio-collared animals were located during all daylight hours by triangulation (1 observer) from the ground which accounted for approximately 75% of all locations obtained between March 1988 and January 1990. The remaining locations were obtained from fixed-winged flights. Deer were located 3-4 times weekly during the spring and fall migrations and 1-2 times weekly during the summer and winter months. Initial ground locations were made from a vehicle equipped with a Telonics TR-2 receiver with an attached program/scanner (TS-1) and a base loaded whip antenna. Triangulation bearings were obtained using a hand-held, 2 element antenna (RA-2A; Telonics, Inc., Mesa, Ariz.). Visual sightings of radio-collared deer were made whenever possible and were marked on U.S. Geological Survey 7.5 and

15 minute series topographic maps.

Fixed-wing flights were conducted once weekly, weather permitting, during the spring and fall migrations and biweekly during the summer and winter months, usually between 0800 and 1000 hours. Flights were conducted from a Cessna 185 at air speeds of 120-180 km/hr.

In situations where the precise date of departure of a radio-collared animal from the winter range was not determined, the midpoint between when a deer was last located and first not located on the winter range was considered to be the date of departure (Kucera 1988). The Julian date at which an individual deer left the winter range in consecutive years was used as the dependent variable in a one-way ANOVA to test for differences between years in the temporal pattern of migration.

Summer home ranges and secondary winter home ranges (Burt 1943) were determined using the Modified Minimum Area method (Harvey and Barbour 1965). Each home range included a minimum of 10 relocation points determined from visual daytime observations. Radio-collared deer were considered to show fidelity to a specific home range if ranges in consecutive years overlapped.

RESULTS

Capture and Marking

Between 1 March and 3 March 1988, 22 and 23 March 1989, and on 10 January 1990, a total of 162 deer were captured, marked and released on the EW and ML winter and spring ranges. Of these 162 deer, 61 were radio-collared, 31 from the EW herd and 30 from the ML herd.

Between 1 March and 3 March 1988, a total of 66 deer were captured, marked and released on 4 different areas on the ML deer herd winter range. On 1 March, a total of 13 deer (11 females and 2 males) were captured on the east slope of the Wassuk Range at two different net sites located at the mouths of Johnston and Cottonwood Canyons. Nine of these (8 females and 1 male) were fitted with radio-collars; 4 deer were marked with ear tags only.

On 2 March, 31 deer (26 females and 5 males) were captured near Rattlesnake Wells in the Excelsior Mountains. Six of these were fawns (3 males and 3 females) and 6 were yearling (2 males and 4 females); 20 were adult does and 3 were adult males. Of the 31 deer captured in the Excelsior Mountains, 10 does and 1 yearling male were radio-collared; the remaining 19 were marked with ear tags only.

On 3 March, 19 deer (17 females and 2 males) were captured in another portion of the Wassuk Range near the mouth of Powell Canyon, located approximately 5 km south of

Johnston Canyon. Of these 19 deer, 5 were fawns (2 males and 3 females) and 13 were adult females; only 1 yearling, a female, was captured. Two of the adult females were radio-collared; 17 were marked with ear tags only. Also on 3 March, 3 deer (2 females and 1 male) were individually captured with a helicopter net gun near Huntoon Valley, a remote portion of the Excelsior Mountains; all were fitted with radio-collars before being released.

On 23 March 1989, two deer (1 adult doe and 1 adult buck) were radio-collared along a migration route of the ML herd after being individually captured with a helicopter net gun. The doe was marked on Powell Flat and the buck was marked in the Bodie Hills near Warm Springs.

A total of 82 deer were captured, marked and released on the EW winter range on 4 and 5 March 1988 and 22 and 23 March 1989. On 4 March 1988, 36 deer were captured at a single drive net site located 1 km north of the East Walker River. Four of these were fawns (2 males and 2 females); 9 were yearlings (8 females and 1 male); 20 were adult females; and 3 adult males. Of these 36 deer, 10 adult females and 1 adult male were equipped with radio collars; the remaining 25 were marked with ear tags only.

On 5 March 1988, 3 adult deer (2 females and 1 male) were radio-collared on remote areas of the EW winter range after being individually captured with a helicopter net gun.

Between 22 and 23 March 1989, 43 deer were captured, marked, and released on the EW winter range at three different drive net sites. Five of these were fawns (3 male and 2 female) and 5 were yearlings (3 male and 2 female); 28 were adult females and 5 adult males. Of these 43 deer, 13 (10 females and 3 males) were instrumented with radio-collars. Also on 23 March, a single adult doe was radio-collared on a remote portion of the EW winter range after being captured with a helicopter net gun.

On 10 January 1990, 6 adult bucks (3 from the ML herd and 3 from the EW herd) were radio-collared on the winter range after being individually captured with a helicopter net gun.

A. WINTER RANGE

East Walker Deer Herd

The primary winter range of the EW herd is located on the south and southeast sides of Bald Mountain, Nevada (Figure 2-1). This area supported deer concentrations in all winters between 1988 and 1990. Radio-collared deer spent the winter months (late October-late January) at elevations of 2300-2500 m, primarily on steep, snow covered north and west facing slopes in relatively dense pinyon pine forest or above tree line ($\geq$2500 m) in large openings of Sagebrush Scrub and on the tops of ridges in large, dense stands of

Cercocarpus ledifolius. All radio-collared deer from the EW herd that were monitored for ≥2 years displayed a high degree of fidelity to individual wintering sites although specific locations occupied varied with weather conditions. During late winter (1 February-1 March) deer displayed dramatic decreases in elevation in response to plant development at lower elevations (1800-2100 m). Once at these lower, secondary winter ranges, deer congregated in large numbers where annual grasses and forbs dominated vegetation, mainly on open slopes at the southern base of Bald Mountain and on the irrigated pastureland immediately adjacent to the East Walker River. Deer trapped on lower elevation winter ranges in March of 1988 and April of 1989 showed a high degree of fidelity to individual home ranges within these secondary winter ranges. Cumulative secondary winter ranges for 4 females followed for three winters averaged 0.9-2.2 sq. km.

One exception to the winter pattern described above was doe #180 who spent 9 months of the year (May-February) on summer/transition range located on the northeast side of Potato Peak in the Bodie Hills, some 23 km south of the East Walker River where she was captured. This area of transition range is located at an elevation of approximately 2,500 m and is dominated by Sagebrush Scrub vegetation. During two consecutive years, this doe returned to the lower secondary winter range along the East Walker River in early February.

Mono Lake Deer Herd

The primary winter range of the ML herd includes the Wassuk and Excelsior mountain ranges in Mineral County, Nevada (Figure 2-2). Between late October and late February, all radio-collared deer (n = 15) which wintered in the Wassuk Mountains remained at elevations ranging from 2500-2900 m, primarily on Buller and Powell Mountains and in Powell, Jim, Johnston and Cottonwood Canyons. During aerial surveys of the Wassuk Range conducted in early January of 1989 and 1990, deer were typically found on steep pinyon covered slopes with north and west aspects or above tree line in open areas of Sagebrush Scrub containing dense pockets of <u>Cercocarpus ledifolius</u>. All radio-collared deer (n = 14) marked in the Excelsior Mountains spent the winter months (November-February) primarily to the south and east of Rattlesnake Flat on steep pinyon covered north and west facing slopes between 2300 and 2500 m elevation.

In late February 1988, 1989 and 1990, deer from both the Wassuk and Excelsior mountain ranges migrated to lower secondary winter ranges at elevations ranging from 1800-2100 m. Mean distance traveled between early winter (9 November-27 December) and late winter/spring (25 February-2 May) locations was 8.3 km (range = 7-13 km) and 4.2 km (range = 3-5 km) for 23 deer from the Wassuk and Excelsior Mountains, respectively. As with deer from the EW herd, deer congregated in areas where green herbaceous forage was abundant, primarily on snow free south and east facing slopes.

From 1988-1990, 12 of 14 radio-collared deer from the Wassuk Range spent the late winter and early spring months (25 February-2 May) on a secondary winter range located at the base of the east slope of the Wassuk Range, primarily within a narrow strip of Sagebrush Scrub vegetation between Nevada Route 359 from the base of the escarpment. Eleven of 14 radio-collared deer from the Excelsior Mountains spent February-March at the base of the west slope of this range, primarily on south and east facing slopes in the Rattlesnake Flat area where they were marked in March 1988 (Figure 2-2).

B. SPRING MIGRATION

Sixty-one radio-collared deer (47 does and 14 bucks) from the EW and ML deer herds were located 3872 times from March 1988 to January 1990. A total of 16 radio telemetry flights were conducted during the spring of 1988 to locate deer during migration. Because of generally poor weather conditions, only 7 and 6 telemetry flights were conducted during the spring migrations of 1989 and 1990, respectively. All deer were migratory with distinct winter and summer ranges. Migratory group sizes ranged from 2-28 deer/group ($\bar{x}$ = 7.2, N = 50).

East Walker Deer Herd

The timing of departure from the winter range varied widely among individuals radioed for two or more consecutive years. In 1989, individuals left the winter range as many as 25 days earlier and 4 days later than in 1988. In 1990, individuals left the winter range as many as 13 days earlier and 40 days later than in 1989.

From 1988-1990, the first radio-collared deer left the EW winter range on 9 April, 30 March and 7 April, respectively (Figure 4-1). The mean date of departure from the winter range in 1988-1990 was 23 April, 14 April and 24 April, respectively. There was a significant difference in mean dates of departure by year (F = 7.07; 2, 51 df; p = .0019). Males left the winter range an average of 5 and 4 days earlier and 21 days later than females in 1988-1990, respectively; there was no significant difference ($P > 0.05$) in the timing of departure dates by sex.

During the spring migrations of 1988-1990, all radio-collared deer migrated south from the EW winter range to summer range located in northern Mono and western Tuolumne Counties, California. The migration corridor used by most deer (n = 24) followed the East Walker River drainage to the Bridgeport Valley. Deer then migrated around the west side of the valley between Bridgeport Reservoir and the base of the east slope of the Sweetwater Mountains and Mt. Jackson

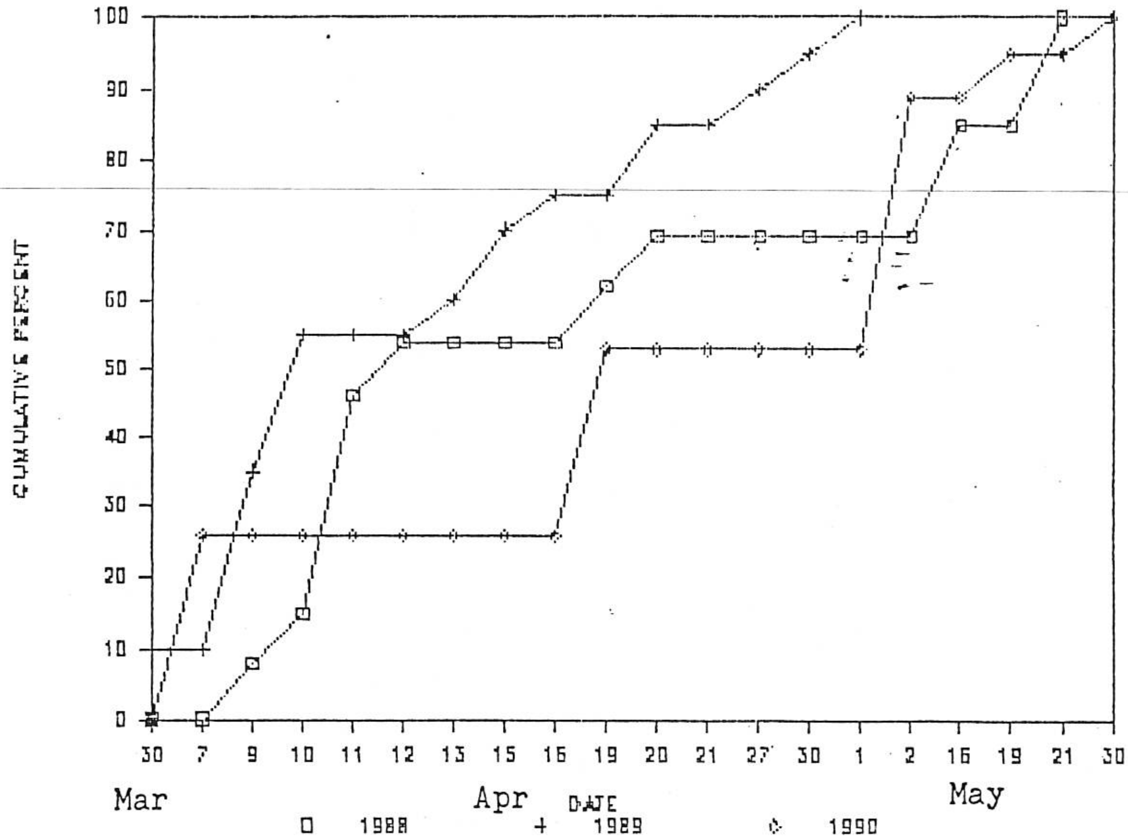

Figure 4-1. Cumulative percent of radio-collared deer migrating from the East Walker winter range by date. Spring 1988-1990.

(Figure 4-2). Terrain in this corridor is moderately sloping and vegetation is dominated by Sagebrush Scrub and Pinyon-Juniper Woodland (Munz and Keck 1959). Elevations range from 2050-2500 m.

After moving through the Bridgeport Valley, 19 deer crossed Route 395 at several major locations between the Bridgeport Ranger Station (post mile 80.7) and the north end of Huntoon Valley (post mile 87.0). Highway kill data provided by the California Department of Transportation (Caltrans) and ground surveys of major migration routes, indicate that the area of most concentrated crossing occurs along a 4.5 km stretch of highway located between the Bridgeport Ranger Station and the south end of Huntoon Valley (post mile 79.7-82.5). Terrain within this crossing is steep and rugged as characterized by several prominent road cuts partitioned by small drainages. It is these drainages where the majority of deer trails cross the highway.

Once south of the highway, deer delayed from 1-4 weeks on the Buckeye holding area (Bertram and Remple 1977) located at the base of the eastern escarpment of the Sierra Nevada mountains. The Buckeye holding area extends from Sawmill Ridge near Lower Twin Lake, north to the Little Walker River at elevations ranging from 2200-2500 m (Figure 4-2). It encompasses the mouths of numerous drainages which flow north from the Sierra, including: Robinson Creek, Buckeye Creek,

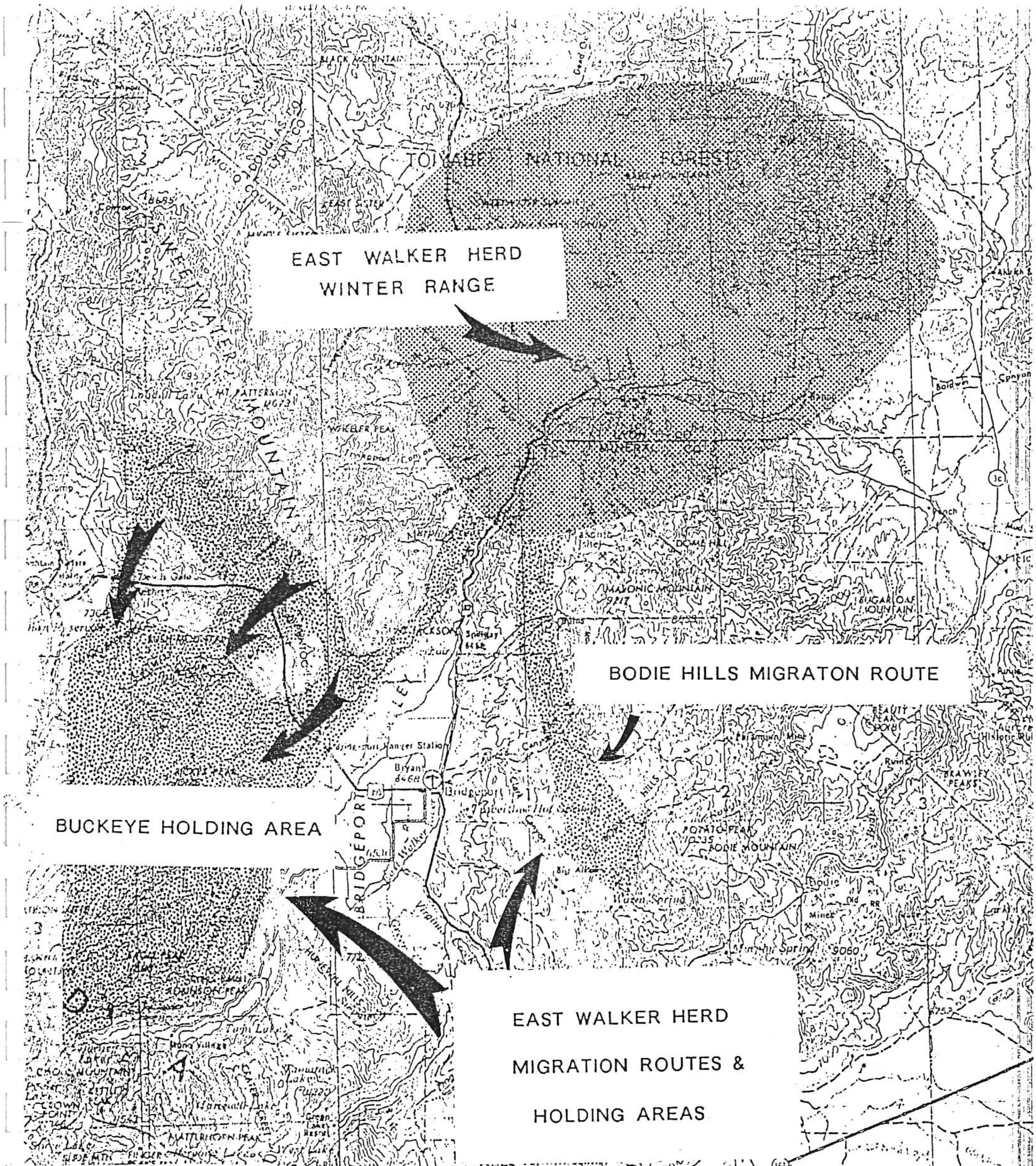

Figure 4-2. Locations of migration corridors of the East Walker deer herd.

Log Cabin Creek, and By-Day Creek; Patterson, Yaney and Sario Canyons; Huntoon Creek, Long Valley Creek and the Little Walker River. This holding area also includes the lower elevation foothills surrounding the mouths of the Swauger Creek, Mack Canyon and Harvey Creek drainages which flow south from the Sweetwater Mountains into Huntoon Valley, north of Route 395.

Five radioed deer, those which did not cross Route 395, delayed in portions of the Buckeye holding area which extend north of the highway. These deer accessed this portion of the holding area by crossing the lower and usually snow free southern end of Mt. Jackson (Figure 4-2).

The areas used by deer on the Buckeye holding area are composed largely of Sagebrush Scrub (Munz and Keck 1959), characterized by stands of _Artemisia tridentata_, _Purshia tridentata_, _Cercocarpus ledifolius_, _Pinus Jeffreyi_, and _Pinus monophylla_. Deer which first arrived on this holding area in late March and early April were often located on snow free south and east facing slopes where succulent herbaceous forage and new growth of browse was readily available.

Of the 19 deer which delayed south of Route 395, 16 deer migrated to summer ranges located to the south and west of the Buckeye holding area (Figure 4-3). Deer dispersed to summer ranges in gradual elevation changes via drainages that connect this holding area with upper elevation summer ranges

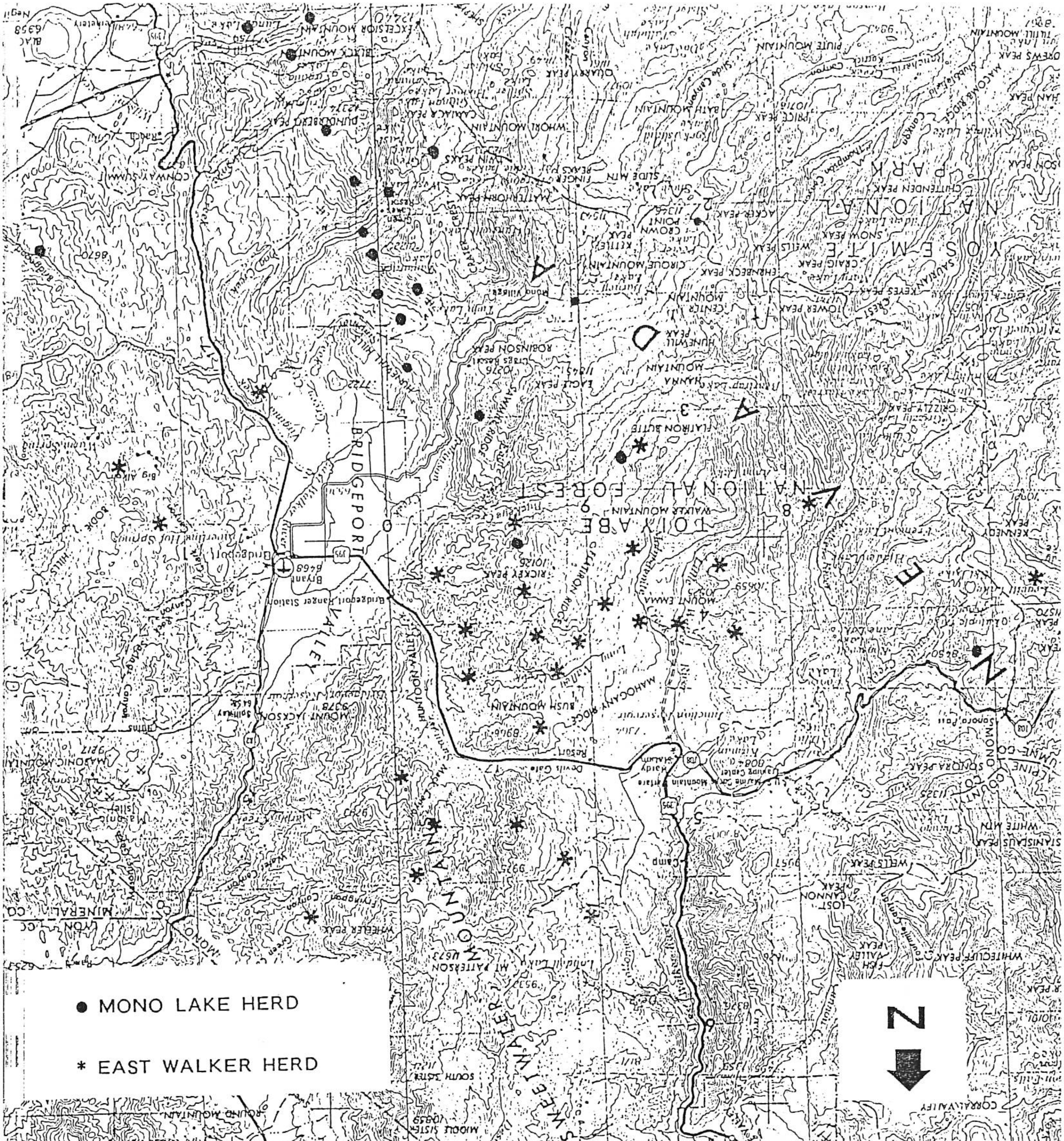

Figure 4-3. Summer range locations of East Walker and Mono Lake radio-collared deer. 1988-1990.

located between Buckeye Creek and Sonora Pass above approximately 2600 m. For example, deer which delayed at the southern end of the Buckeye holding area near the mouth of Buckeye Creek, used this drainage to reach summer range located near the Sierra crest (Figure 4-3). Deer which delayed in the vicinity of Patterson and Yaney Canyons used these drainages to access summer range in the Rickey Peak area. The Sario Canyon and Huntoon Creek drainages were used by deer from the Buckeye holding area to access summer range which extends from Rickey Peak, west to Sonora Pass and the west slope of the Sierra (Figure 4-3). The three deer which did not migrate south occupied summer home ranges located on upper elevation peaks within the Buckeye holding area.

All 5 deer which delayed north of Route 395 in the vicinity of Swauger Creek and Mack Canyon, migrated northwest to summer range located on the west slope of the Sweetwater Mountains at elevations > 2500 m (Figure 4-3).

Five EW deer migrated south into Mono County along a migration route which contours the west slope of the Bodie Hills, east of Bridgeport Valley (2100-2500 m elevation) (Figure 4-3). Topography within this migration corridor is steep and rugged and vegetation is dominated by Pinyon-Juniper Woodland (Munz and Keck 1959). Deer which used this corridor did not delay spring migration but instead migrated directly to summer range located in the south end of the

Bodie Hills (Figure 4-3). Two of the 5 deer which used this migration route summered on the west side of Potato Peak; 1 summered on Bodie Mountain; 1 summered near Willow Springs; and 1 near Twin Lakes (Figure 4-3).

EW deer showed strong fidelity to summer range sites ($P < 0.001$). Mean distances between consecutive summer range sites was $\leq$ 1 km for 100 percent (19 of 19) adult does. The only buck radioed for >2 consecutive years returned to within >2 km of its previous years summer location.

Changes in elevation between secondary winter range located along the East Walker River, where deer spent the late winter and early spring months, and summer ranges along the east slope of the Sierra varied from +450 to +1200 m (Figure 4-4). The mean straight line distances between winter and summer ranges of deer was 35 km (range 23-58 km) (Figure 4-5).

Mono Lake Deer Herd

From 1988-1990, the first radio-collared deer left the ML winter range on 20 March, 17 March and 17 March, respectively (Figure 4-6). The mean date of departure from the winter range in 1988-1990 was 9 April, 29 March and 14 April, respectively. The mean dates did not differ significantly by year ($\underline{F}$ = 3.25; 2, 51 df; $\underline{p}$ = 0.042) and there was no difference by sex in mean departure dates

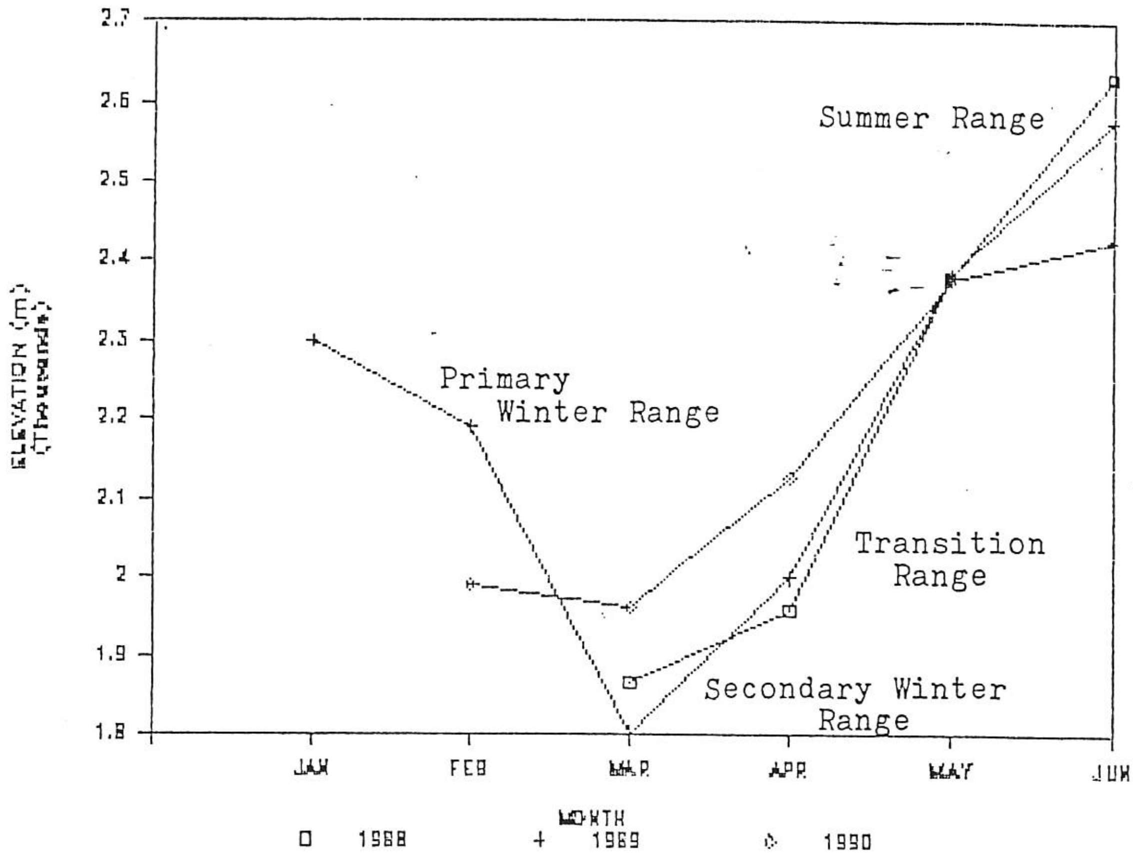

Figure 4-4. Mean elevations inhabited by East Walker radio-collared deer during the winter and spring migration periods. 1988-1990.

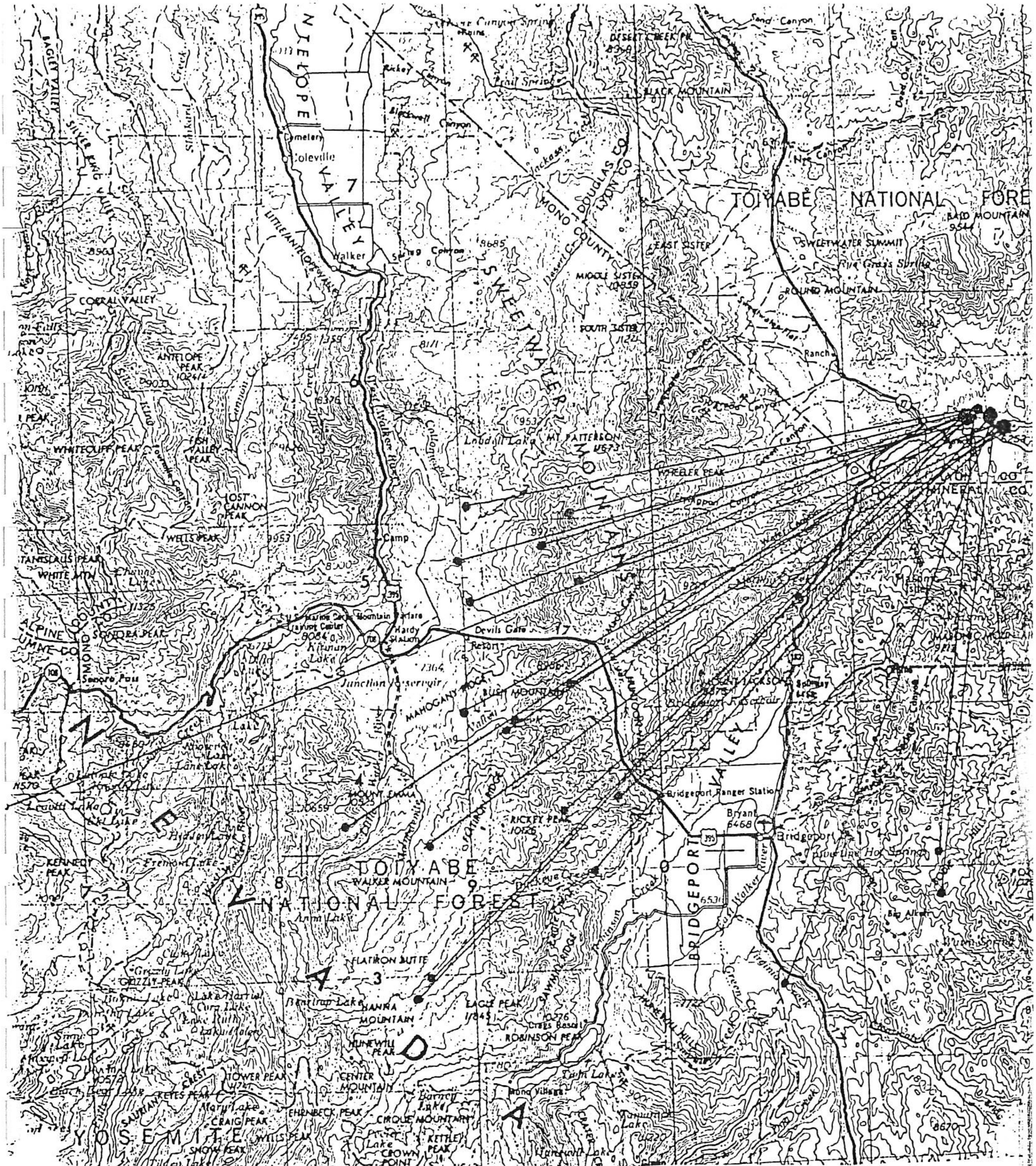

Figure 4-5. Movements of East Walker radio-collared deer marked on winter ranges (large circles) and subsequently found on summer ranges (small circles). 1988-1990.

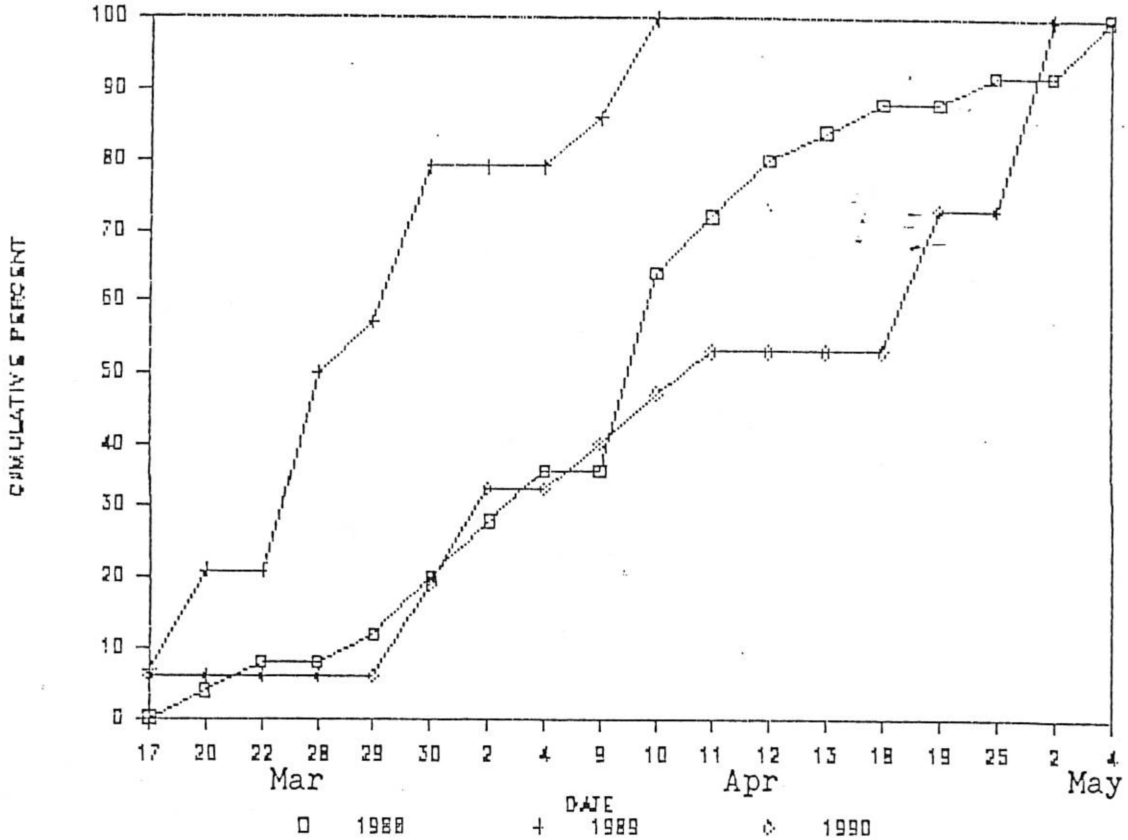

Figure 4-6. Cumulative percent of radio-collared deer migrating from the Mono Lake winter range by date. Spring 1988-1990.

(P > 0.05).

Mean departure dates differed significantly between the EW and ML herds in 1988 (23 April vs 9 April; $\underline{t}$ = 3.14, 36 df, $\underline{p}$ = 0.01;) and 1989 (14 April vs 29 March; $\underline{t}$ = 5.37, 32 df, $\underline{p}$ = 0.01), with ML deer leaving the winter range an average of 14 and 15 days earlier than EW deer in 1988 and 1989, respectively. There was no difference between herds in the mean departure dates for 1990 (24 April vs 14 April, $\underline{t}$ = 1.95, 32 df, $\underline{p}$ = 0.01).

As with the EW herd, the timing of departure from the ML winter range varied widely among individuals radioed for two or more consecutive years. In 1989, individuals left the winter range as many as 20 days earlier and 7 days later than in 1988. Of 8 deer radioed for two consecutive years in 1990, only 1 migrated earlier (-1) than it did in 1988. The remaining 7 deer migrated from 1 to 34 days later in 1990 than the previous year.

During the spring migrations of 1988-1990, 30 of 30 radio-collared deer from the ML herd migrated to summer range located in northern Mono and western Tuolumne Counties, California. Beginning in late March and early April, deer leave their respective winter ranges in the Wassuk Range and Excelsior Mountains and move in a southwesterly direction along separate migration routes toward the Bodie Hills (Figures 4-7a and 4-7b). Most deer from the Wassuk Range had

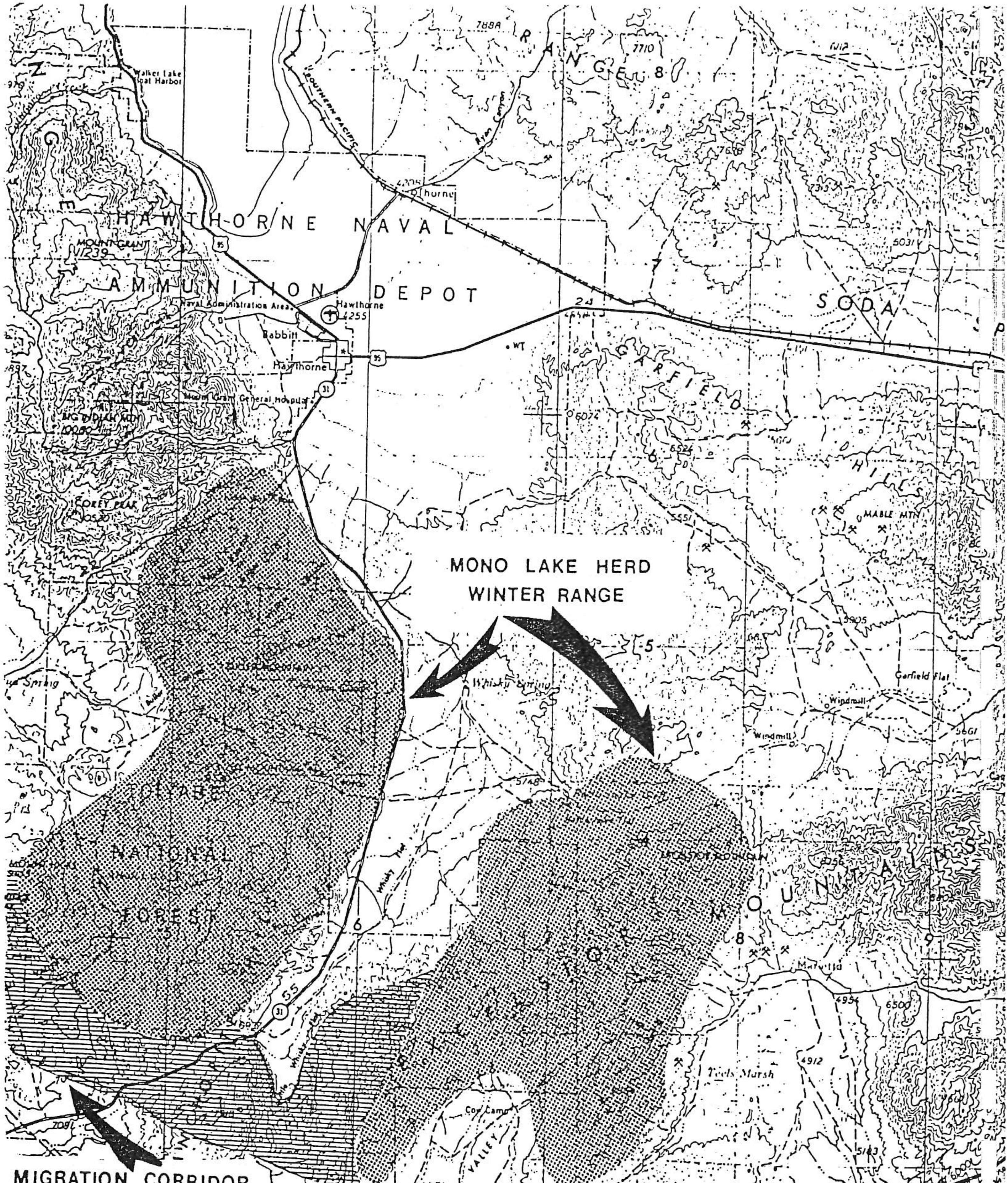

Figure 4-7a. Locations of migration corridors of the Mono Lake deer herd.

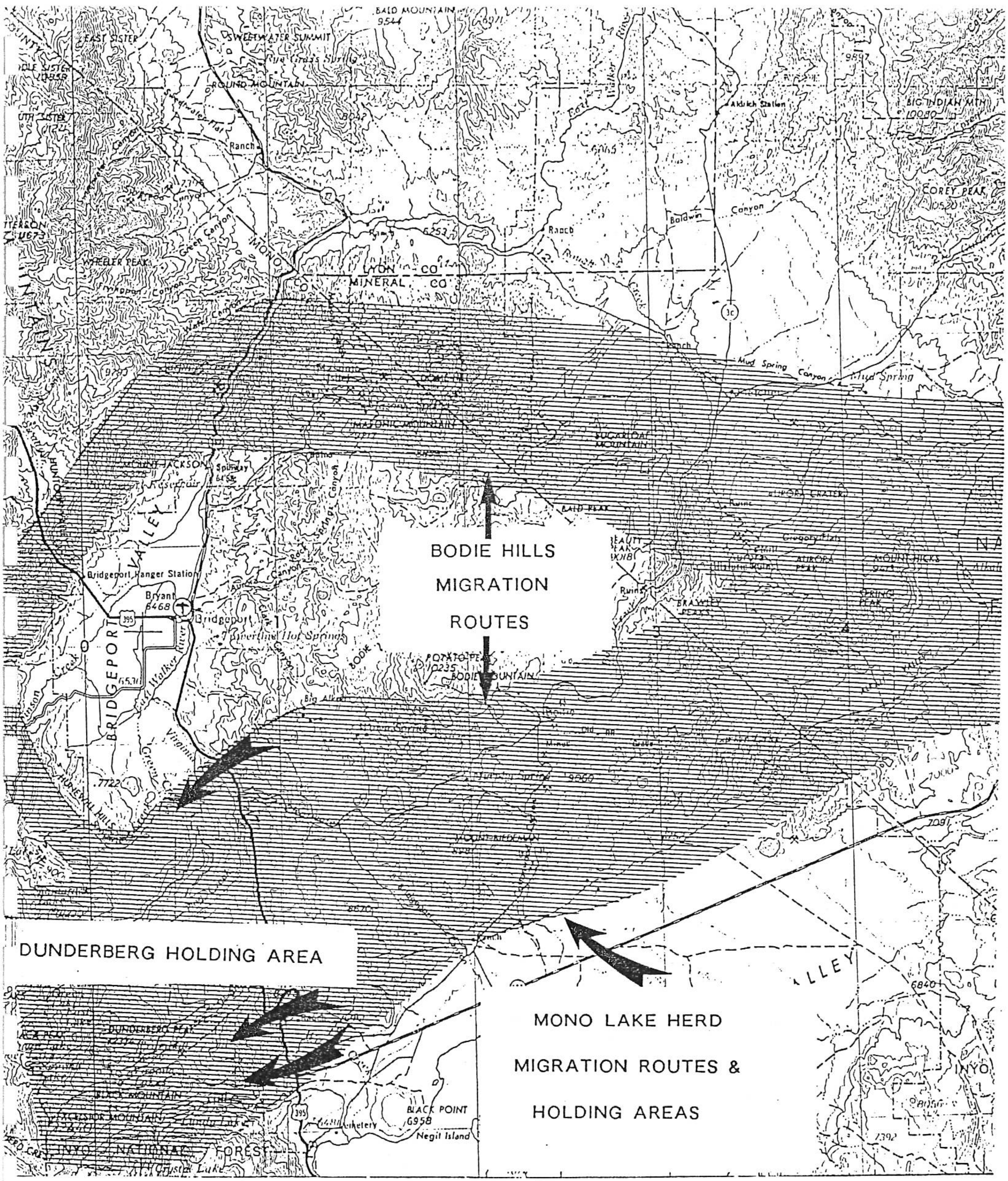

Figure 4-7b. Locations of migration corridors of the Mono Lake deer herd.

to first ascend the steep east side of this major range via several drainages including Powell, Johnston and Cottonwood Canyons. After crossing to the west side, deer then moved in a southwesterly direction around the north end of Alkali Valley toward the Bodie Hills.

Radio-collared deer which wintered in the Excelsior Mountains migrated southwest around the east side of Whiskey Flat, and then crossed Nevada Route 359 just north of Anchorite Pass. Once west of Route 359, deer then crossed the Anchorite Hills and continued in a westerly direction toward the Bodie Hills, eventually merging their migration with deer from the Wassuk Range (Figure 4-7a and 4-7b).

From 1988-1990, all 30 radioed deer marked on ML winter ranges moved through the Bodie Hills during spring migration. The migration corridor through the Bodie Hills extends from Route 167, north to Bodie Mountain, and from Route 395 east to the Anchorite Hills at elevations ranging from 2000-2500 m (Figure 4-7b). Vegetation throughout this migration corridor is largely Sagebrush Scrub (Munz and Keck 1959), characterized by vast stands of _Artemisia tridentata_, and _Purshia tridentata_. Small meadows and isolated patches of _Populus tremulodies_ also occur along watercourses. Large stands of _Pinus monophylla_ dominate lower elevations foothills of the south slope, from Alkali Valley west to Conway Summit, and the west slope, from Willow Springs north to Masonic.

Of the 30 deer which migrated through the Bodie Hills, 23 crossed Route 395 at three major locations between the junction of Route 167 and Willow Springs (Figure 4-7b). Of these 23 deer, 7 crossed the highway south of Conway Summit near the vicinity of the Conway Ranch (post mile 61.2); 7 deer crossed the highway just south of its junction with Route 270 (post mile 69.9) in the vicinity of Dog Town; and at least 7 deer crossed the highway to the north of Willow Springs in the vicinity of the Green Creek Road (post mile 72.0). The exact crossing locations of 2 deer are unknown; however, because both summered in the vicinity of Twin Lakes it is likely that they crossed the highway somewhere between Conway Summit and the Green Creek Road.

From approximately 1 April-15 May, ML deer delayed at elevations of 2,200-2500 m on the Dunderberg holding area. This holding area is located at the base of the Sierra escarpment and encompasses nearly 40 sq. km from Dechambeau Creek in the south to the Hunewill Hills in the north (Figure 4-7b). The areas used by deer on the Dunderberg holding area are composed largely of Sagebrush Scrub (Munz and Keck 1959), characterized by immense stands of Artemisia tridentata, Purshia tridentata, with isolated pockets of Pinus Jeffreyi/ Pinus monophylla. Stands of Populus tremuloides and large meadows occur adjacent to watercourses. Deer which first arrived on the Dunderberg holding area in early April congregated on snow free south and east facing slopes where succulent herbaceous forage was readily available.

All deer which delayed on the Dunderberg holding area migrated west to summer ranges located above 2600 m on the east slope of the Sierra, from Lundy Canyon north to the Twin Lakes/Robinson Creek drainage. As with the EW herd, ML deer dispersed to summer ranges via major drainages that connect the Dunderberg holding area with upper elevation summer ranges. Drainages used by deer to access the summer range include Lundy Canyon, Virginia Creek, Dunderberg Creek, Green Creek, and Robinson Creek.

Four radioed deer from the ML herd did not summer west of Route 395 but instead summered in the Bodie Hills at elevations $\geq$ 2500 m (Figure 4-3). Two of these summered at the head of Rough Creek north of Bodie Mountain; 1 summered on Bodie Bluff near the town of Bodie; and 1 summered in Bridgeport Canyon at the southern end of the Bodie Hills.

To access summer range located to the north of the Twin Lakes/Robinson Creek drainage, three ML deer (1 buck and 2 does) migrated across the north end of the Bodie Hills in the vicinity of Masonic Mountain, and then crossed the East Walker River gorge below Bridgeport Reservoir (Figure 4-7b). They then merged their migration with deer from the EW herd and continued south to the Buckeye holding area where they delayed for 2-4 weeks. After delaying on the Buckeye holding area, the 2 does migrated west around the north side of Mt. Emma to Sonora Pass. One doe crossed Sonora Pass to her summer range located on the west side of the Sierra near Red Peak in Tuolumne County; the other summered just east of Sonora Pass near Sardine Falls. The buck summered in the Buckeye Creek drainage.

Changes in elevation between secondary winter range and summer ranges used by deer varied from +600 to +1200 m (Figure 4-8). The mean straight line distances between winter and summer ranges of deer was 65 km (range 37-95 km) (Figure 4-9). Adult ML does displayed strong fidelity to summer range sites ($P < 0.001$). Ninety-six percent of deer were located within $\geq$ 1 km of their previous year's summer location.

C. FALL MIGRATION

Because of generally poor weather conditions from September-December, only 1 telemetry flight was conducted in the fall 1988. A total of 5 telemetry flights were conducted in the fall of 1989; there were no flights conducted in the fall of 1990. In addition to telemetry flights, some general information regarding fall deer movements was obtained from ground monitoring of radioed deer during the 1988 and 1989 fall migration periods.

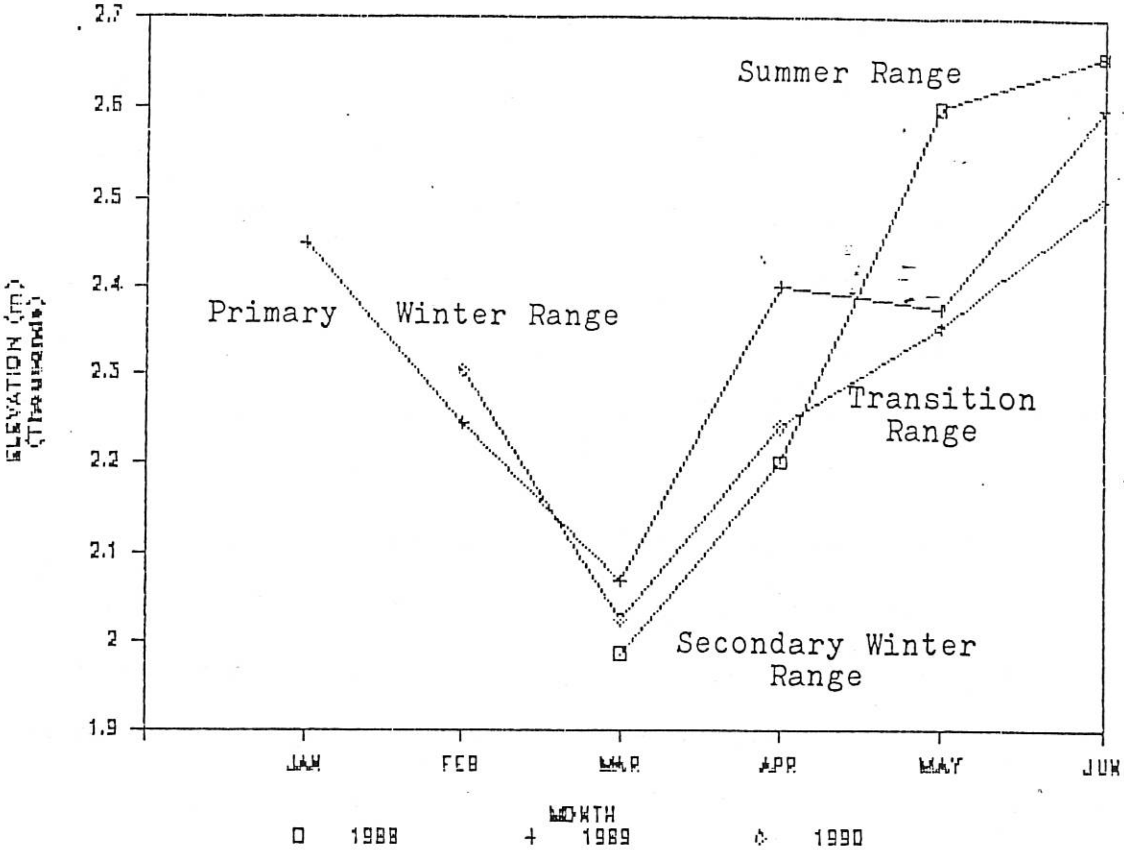

Figure 4-8. Mean elevations inhabited by Mono Lake radio-collared deer during the winter and spring migration periods. 1988-1990.

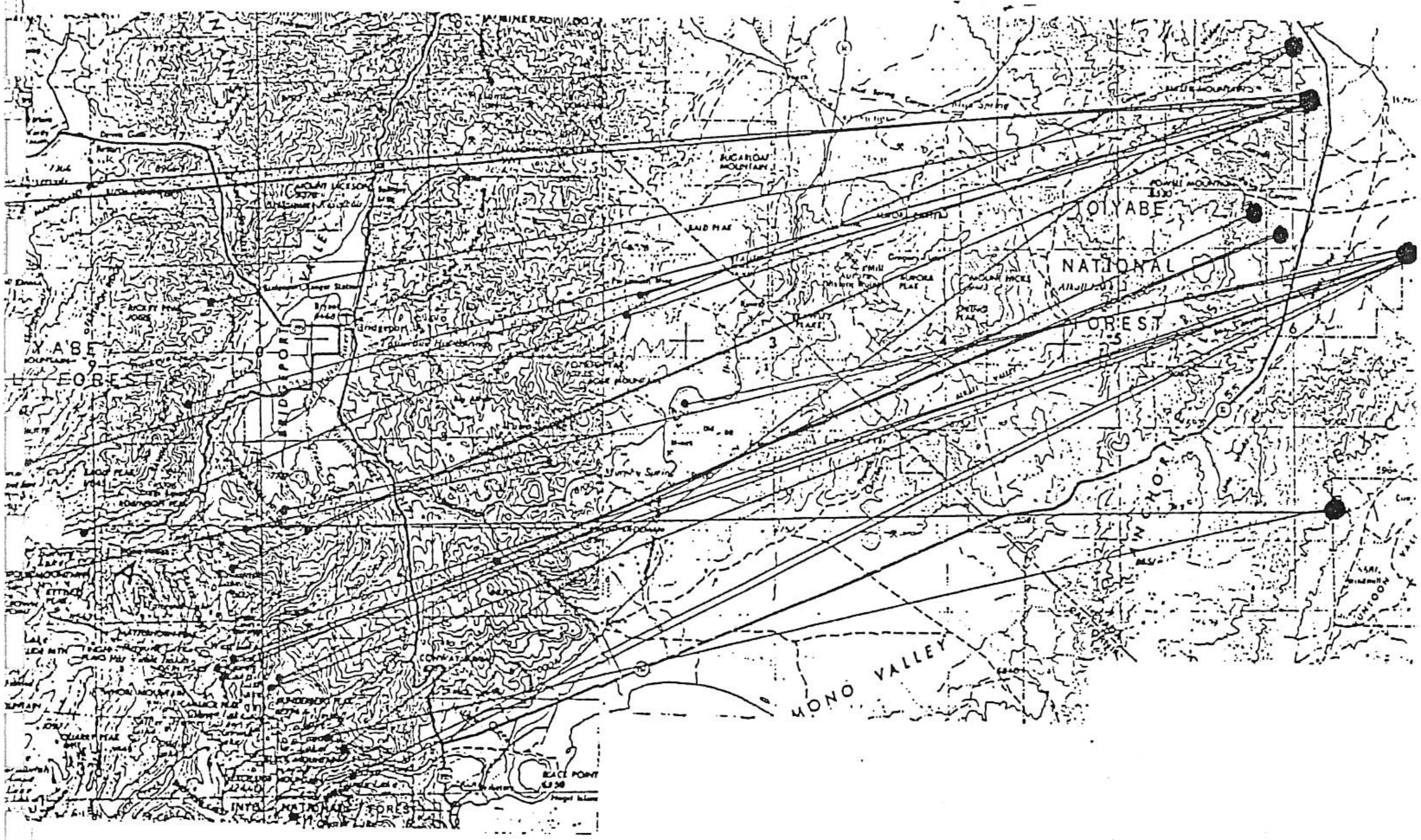

Figure 4-9. Movements of Mono Lake radio-collared deer marked on winter ranges (large circles) and subsequently found on summer ranges (small circles). 1988-1990.

In the fall of 1988, deer migration from the summer range occurred on a gradual basis between early October and mid-December. On 9 November, during the only telemetry flight conducted, the locations of 28 radioed deer were obtained. Of these 28 deer, 17 (60%) deer were located on the summer range; 11 (40%) deer, all from the ML herd, were located at various points along the migration corridor. Of the 17 deer that remained on the summer range, 11 appear to have migrated in response to a fall snow storm on 12-14 November. Five deer, 1 buck from the ML herd and 4 does from the EW herd, delayed on the Buckeye holding area near the mouth of Buckeye Canyon for 3-5 weeks (11 November-16 December). One of these deer, an adult doe died on this holding area from causes related to malnutrition. The other 4 migrated to their respective winter ranges on 16 December in response to a major winter snow storm.

In the fall of 1989, deer began migrating from the summer range in late October and early November subsequent to a fall storm on 22-25 October. A flight conducted on 2 November revealed that 17 (46%) of 38 radioed deer had migrated from the summer range. These deer were located on the winter range and at various points along migration corridors.

On 23-25 November, approximately 3.8 cm of snow fell at the 1600 m level (DFG, Unpubl. data). During a flight conducted on 29 November, it was determined that 26 of 38 radioed deer had left the summer range. The remaining 12 deer, all from the EW herd, delayed on the Buckeye holding area during the first two weeks of December. Two deer, a buck and a doe, remained on Buckeye holding area until early January when they were both killed by mountain lions.

D. SUMMER RANGE

Deer from the EW and ML herds occupy approximately 2000 sq. km of summer range throughout the eastern Sierra Nevada mountains in northern Mono County, California (Figure 4-3). Radio-collared does from both herds summered at elevations ranging from 2500-3250 m ($\bar{x}$ = 2654 m). The mean summer range elevation of 14 adult bucks (8 from the EW herd and 6 from the ML herd) was 2762 m (range = 2250-3400 m).

Summer home range areas were obtained for 9 randomly selected deer (2 bucks and 7 does). Summer home ranges for the 2 adult bucks were 59.1 and 221.5 ha, respectively. Summer home range size for the 7 adult does (4 from the ML herd and 3 from the EW herd) ranged from 10.7-37 ha ($\bar{x}$ = 21.4 ha, SE = 3.76) (Table 4-1). There was a significant difference ($P \leq 0.025$) in the summer home range sizes of does which occupied grazed versus ungrazed habitats. The average size of summer home ranges grazed by livestock was 2.5 times larger (25.87 ha) than those that were ungrazed (10.23 ha).

Table 4-1. Summer home range areas, mean summer range elevations and dates inhabiting summer range for 9 (7 female and 2 male) radio-collared mule deer from the East Walker and Mono Lake herds, 1988-1990.

Radio No.	Herd	Sex	Age	Mean Summer Range Elevation (m)	Summer Home Range Size (ha)	Dates Inhabited
175	ML	F	4	2,600	10.27	5-04-88/11-04-88
215	EW	F	4	2,200	** 26.60	5-10-88/11-14-88
306	ML	F	3	2,700	17.88	4-15-89/10-21-89
327	ML	F	3	2,500	** 19.42	5-09-88/11-15-90
345	ML	M	3	2,500	59.08	4-11-88/09-28-89*
355	EW	M	2	2,500	221.52	4-15-89/09-09-89*
414	EW	F	4	2,340	10.19	5-02-89/11-28-89*
456	ML	F	5	2,500	** 37.48	4-07-89/10-30-89
475	EW	F	4	2,100	** 27.97	1-11-89/10-01-90

* Deer died on summer range.
** Summer home ranges grazed by livestock.

For example, doe #175 summered within a portion of the Green Creek drainage, ungrazed by livestock, where high quality habitat in the form of small meadows, aspen and willow thickets, small pockets of browse and water were all within her 10.3 ha home range area. Conversely, doe #456 summered within 2 km of doe #175 in an area with similar habitat characteristics, but intensely grazed by sheep. The home range size of this animal was 37.5 ha.

During the course of this study, the investigator examined the summer home ranges of 38 randomly selected adult does. Of these 38 home ranges, 33 (87%) were grazed by livestock to varying intensities.

Nineteen of 31 radio-collared deer from the EW herd summered to the south and west of Route 395, from the Twin Lakes-Robinison Creek drainage, north to Route 108 (Figure 4-3). This portion of the summer range encompasses some 290 sq. km at elevations ranging from 2200-3000 m.

Five EW deer summered in the Sweetwater Mountain Range, located to the west of the East Walker River and north of the Bridgeport Valley (Figure 4-3). These deer occupied Aspen-Riparian habitats within the Swauger, Green, Burcham and Cottonwood Creek drainages.

Four EW does summered in the Bodie Hills. One of these occupied a small riparian area on the north side of Potato Peak. Another, which was killed by a mountain lion in July of 1988, summered on the north side of Bodie Mountain. A third doe summered near Warm Springs and a fourth at Willow Springs, just west of Route 395. In addition, 1 EW doe summered on the west slope of the Sierra in the Kennedy Creek drainage on the SNF.

Deer from the ML herd occupy summer range primarily on the east slope of the Sierra and throughout the Bodie Hills (Figure 4-3). Twenty-five radio-collared deer from the ML herd summered on the east slope of the Sierra, from the Lundy Creek drainage, north to Sonora Pass and Route 108. Most of these deer summered to the south of the Buckeye Creek drainage, in the Robinson Creek, Tamarack Creek, Green Creek, Dunderberg Creek and Lundy Canyon drainages (Figure 4-3).

One doe marked on the Wassuk wintering area summered on the west slope of the Sierra near Red Peak, approximately 6 km west of Sonora Pass. Four does summered in the Bodie Hills, from Bodie Bluff west to Bridgeport Canyon and north to Rough Creek (Figure 4-3).

Marked deer from different winter ranges were found to occupy summer range of close proximity. Conversely, marked deer from the same winter range were found to disperse to opposite ends of the summer range. For example, one ML doe from Johnston Canyon summered at the southern end of the herd range in the Green Creek drainage, while another ML doe from the same wintering location summered at the extreme northern end of the range near Sonora Pass.

DISCUSSION

Information regarding the timing of migration is important to deer managers because disturbance impacts of development projects within corridors can often be mitigated by avoiding disruptive activities during this critical period. In 1988-1990, deer from the EW herd delayed their migration from the winter range an average of 14, 15 and 10 days later, respectively, than deer from the ML herd. One reason for this may be the presence of irrigated pasture land located on secondary winter range adjacent to the EW River.

Irrigation of pasture land typically begins in early March at the start of the growing season and continues through the summer months. Therefore, these pastures offer an abundance of succulent high quality forage for deer from the time they move to lower secondary winter range in late-February and early March until they leave the winter range in late May.

Because deer congregated in large numbers on irrigated pasture land, I believe that late spring dispersal of EW deer from the winter range is a result of deer delaying on pasture land in order to regain condition lost over the winter. When deer increase their intake of easily and quickly digested types of forage, metabolites are readily absorbed and the net energy available to deer is greatly increased (Short 1981). As a result, deer can reverse the negative energy balance acquired over the winter and improve their overall physiological condition (Garrott et al. 1987).

Another reason for delayed departure of EW deer from the winter range may be related to the effects of weather on plant phenology, which is paramount among factors that influence forage availability (Nelson and Leege 1982). Throughout the eastern Sierra, the availability of succulent forage is related closely to snow conditions in the spring, and these two factors appear to strongly influence the timing and rate of migration from lower to higher elevations. Delaying spring migration an additional two weeks until snow conditions have retreated allows EW deer to move quickly through the migration corridor to holding areas where quality forage is readily available. By arriving on holding areas at a time when the snowpack has receded and plant phenology is at a later stage, pregnant does with increased energy demands can maintain the high gross energy intake levels they experienced on irrigated pasture land adjacent to the East Walker River.

There was a significant difference among years in the timing of deer departure from the ML winter range, but not from the EW winter range. For the ML herd, this difference may be related to the timing of forage availability and quality on lower secondary winter ranges during late March and early April. When the availability of herbaceous spring forage on lower secondary winter ranges is prolonged as a result of a wet winter or spring rains, deer delay migration in order to improve their overall physiological condition (Bertram 1984, Garrott et al. 1987).

Conversely, when the availability of herbaceous spring forage on lower secondary winter ranges becomes limited as a result of drought or overgrazing by livestock, deer must migrate earlier in order to seek nutritional relief on mid elevation holding areas. In this study, field surveys indicate intensive cattle grazing of secondary winter ranges (Whiskey Flat and most major drainages of the Wassuk Range) used by the ML herd. In addition, increasing temperatures, relative humidity, and insect activity may also be factors motivating deer to begin spring migration from the winter range (Russell 1932, Leopold et al. 1951, McCullough 1964, Loft et al. 1989).

Another reason for differences in the timing of deer departure from the ML winter range may be related to variations in snow pack depth along the migration route and upper elevation holding areas. In years of greater snow pack, plant phenology on upper elevation holding areas is predictably later. This results in deer delaying spring migration on lower secondary winter ranges until the snowpack at upper elevations has receded and spring forage conditions improve.

Garrott et al. (1987) suggested that persistent snow pack at upper elevations may discourage deer from migrating because it is likely to impede their movements. Conversely, Kucera (1988) found that snow depths in mountain passes of the eastern Sierra did not impede migration because spring snow was consolidated, usually enabling deer to walk over the surface. In the present study, deer often crossed large snow drifts on north and west facing slopes as they moved between winter and upper elevation spring and summer ranges. In most cases, deer would use trails made by other deer when negotiating large snow fields. This would result in compaction of snow, enabling deer to cross even deep snow fields with relative ease.

Deer from both the EW and ML herds delayed migration for 3-5 weeks on spring holding areas where succulent herbaceous forage and new growth of browse was the principal diet component. The use of spring holding areas is characteristic of Sierra Nevada deer herds (Jordon 1967, Bertram and Remple 1977, Kucera 1988, Taylor 1988, Loft et al. 1989). These areas are recognized for their importance in providing nutritional spring forage for does in their third trimester of pregnancy (Bertram and Remple 1977, Holl et al. 1979, Kucera 1988, Loft et al. 1989).

Many researchers have associated deer departure from the summer range with fall snow storms and increasing snow depths at higher elevations (Russell 1932, Leopold et al. 1951, Loveless 1964, Gilbert et al. 1970, Moen 1973, Bertram and Remple 1977, Kucera 1988). Garrott et al. (1987) postulated that deer departure from summer ranges in northwest Colorado was not in response to snow, but instead to photoperiod. When deer migrated prior to fall snow storms it was to take advantage of high quality forage on irrigated and fertilized hay meadows near the winter range. If deer waited until snow forced them to migrate, they would arrive on the winter range after meadows were senescent and snow covered.

In the present study, fall migration began in early October and continued through early January. In 1988, 11 deer from the ML herd migrated prior to the first fall snow storm on 9 November. These movements could not have been motivated by weather, but instead may have been in response to energetic demands as Garrott et al. (1987) suggested. By migrating prior to the first fall snow storms, ML deer can take advantage of browse located on transition ranges and upper elevations of the winter range before the first heavy snows cover vegetation. Moreover, deer can avoid deep snows that could potentially affect the summer range and higher portions of the migration route, e.g., the Bodie Hills, thereby increasing the energetic costs of movement. Energy reserves are quickly drained when deer are forced to traverse on snow (Wallmo and Gill 1981), and the energy expenditure required by deer to feed in deep snow often exceeds that provided by the forage they consume (Kelsall 1969). Mattfeld (1973) reported that the energy costs of running, especially in deep snow, is many times that of walking on bare ground. It is especially difficult for fawns only 3 to 4 months old to negotiate the deep, heavy snow produced by early fall storms.

Why EW deer migrated later than ML deer can perhaps also be explained by the fact that EW deer had a much shorter distance to migrate between summer and winter ranges. The mean straight line distance between summer and winter ranges of the EW herd was 35 km, slightly more than half the mean distance (65 km) traveled by ML deer. Consequently, fall snow storms are not a threat for EW deer because they can migrate to the winter range in a relatively short period of time once heavy snows begin to fall.

Some EW deer delayed fall migration on the Buckeye holding area for 3-7 weeks during the mild winters of 1988-89 and 1989-90. Since the Buckeye holding area is located at intermediate elevations near the base of the Sierra escarpment, it provides an area where deer can rapidly descend to once weather on upper elevation summer ranges becomes severe. It also provides an abundance of browse, water and dense cover in an area relatively free of human disturbance.

Fall food habits information indicates that deer which occupied the Buckeye holding area from mid November to late December 1989, fed almost exclusively on browse with Artemisia and Purshia comprising approximately 50% and 30% of diets, respectively (Chapter 5). In the western Sierra, Bertram and Remple (1977) reported extensive use of fall holding areas by deer from the North Kings herd. These areas provided forage and cover for deer, the latter of which was determined to be an important component of fall holding areas during hunting season.

Deer from the EW and ML herds displayed strong fidelity to individual summer range areas, a behavior common to this species (Ashcraft 1961, Gruell and Papez 1963, Robinette 1966, Jordon 1967, Bertram and Remple 1977, Garrott et al. 1977, Kucera 1988, Loft et al. 1989). With a few exceptions, all adult does and the only adult buck radioed for $\geq$ 2 years returned to the same summer ranges occupied in previous years.

The mean summer home range size for seven adult does averaged 21.54 ha (range = 10.2-37.5 ha), significantly less than the home ranges reported for mule deer in other studies. Home range areas of adult does from another eastern Sierra deer herd, the Casa Diablo herd, averaged 100 ha (range = 34-

167 ha) (Taylor 1988a). Pac et al. (1988) reported that the calculated summer home range size of 19 female and 3 male Rocky Mountain mule deer varied from 0.2 to 13.5 sq. km and 2.6 to 34.0 sq. km, respectively. Loft et al. (1989) calculated summer home range areas of 40-200 acres for California mule deer (Odocoileus hemionus californicus) on the west side of the Sierra Nevada. Geduldig (1981) reported that Rocky Mountain mule deer fawns in Colorado had a mean summer home range size of 219.6 ± 95.6 ha, much larger than the mean home range size of adult does in this study.

Two adult bucks from this study had home ranges of 59.0 and 221.5 ha, between 2 and 6 times larger than home ranges of adult does. Dasmann and Taber (1956) found that Columbian black-tailed deer (O. h. columbianus) bucks had home ranges that were about 50 percent greater than does. Adult male white-tailed deer (O. virginanus) were documented by Olsen (1938) and Michael (1965) as having home ranges two to four times larger than adult females. Pac et al. (1988) reported that the average home range size of male Rocky Mountain mule deer in Montana was twice that of females.

According to Robinette (1966) home range size may be influenced by factors such as heredity, population density, topography, season, and the availability of food, cover and water. Several mammal researchers including Sanderson (1966), Marchinton and Jeter (1967) and Ellisor (1969) have associated smaller home ranges with higher population densities. Loft et al. (1987) found that summer home range sizes of adult does increased as the intensity of cattle grazing increased.

As suggested by Sanderson (1966) and others, the relatively small home ranges of adult does in this study may also be the result of higher population densities. Areas of summer range supporting higher densities of deer can likely be attributed to good habitat quality due to the absence of livestock grazing and a close interspersion of basic habitat requirements (food, cover and water).

CHAPTER 5. FOOD HABITS AND NUTRITION

Adequate nutrition has long been recognized as a critical factor in producing healthy, prolific game populations. Proper growth, adequate maintenance, and successful reproduction ultimately depend on quality nutrition (Julander 1972, Dimeo 1977, Short 1981). As a result, many wildlife managers have been interested in knowing the quality of deer diets. To this end, several direct methods for evaluating diet quality and ultimately, the current nutritional well-being of ungulate populations, have been developed. These methods include nutrient analysis of ungulate feces, hand collected forages, rumen contents and blood samples. The latter two methods often require death of wild ungulates (Howery and Pfister 1990), while hand-collected forages are considered a generally unreliable method (Theurer et al. 1976) due to the ability of ungulates to select the most nutritious forage available (Swift 1948).

Over the past few years, the use of fecal nutrient levels to study diet quality has received renewed research application in deer management (Leslie et al. 1989). This is primarily because fecal indices are recognized as feasible and noninvasive alternatives to costly and time intensive approaches for determining nutritional contents of diets (Hobbs et al. 1981, Leslie 1984). However, the use of fecal indices such as fecal nitrogen (FN) is controversial (Hobbs

1987, Leslie and Starkey 1987) because secondary plant metabolites might influence indices by producing elevated FN in diets that normally are of low quality (Mould and Robbins 1981, Leslie and Starkey 1987, Kucera 1988).

A less controversial indicator of dietary quality is fecal diaminopimelic acid (DAPA) because it does not appear to be influenced by factors such as secondary plant compounds (Nelson and Davitt 1984). Fecal DAPA is an amino acid residue found in the cellular walls of rumen bacteria which is eventually passed into the feces with no measurable loss. It appears to reflect fluctuations in percent digestible energy (DE) and therefore is low when diet quality is low, such as in winter, and is high when diet quality is high, such as early in the growing season (Nelson et al. 1986).

Diets of mule deer in the Rocky Mountain/Intermountain region have been widely studied (Klein 1970, Wallmo and Regelin 1981, Halls 1984). Numerous food habit studies of Rocky Mountain mule deer were summarized by Kufeld et al. (1973). This review contained a list of 788 plants reported eaten by Rocky Mountain mule deer, of which 488 (61 percent) were forbs, 202 (26 percent) were shrubs and trees, and 84 (11 percent) grasses, sedges and rushes. The review by Kufeld et al. (1973) suggests that browse plants, which tend to be available throughout the year, were used in greatest variety in summer and fall when the plants are presumably in leaf. Among the most commonly reported browse plants used by mule deer throughout the Great Basin were big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpos* spp.), willow (*Salix* spp.), curl-leaf mountain mohagany (*Cercocarpus ledifolius*), rubber rabbitbrush (*Chrysothamnus nauseosus*) and tobacco brush (*Ceanothus velutinus*).

On seasonal ranges of EW and ML deer, *Artemisia*, *Purshia* and *Chrysothamnus* are the most common shrubs, followed by *Symphoricarpos*, *Salix*, *Cercocarpos* and *Ceanothus*. Several researches have demonstrated the importance of *Artemisia tridentata* and *Purshia tridentata* in the diets of mule deer throughout the Great Basin (Leach 1956, Longhurst et al. 1968, Alldredge et al. 1974, Regelin et al. 1974, Gill and Wallmo 1973). Bitterbrush was highly preferred by deer in eastern Washington but was not a factor affecting herd survival during winter months because of the presence of alternate food sources (Burrell 1982). In northeastern California, Dasmann and Blaisdell (1954), linked fawn production and survival to browsing intensity on *Purshia*. In the eastern Sierra Nevada, Kucera (1988) reported that *Purshia* was most frequent in the diets of deer during the first few months of winter, while *Artemisia* was most common in mid-winter.

The objectives of this investigation were (1) to examine patterns of food use by mule deer on all seasonal ranges, (2) to identify major species in seasonal deer diets, and (3) to estimate quality of seasonal deer diets using fecal indices.

METHODS

Fecal pellets were collected monthly from March 1988-March 1989. During the middle of each month, a total of 5 pellets were collected from each fresh dropping observed, and after being air dried in paper bags, stored for subsequent laboratory analysis. Pellets collected were composited by month and, on the winter range, by herd. Monthly composite samples consisted of 5 pellets from at least 10 different defecations. Ten defecations is considered to be the minimum number of droppings needed to be representative of the diet of a herbivore population over a given period (Stewart 1971).

Composited fecal samples were sent to the Wildlife Habitat Laboratory at Washington State University, Pullman, Washington, and examined for species composition by identifying and quantifying fragments of plant epidermis (Sparks and Malachek 1968). Composited samples were also used to estimate fecal crude protein (CP), FN and fecal DAPA (diaminopimelic acid; Nelson et al. 1986) as indicators of diet quality.

Diets included 3 major forage classes: (1) browse or shrubs, which included both shrub (*Purshia*, *Artemisia*) and tree material (*Salix*, *Pinus*, etc.); (2) graminoides, which include sedges (*Carex*) and rushes (*Juncus*) and grass-like species; and (3) forbs, which also includes lower plant forms such as mosses and lichens.

A simple linear regression was used to examine relationships between fecal indices (FN, DAPA) and the percent composition of major forage classes and major forage species in yearlong deer diets.

RESULTS

Diet Composition of Feces

Spring.--Shrubs were the largest component of the spring diet, comprising 84%, 72% and 86% of April, May and June diets, respectively (Table 5-1a). *Artemisia* was by far the most common shrub, comprising between 38%-65% of spring diets. Snowberry (*Symphoricarpos vaccinoidies*) was the second most frequent shrub comprising 6% and 20% of May and June diets, respectively. Other shrubs which appeared in spring diets in varying proportions were *Purshia*, *Ceanothus*, *Ephedra* and *Salix*. Grasses and forbs were important components of the spring diet, comprising 16%, 27%, and 14% of April, May and June diets, respectively (Table 5-1a).

Summer.--Shrubs were the largest component of the summer diet, comprising 64% and 61% of July and August diets,

Table 5-1a Composition (%) of spring diets of Rocky Mountain mule deer on East Walker and Mono Lake holding areas, Mono County, California, March 1988-June 1988, as determined from microhistological analysis of fecal pellets.

Species	March EW	March ML	April	May	June
SHRUBS					
Artemisia tridentata	66.1	62.5	65.0	37.8	49.2
Purshia tridentata		2.7	4.8	2.2	11.5
Ceanothus spp.		tr	6.1	10.1	1.3
Symphoricarpos vaccinoidies		tr	1.3	6.3	19.4
Ephedra nevadaensis					0.2
Salix spp.				7.6	
Shrub Flower part		0.1			
Other Shrubs*		1.2	7.2	8.3	4.2
Percent Total Shrubs	66.1	69.9	84.4	72.3	85.8
GRASSES					
Bromus spp.	9.7	9.4	1.4	0.2	0.3
Festuca spp.	2.0	0.2		0.2	
Poa spp.	5.2	5.5	8.6	2.5	1.0
Sitanion hystrix	3.0	0.5	0.7		
Oryzopsis hymenoides	1.4				
Stipa comata	1.8	0.9			
Other Grasses and Sedges	10.2	3.1	2.2	1.1	1.4
Sedges					0.5
Total Percent Graminoides	33.3	19.6	12.9	4.0	3.2
FORBS					
Achillea spp.		tr	1.9		0.6
Lupinus spp.			tr	5.1	1.2
Mustard trichome			0.1		0.1
Forb Trichomes (hair)			tr	14.3	3.1
Other Forbs	0.6	0.2	0.7	3.9	5.5
Total Percent Forbs	0.6	0.2	2.7	23.3	10.5
Composite trichome**				0.4	0.2
Insect part:					0.3
Seed/nut:		0.1			
Lichens		0.1			

* Includes *Ribes*/*Symphoricarpos* trichome, *Ribes* spp., and other shrubs.
**Could be either shrub or forb.

Table 5-1b. Composition (%) of summer diets of Rocky Mountain mule deer on the East Walker and Mono Lake summer ranges, Mono County, California, July-August 1988, as determined from microhistological analysis of fecal pellets.

Species	July	August
SHRUBS		
Artemisia tridentata	6.4	1.4
Purshia tridentata	29.2	24.9
Ceanothus spp.	2.0	3.2
Symphoricarpos vaccinoidies	16.0	4.4
Rosa woodsii		4.0
Salix spp.	1.3	4.7
Other Shrubs*	8.6	18.5
Conifers:	0.4	
Percent Total Shrubs	63.9	61.1
GRASSES		
Bromus spp.	1.8	
Festuca spp.	0.8	
Poa spp.	11.3	
Sitanion hystrix	0.4	1.8
Stipa comata	0.9	
Other Grasses and Sedges	7.4	
Sedges	3.8	
Total Percent Graminoides	26.4	1.8
FORBS		
Achillea spp.		
Lupinus spp.	3.9	18.3
Mustard trichome	0.2	
Forb Trichomes (hair)	1.0	7.7
Other Forbs	3.5	10.5
Total Percent Forbs	8.6	36.5
Composite trichome:**	0.3	0.3
Unknown Leaf:	0.1	

* Includes *Ribes*/*Symphoricarpos* trichome, *Ribes* spp., and other shrubs.
**Could be either shrub or forb.

Table 5-1c. Composition (%) of fall diets of Rocky Mountain mule deer on the East Walker and Mono Lake transition ranges, Mono County, California, September-November 1988, as determined from microhistological analysis of fecal pellets.

Species	Sept.	Oct.	Nov.
SHRUBS			
Artemisia tridentata	6.3	28.2	48.9
Purshia tridentata	28.8	51.4	30.4
Ceanothus spp.	0.6		
Salix spp.	5.8	3.2	4.0
Symphoricarpos vaccinoides	2.9	0.5	
Shrub Flower part	6.2	1.4	0.5
Other Shrubs *	14.3	12.5	3.5
Total Percent Shrubs	64.8	97.2	87.3
GRASSES			
Bromus spp.		0.5	3.1
Festuca spp.			
Poa spp.	5.7		
Sitanion hystrix	2.4		
Stipa comata	8.2		
Other Grasses or Sedges	9.3	1.3	1.0
Sedges	8.4		
Total Percent Graminoides	34.0	1.8	4.1
FORBS			
Lupinus spp.		0.8	0.1
Mustard trichomes			
Forb trichomes (hair)			3.9
Other Forbs	1.0	0.2	4.6
Total Percent Forbs	1.0	1.0	8.6

* Includes _Ribes/Symphoricarpos_ trichome, _Ribes_ spp., and other shrubs.

Table 5-1d. Composition (%) of winter and early spring diets of Rocky Mountain mule deer on the East Walker and Mono Lake winter ranges, Lyon and Mineral Counties, Nevada, December 1988-March 1989, as determined from microhistological analysis of fecal pellets.

	EAST WALKER				MONO LAKE			
Species	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar
SHRUBS								
Artemisia tridentata	52.3	35.2	49.7	70.2	34.3	65.4	57.2	65.8
Purshia tridentata	36.9	27.5	25.6	1.3	28.4	10.4	16.1	3.9
Chrysothamnus spp.	tr	5.2	2.4		0.4		0.3	tr
Ceanothus spp.	3.5	0.1			6.2	0.9	1.3	tr
Ephedra nevadaensis		1.6	0.6		1.2	1.6	0.8	
Rosa woodsii	1.2	3.0			2.3	3.1	0.3	
Salix spp.	2.0	6.3	5.4		11.4	1.3	1.6	
Other Shrubs	2.7	0.9	4.3		6.9	4.6	3.9	2.3
CONIFERS								
Pinus contorta					0.5			
Pinus jeffreyi								
Pinus monophylla		2.3	6.8			4.0	4.0	7.7
Pinus spp.		0.5	4.3				2.5	0.3
Other Conifers		0.3				0.1		0.5
Total Percent Shrubs	98.6	82.9	99.1	71.4	91.6	91.5	88.0	80.5
GRASSES								
Bromus spp.	0.5	tr		8.6		tr		7.4
Festuca spp.				3.1				1.2
Poa spp.				5.5		tr	2.5	5.9
Sitanion hystrix				2.0		tr	2.1	0.2
Oryzopsis hymenoides				2.4				tr
Stipa comata				1.7				0.7
Other Grasses or Sedges	0.1	0.9		5.0		0.9	1.1	3.1
Total Percent Grasses	0.6	0.9	0.0	28.3	0.0	0.9	5.7	18.5

Table 5-1d. Composition (%) of winter and early spring diets of Rocky Mountain mule deer on the East Walker and Mono Lake winter ranges, Lyon and Mineral Counties, Nevada, December 1988-March 1989, as determined from microhistological analysis of fecal pellets.

	EAST WALKER				MONO LAKE			
Species	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar
FORBS								
Lupinus spp.	tr	0.4			2.1	1.8	tr	tr
Mustard trichomes		0.1			0.6			tr
Phlox spp.		1.2	tr		tr			
Other Forbs	0.8	0.2	0.4	0.3	1.1	0.5	1.6	0.8
Total Percent Forbs	0.8	1.9	0.4	0.3	3.8	2.3	1.6	0.8
Seed/nut:		11.7			4.4	5.3	3.5	0.1
Lichens:	tr				0.1			0.1
Flowers:					0.1			
Ferns:							1.2	
Mosses:						2.6		
Unknown leaf:							0.5	
Total Percent Forbs	0.8	13.6	0.4	0.6	8.4	10.2	6.8	0.2

respectively (Table 5-1b). *Purshia* was the most frequent shrub comprising between 25% and 30% of July and August diets while *Artemisia* was present in small amounts (Figure 5-1). *Symphoricarpos*, *Ceanothus*, *Rosa* and *Salix* appeared in varying proportions in summer diets with *Symphoricarpos* being the most represented. Graminoides, primarily *Poa* spp., and forbs were major components of summer diets. Grasses comprised 26% of the July diet while forbs, primarily *Achillea*, comprised 37% of the August diet (Table 5-1b).

Fall.--Shrubs dominated fall diets with *Artemisia*, *Purshia*, *Salix* and *Symphoricarpos* all well represented (Table 5-1c). *Purshia* was the most frequent shrub in September and October, comprising from 29% to 51% of these early fall diets. There was a high level of *Purshia* stems in the fall diet; stems comprised 16%, 21.9% and 10.3% of September-November diets, respectively. *Artemisia*, which comprised only 6% of the September diet, was most frequent in November at nearly 50%. Graminoides and sedges comprised 34% of the September diet but were only minor components in October and November diets.

There was a weak negative relationship between amounts of *Purshia* and *Artemisia* in diets during 1988 (EW: $r2$ = 0.20; ML: $r2$ = 0.34), perhaps reflecting constant dietary shifts in the relative proportions of these two shrubs consumed throughout the course of the year (Figure 5-1). However,

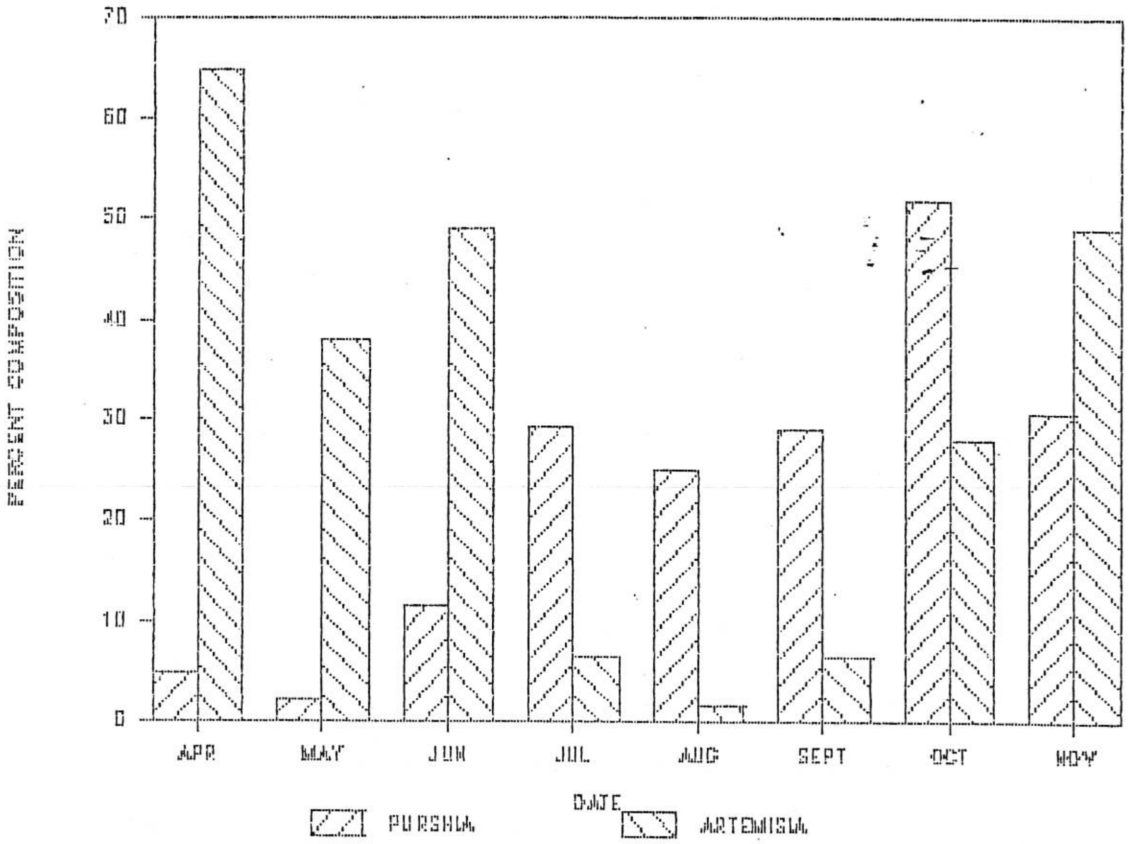

Figure 5-1. Percent composition of <u>Artemisia</u> and <u>Purshia</u> in the spring, summer and fall diets of mule deer from the East Walker and Mono Lake deer herds, Mono County, Calif., 1988.

there was a strong negative relationship ($r2$ = 0.92) between amounts of shrubs and amounts of grasses and forbs in the diet (r = -0.82, p = 0.02), perhaps reflecting a shift in feeding emphasis from winter browse to new spring growth of grasses and forbs.

Winter.-- Some 25 plant genera were identified in winter diets of EW and ML deer from microhistological identification of epidermal plant fragments (Table 5-1d). Shrubs constituted >90% of the winter diets of both herds in December and $\geq$80% of diets in January and February (Table 5-1d). Grasses (Bromus spp. and Festuca spp.) and forbs (Phlox spp.) comprised <6% of December-January diets. Conifers, primarily Pinus monophylla comprised up to 11% of December-February diets, and nuts, primarily of Pinus monophylla, comprised 11.7% of the January diets of EW deer and from 3.5-5.3% of the December-February diets of ML deer. A small percentage (<3%) of materials from mosses, lichens and ferns occurred in December-February samples of the ML herd.

Shrubs appeared less frequently in late-winter diets of the EW and ML herds, but were still common, comprising 71.4% and 80.5% of March 1989 diets, respectively. During the same period, grasses became more common, comprising 28.3% and 18.5% of EW and ML diets, respectively, while the use of forbs decreased slightly (Table 5-1d). Trees, primarily

Pinus monophylla appeared more frequently in the March diets of ML deer (13.1%), but were not a component of EW diets.

Two shrubs, big sagebrush (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*), comprised most of the winter diet (Table 5-1d). In all winter months (December-March), *Artemisia tridentata* was the most common shrub in the diets of both herds (Figure 5-2). Relative amounts of *Artemisia* in the winter diets of both herds fluctuated on a monthly basis and were greatest in March when it comprised >60% of diets. Conversely, *Purshia*, which comprised between 10%-37% of mid-winter diets of both herds, declined steadily from December-January, reaching its lowest level in late-winter when it comprised 1.3% and 3.9% of EW and ML March diets, respectively. During all winter months, there were nearly equal amounts of *Purshia* leaves and stems in the diets of EW and ML deer (Figure 5-2). Other shrubs which appeared in varying amounts in the winter diets of EW and ML deer include rabbitbrush (*Chrysothamnus* spp.), tobacco brush (*Ceanothus* spp.), wild rose (*Rosa woodsii*), Mormon tea (*Ephedra nevadensis*), and willow (*Salix* spp.) (Table 5-1d).

Diet Quality

Fecal Crude Protein.--Fecal CP was high during the spring and summer growing seasons and low in autumn and winter. Winter-long trends in CP content varied between

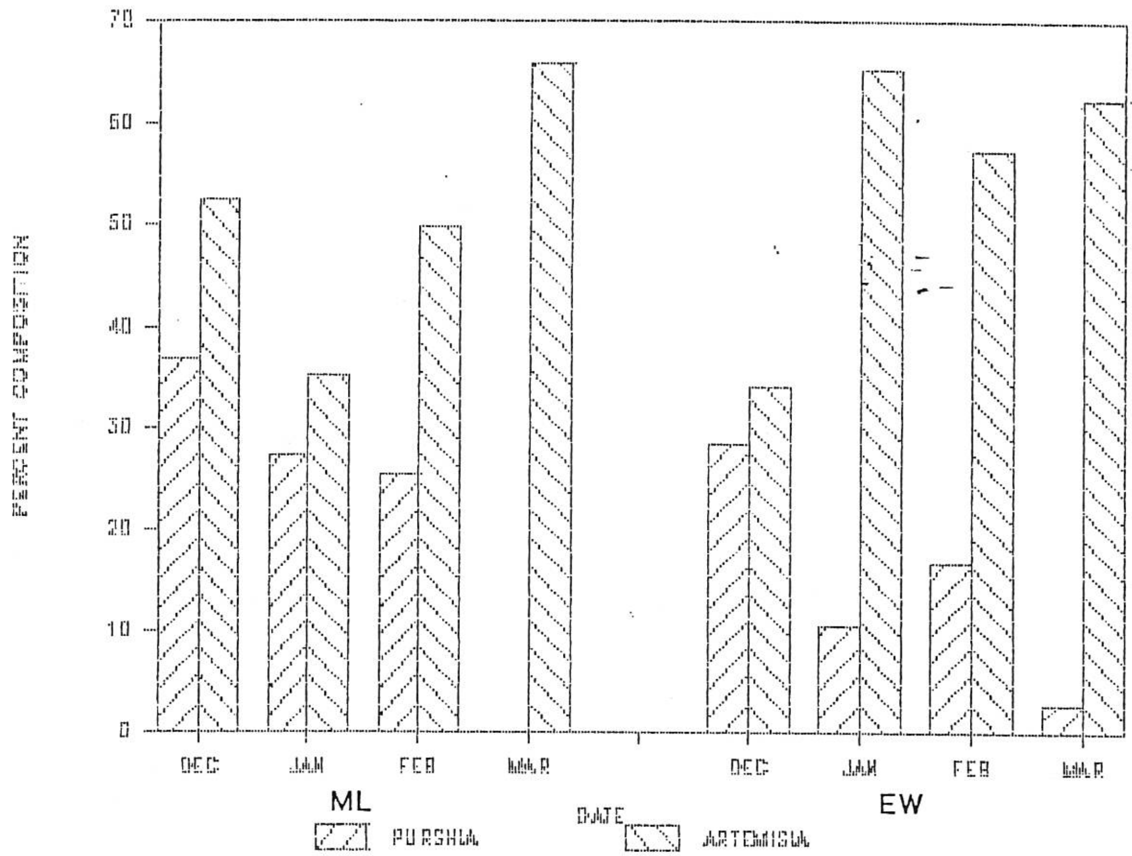

Figure 5-2. Percent composition of Artemisia and Purshia in the winter diets of mule deer from the East Walker and Mono Lake deer herds, Mono County, Calif., 1988.

herds (Figure 5-3). On the EW range, fecal CP decreased from 11% in December to a low of 8.5% in February, then subsequently increased in March to 11.2%. On the ML range, fecal CP decreased from 8.8% in December to a low of 7.4% in January and then rose again in February and March to 10.5% and 11.4%, respectively. The higher CP content of EW December and January samples may be related to greater proportions of bitterbrush in the diet.

In the spring, CP content of composited pellet samples collected from mid elevation holding areas shared by both herds increased to 15.5% in April and nearly 17% in May (Figure 5-4).

On the summer range, fecal CP was highest in June with values of about 20%, then subsequently declined in July to 15.8%, only to rise again in August to 17.8% (Figure 5-4). During the fall, CP levels in composited diets collected from both summer and transition ranges were fairly stable, varying between 12.3% and 14.1% (Figure 5-4).

There was a negative correlation between CP and <u>Artemisia</u> in the EW and ML diets (EW: $\underline{r} = -0.18$, $\underline{p} = .049$; ML: $\underline{r} = -0.22$, $\underline{p} = .039$), a reasonable relationship given the questionable nutritional value of sagebrush. There was a weak positive relationship between CP and <u>Purshia</u> in diets (EW: $\underline{r}2 = 0.12$; ML: $\underline{r}2 = 0.17$), which is also in the direction anticipated. There was also a weak positive

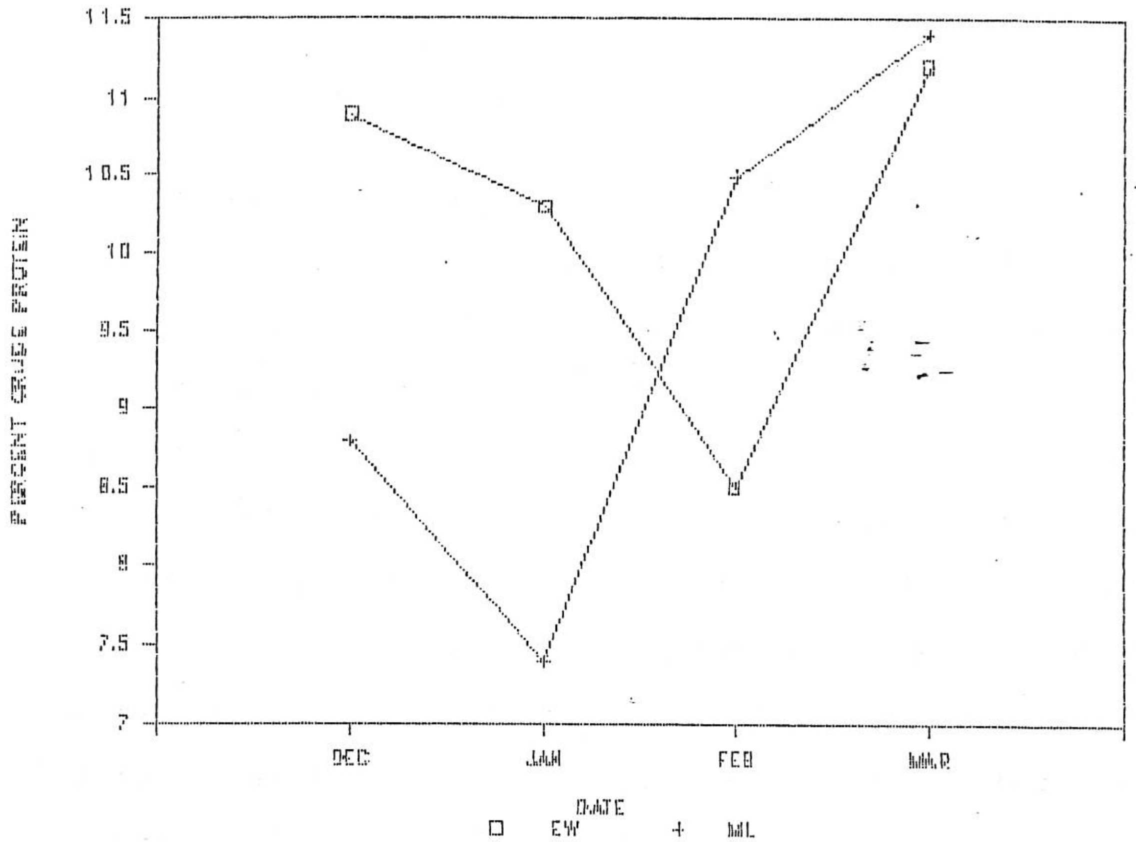

Figure 5-3. Crude protein (%) in winter diets of East Walker and Mono Lake deer, Mineral and Lyon Counties, Nevada, March 1988 and December-February 1989.

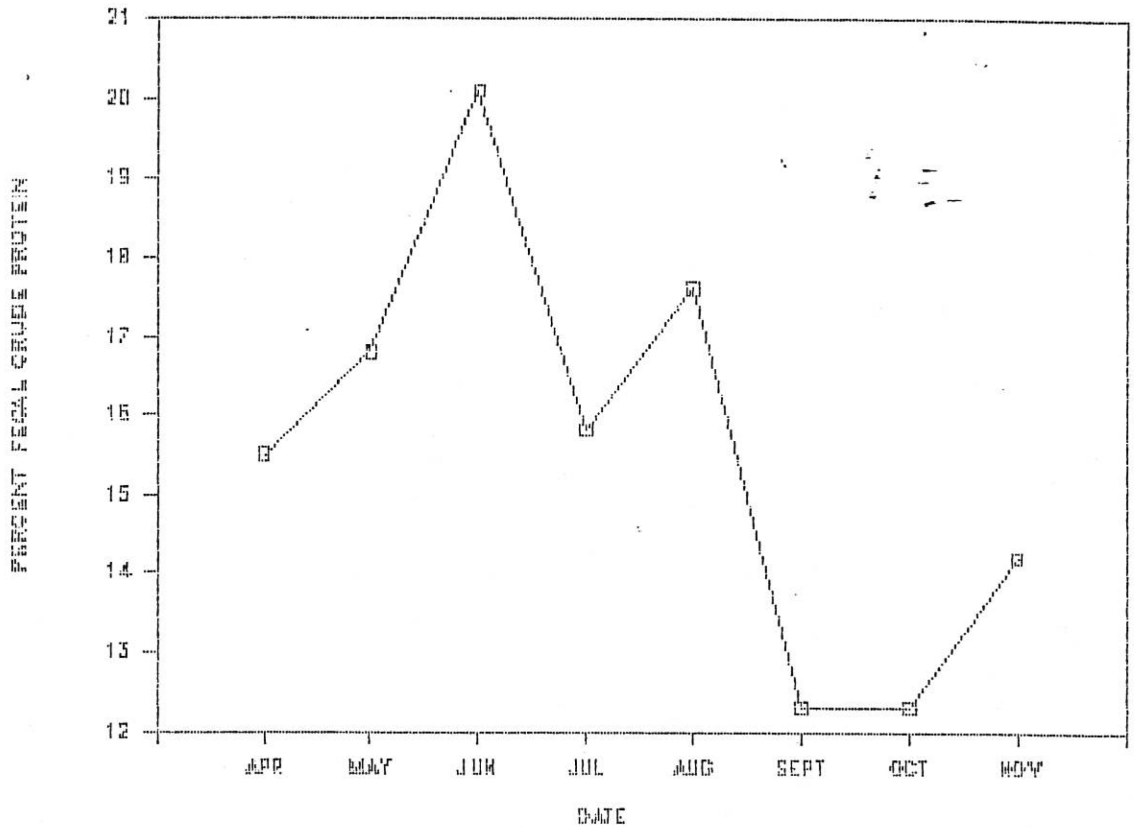

Figure 5-4. Crude protein (%) in spring, summer and fall diets of East Walker and Mono Lake deer, Mono County, Calif., April-November 1988.

relationship between CP and herbaceous forage in composited pellet samples ($\underline{r}2$ = 0.19).

Fecal Nitrogen

Seasonal patterns of FN were similar to fecal CP, low in the fall and winter and high in the spring and summer. Winter-long trends in FN were also similar to fecal CP for both herds (Figures 5-5 and 5-6). On the EW range, FN declined from 1.75% in December to a low of 1.36% in February and then rose in March to 1.79% (Figure 5-5). On the ML range, winter FN levels declined from 1.41% in December to a low of 1.18% in January, the lowest recorded, and then rose again to 1.68% in February and 1.82% in March (Figure 5-5).

As with fecal CP, spring FN levels were highest in June (3.21%) and August (2.82%) and then declined sharply with the onset of fall to 1.97% in September and October (Figure 5-6).

There were obvious differences in monthly wintertime FN levels between herds. For the ML herd, FN was 0.34% and 0.47% lower than the EW herd in December and January, respectively, while February FN was 0.32% higher. Late-winter March FN was similar between the EW and ML herds with values of 1.79% and 1.82%, respectively (Figure 5-5).

There was a weak negative relationship between FN and Purshia in the diet ($\underline{r}2$ = 0.34), which is opposite the direction predicted and may be attributed to animals eating a

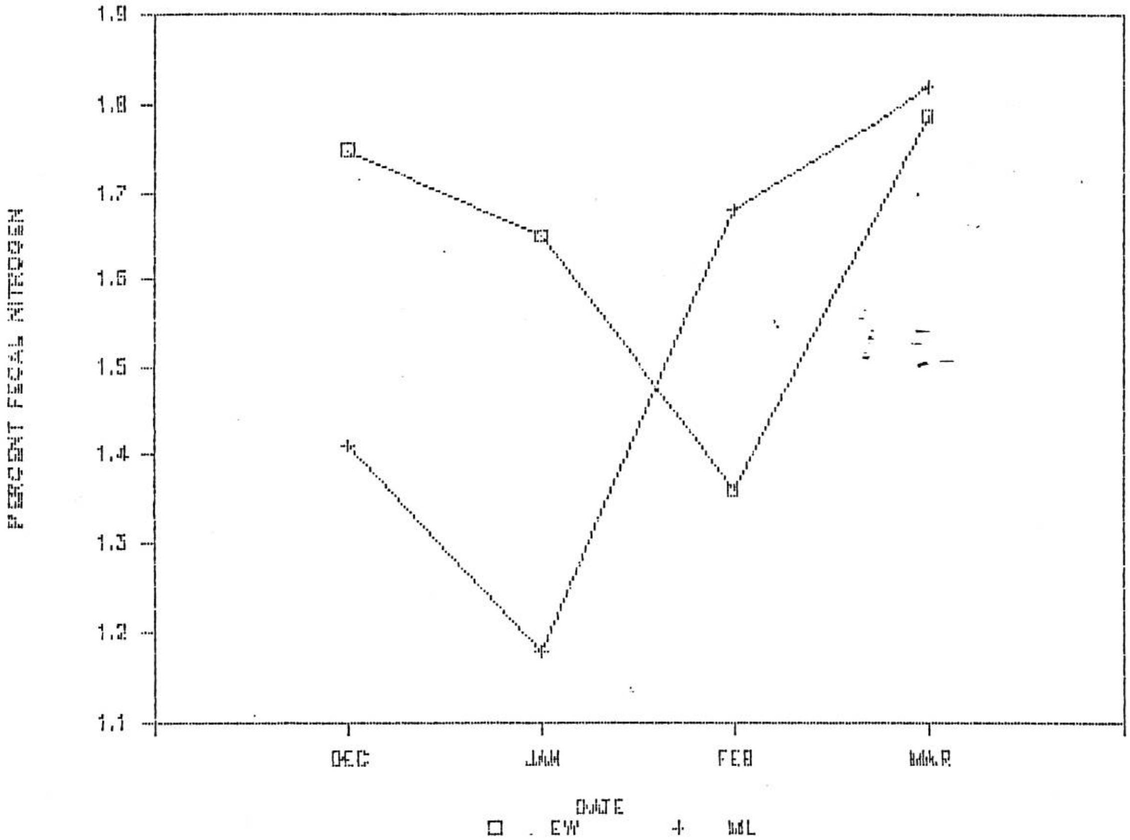

Figure 5-5. Fecal nitrogen (%) in winter diets of East Walker and Mono Lake deer, Mineral and Lyon Counties, Nevada. March 1988 and December-February 1989.

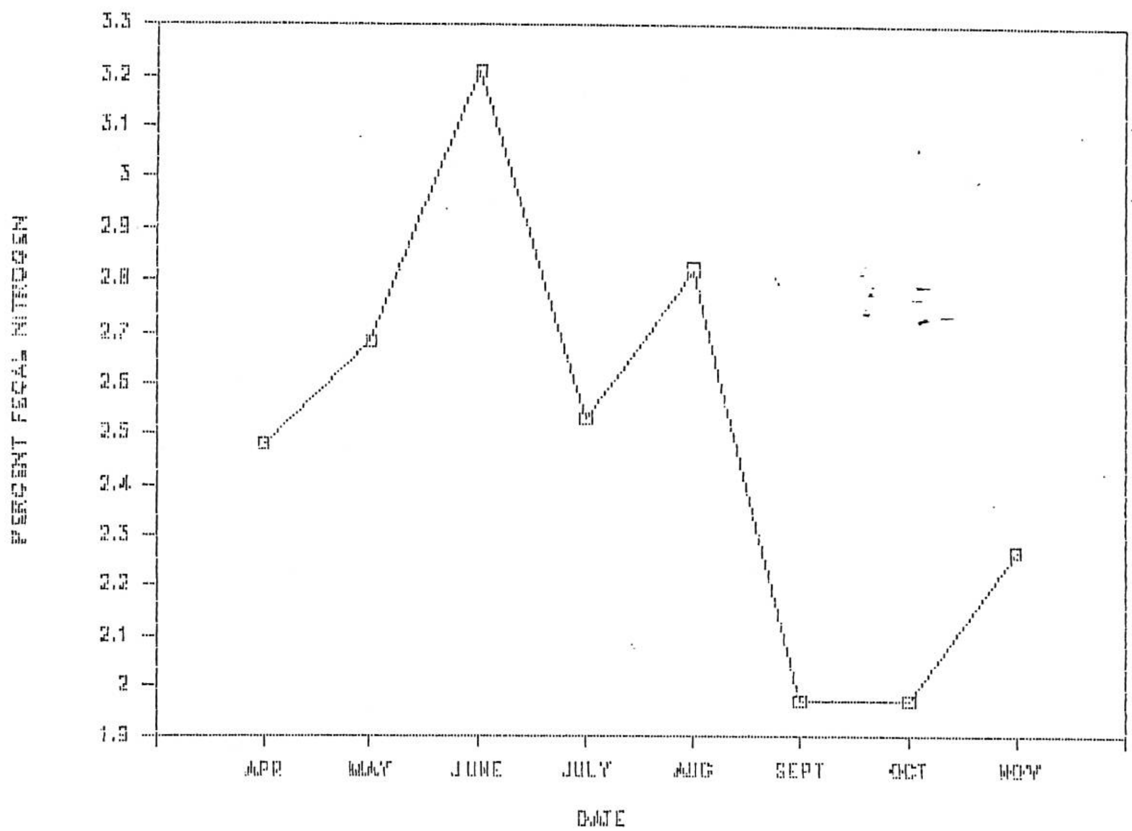

Figure 5-6. Fecal nitrogen (%) in spring, summer and fall diets of East Walker and Mono Lake deer, Mono County, Calif., April-November 1988.

higher proportion of less nutritious forages including *Artemisia*, evergreens and *Purshia* stems. There was a weak negative relationship between FN and *Artemisia* in year-round diets ($r2$ = 0.20).

Fecal DAPA

Fecal DAPA in February collections was higher than that of March collections (Figure 5-7). Additionally, the February DAPA value of 0.698 mg/g obtained for the EW herd was the third highest recorded in 1988. Throughout the course of 1988, monthly DAPA values ranged from a low of 4.40 mg/g in January to a high of 7.29 mg/g in June (Figure 5-8). As with FN, there was a weak negative correlation between *Artemisia* and DAPA in diets (r = -0.003, p = 0.08); there was no clear relationship between *Purshia* and DAPA.

DISCUSSION

Diet species composition data was obtained from single samples consisting of a minimum of 10 defecations which were composited by month. This precluded the use of statistical tests to determine differences in the relative proportions of species at monthly intervals or between herds. However, species composition data was useful in determining temporal differences in diet compositions of the EW and ML deer.

Food habits of EW and ML deer appear to be influenced

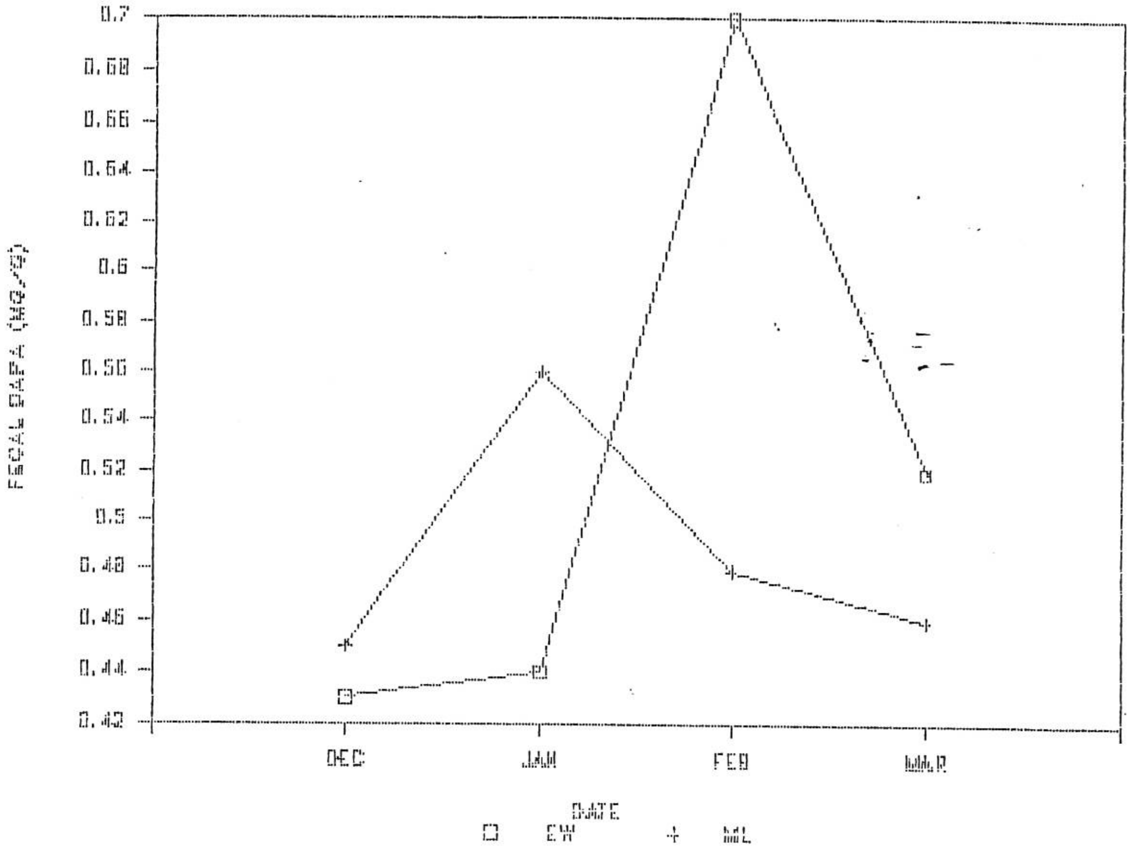

Figure 5-7. Fecal diaminopimelic acid (mg/g) in winter diets of East Walker and Mono Lake deer, Mineral and Lyon Counties, Nevada. March 1988 and January-February 1989.

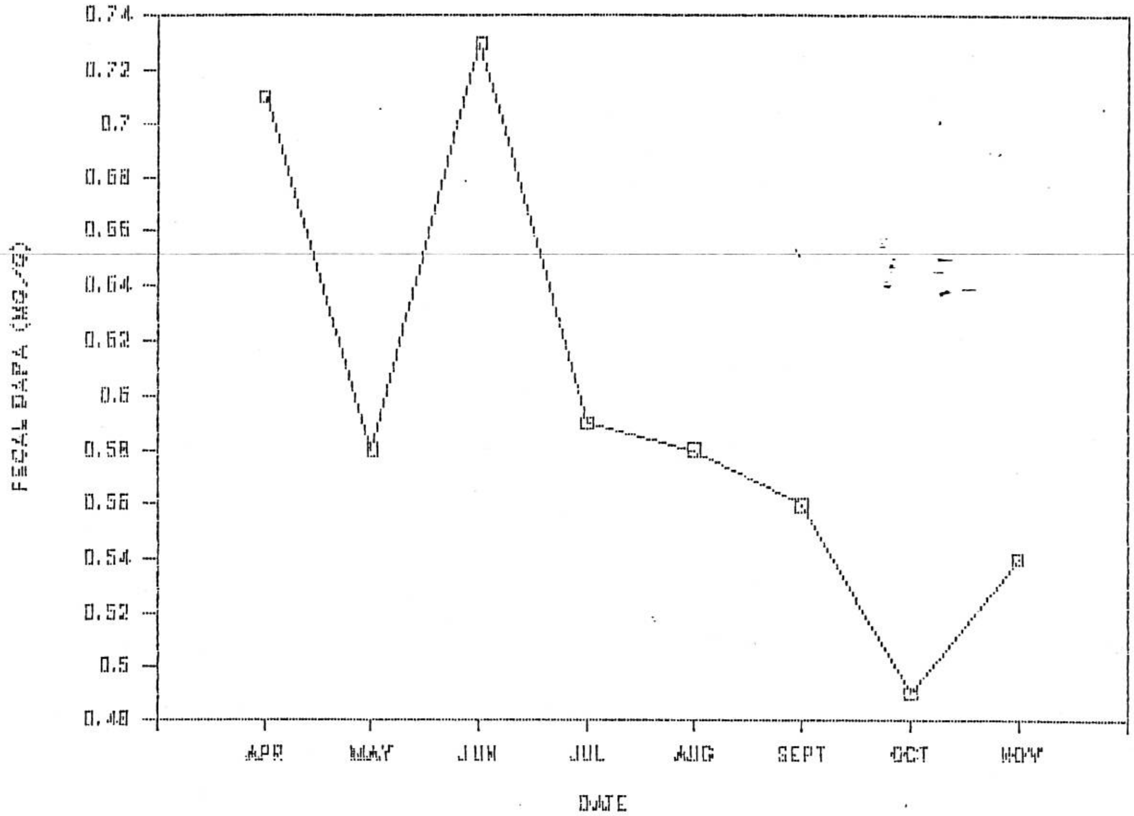

Figure 5-8. Fecal diaminopimelic acid (mg/g) in spring, summer and fall diets of East Walker and Mono Lake deer, Mono County, Calif., April-November 1988.

primarily by phenological changes in forages as well as the relative abundance of different species. Browse dominated the yearlong diets of EW and ML deer, receiving the highest use in December (99%) and the lowest use in August (61%). Browse use peaked in October-December (>87%) and then gradually tapered off through the late winter months before declining in March when new growth of succulent grass and forbs became available on the winter range. Browse use increased again in April when deer arrived on mid elevation spring holding areas and remained high (>70%) through June before declining to its lowest levels (61%-65%) in July, August and September.

Artemisia was the most abundant shrub in the diet from June-November. It comprised >50% of fall and winter diets and >60% of April and May diets. On the summer range (June-September), use of Artemisia was reduced substantially in favor of Purshia and other shrubs, primarily Salix and Symphoricarpos, and grasses and forbs. Purshia remained common through the winter months but amounts of this shrub in the diet were greatly exceeded by Artemisia, particularly from January-March. In addition, conifers comprised 3% to 13% of January-March diets. Use of Purshia was lowest from March-May when it comprised between 3% and 12% of spring diets.

Seasonal patterns of Artemisia-Purshia use by deer have been reported by others using different techniques to determine diet. Kufeld et al. (1973), in his review of food habits of Rocky Mountain mule deer, reported "generally" heavy sagebrush use during winter and spring. From examination of deer rumen contents in Montana, Wilkens (1957) determined that bitterbrush use declined and sagebrush use increased with the onset of winter. Leech (1956) examined the stomach contents of deer in various portions of northeastern California and reported that sagebrush was used most heavily in winter while bitterbrush was common only in winter and early spring. In the Piceance Basin of Colorado, Cahart (1943) reported 37% and 27% sagebrush in deer rumen samples collected during winter and spring, while Bartmann (1983), using a bite-count technique, found that sagebrush comprised 11% of November diets of tame deer.

The role of <u>Artemisia</u> in deer nutrition is poorly understood, and as a result many questions have been raised regarding its nutritional value (Wallmo and Regelin 1981). A potential problem with consumption of sagebrush, and also juniper and pinyon, is inhibition of bacterial activity in the rumen by volatile oils (Bissell et al. 1955, Nagy et al. 1964, Jobman 1972). Carpenter (1976) documented physical deterioration in tame deer when levels of sagebrush in the diet approached 30%, and Longhurst et al. (1968) reported heavy mortality in wild deer with excessive use of sagebrush.

In the eastern Sierra Nevada of California, Kucera (1988) related heavy use of sagebrush by deer to extreme nutritional stress as determined by poor body condition, poor reproduction and a declining deer population. Schwartz (1979) reported that volatile oils in Douglas fir adversely affect ruminant digestion.

The nutritional value of sagebrush in vivo has yet to be substantiated. However, in light of current information pertaining to the effects of Artemisia on ruminant digestion, it appears that heavy use of sagebrush may be an indication that winter diets were of low quality and that both herds were experiencing a low nutritional plane. Evidence of low diet quality may be reflected by the relatively low FN and DAPA values of winter samples. FN levels in December-February samples ranged from a low of 1.18% for the ML herd in January, to a high of 1.75% for EW herd in December. For the ML herd, November-March DAPA values ranged from a low of 0.433 mg/g in December to a high of 0.479 mg/g in February; the EW herd had November-March DAPA concentrations ranging from 0.433 and 0.698 mg/g.

The range of winter FN and DAPA values in this study approximate those found by Kucera (1988) in his study of another eastern Sierra mule deer herd. This author reported that deer experiencing extreme nutritional stress, as indicated by a low kidney fat index (KFI), had FN levels of 1.3% in November and 0.9% in December. He also found that the lowest FN occurred in a winter following a year with the lowest precipitation and forage growth. Kie and Burton (1984), reported FN concentrations as low as 2.1% for black-tailed deer, which is much higher than the January low of 1.18% recorded for the ML herd.

The winter DAPA values for the ML herd were much lower than those reported by Kie and Burton (1984). The lowest winter DAPA values reported by these authors was about 0.7 mg/g. Kucera (1988) reported winter DAPA concentrations between 0.42 and 0.52 mg/g for deer in the eastern Sierra.

When considering FN and DAPA concentrations reported for mule and black-tailed deer in other studies, the values recorded in this study appear to indicate low diet quality and perhaps, poor nutritional well-being during the winter months. However, it is important to note that Kucera (1988) attempted to correlate measures of diet quality (FN and DAPA) with measures of animal condition and found no close relationships, suggesting that these indices may not be reliable indicators of nutritional well-being.

The relatively high FN and DAPA concentrations of spring samples (March-June) indicate that despite continued heavy use through June, sagebrush did not have an adverse effect on the quality of spring diets. This is perhaps due to the effects of increased levels of herbaceous forages in the diet. Grasses and forbs, with high cellulose and high digestability, and low protein may serve to increase the digestability of shrubs with lower digestability, but higher protein levels (Wallmo and Regelin 1981).

In March, grasses comprised 33% and 20% of EW and ML deer diets, respectively. According to Kufeld et al. (1973), other studies have also shown the use of grass to be heaviest in the spring. Grasses and other succulent forages which are easily and quickly digested, are an essential component of the spring diet. Readily digested high quality forages greatly increase the net energy available to deer and therefore, they rapidly reverse the negative energy balance experienced by deer during the winter (Short 1981, Garrott et al. 1987).

The amount of grass in the March diets of EW and ML deer may be proportional to its availability. Deer from the EW herd have access to irrigated pastureland adjacent to the East Walker River where succulent herbaceous forage is readily available. Therefore, heavy use of these pastures is the most likely reason for the greater amount of grass in the March diets of EW deer. Additionally, for reasons explained in Chapter 4, these pastures and the herbaceous forage which they provide are also likely factors contributing to the delayed spring migration of the EW herd.

On EW and ML winter and transition ranges, browse is critical to the winter survival of deer because it is the most available forage in deep snow. Shrubs, primarily _Artemisia_ and _Purshia_, also have nutritional advantages over grasses and forbs because they are a better source of crude protein (Dimeo 1977, Bartmann 1983). In the fall, shrubs transfer nitrogeneous and mineral compounds, from which proteins are synthesized, from leaves to twigs and stems which are available to browsers (Dietz 1972). Conversely, grasses and forbs store nitrogenous compounds in the roots where they are unavailable to deer. Therefore, an abundance of high quality browse must be available during the winter stress period so that a condition of irreversible undernourishment is not reached (Short 1981). Julander (1962) reported that over-winter losses were three and five times as great on deteriorated and severely depleted ranges, respectively, than on ranges with fair browse conditions. An abundance of high quality winter forage is also essential for reproduction in mule deer. If nutrition is suitable only for maintenance, low reproductive success will occur (Short 1981).

CHAPTER 6. REPRODUCTION AND CONDITION

Within the last five years, the East Walker and Mono Lake deer herds have been of management concern because of poor fawn survival and low recruitment. Fall fawn:doe ratios have averaged 35 fawns:100 does; spring ratios have averaged 16 fawns:100 does (Ron Thomas, pers. comm.).

The first priority of management in any deer herd where fawn production is suboptimal should be to consider the nutritional status of does at breeding and during pregnancy (Connolly 1981). Numerous studies have documented the importance of maternal nutrition to reproduction (Verme 1965, Robinette et al. 1973, Ozaga and Verme 1982). These studies have consistently shown that does on good range have higher rates of ovulation, conception and pregnancy than does on poor range.

Accurate assessment of body condition of individual deer is fundamental to establishing and understanding relationships between deer populations and their habitat. Based on this understanding, management activities can be better designed and more successful in attaining management goals. Fat is the body component most often associated with animal condition and various indices have been developed to estimate fat reserves. The most commonly used body composition indices include bone marrow fat concentration and kidney fat index (KFI) which have been shown to be useful measures of nutritional state in mule deer.

In this portion of the investigation, body composition indices and reproductive tracts were used to determine the physical condition and reproductive potential of adult does collected from the East Walker (EW) and Mono Lake (ML) herd winter ranges in southwestern Lyon and Mineral Counties, Nevada.

METHODS

From 21-23 March 1990, deer from the EW and ML herd winter ranges were collected by California Department of Fish and Game (DFG) and Nevada Department of Wildlife (NDOW) personnel. Deer were collected by several teams which consisted of a shooter and a spotter. All collection teams were instructed to shoot the first identifiable adult doe, regardless of the animal's apparent age and condition. Binoculars and spotting scopes were used by the spotter to distinguish adult does from fawns and antlerless bucks. Once an adult doe was identified, it was shot in the head or anterior portion of the body cavity with a high powered rifle.

All animals were brought to a field processing station where they were weighed to the nearest pound using a spring scale ("bled carcass weight" BCW; Anderson et al. 1972) and measured. External carcass measurements of adult animals included chest girth, contour length, tail length and left hindfoot. Reproductive tracts (uterus and ovaries) were extracted and frozen for later analysis in the laboratory. The ages of all animals collected were estimated by tooth wear and replacement (Larson and Taber 1980). Age is the number of years to the nearest birthday in June or July, e.g., age 3 years refers to animals that are approximately 2.7 years old. To provide suitable sample sizes, age classes were formed by pooling 2 consecutive year cohorts (e.g., 2-3 yr).

Once reproductive tracts were thawed the ovaries were sectioned and examined macroscopically for the presence of corpora lutea of pregnancy (CLP) which were used to estimate ovulation rates (Cheatum 1949). Fertilization rates were determined by the ratio of viable embryos to CLP. All fetuses were counted, sexed, weighed to the nearest half ounce, and measured. I measured forehead-rump distances of fetuses to estimate fetal age, and thus conception and fawning dates. The forehead-rump measurement, fawning, and conception dates were obtained using a fetus scale (Forestry Suppliers Inc., Jackson, Mississippi). I used the midpoint in ranges of fetal age based on length to assign ages to individual litters.

Right kidneys only were used to determine kidney fat index (KFI: Riney 1955). The kidney-fat index was calculated by dividing the fresh weight of the kidney fat by the fresh weight of the fat free kidney from each deer and multiplying by 100. Left femur marrow fat (FMF) was analyzed for percent fat content. An index (CONINDEX) based on femur marrow fat concentration and right trimmed KFI was calculated following Connolly (1981:334), since this method was more subjective.

I used a Mann-Whitney U Test and parametric t-test to examine differences in reproductive and condition parameters between herds. A 1-way analysis of variance was used to examine differences in age classes for each of the condition indices: KFI, FMF and BCW.

RESULTS

On 21 and 23 March, 17 does (3 yearlings and 14 adults) were collected from the EW winter range. One of these does, a yearling, was a vehicle killed animal collected on 21 March from Route 182 near the north end of Bridgeport Lake. On 22 March, a total of 19 does (2 yearlings and 17 adults) were collected from the ML deer herd winter range. Four of these deer were taken from the Rattlesnake Flat area located at the base of the north slope of the Excelsior Mountains; 15 deer were collected from the base of the east slope of the Wassuk Range, between Anchorite Pass and Cottonwood Canyon. On 7 April 1990, an adult doe killed by a vehicle on Route 395 near its junction with Route 270 was also included in the collection sample.

Table 6-1 presents summary data, stratified by herd and by age (adult or yearling), for does collected in March of 1990. Although not statistically significant, the ages of adult does averaged slightly older for the ML herd. The age

Table 6-1. Summary table of reproduction and body characteristics of 32 adult female mule deer collected on the East Walker and Mono Lake herd winter ranges, Mineral and Lyon Counties, Nevada. March 1990.

					ADULTS											
					FETAL RATE		FETAL AGE (DAYS)			FETAL CR LENGTH (mm)			AVE	AVE	AVE
HERD	AVE. AGE	BCW (lbs)	% PREG.	C.L. RATE	#/ DOE	#/ PREG.	AVE	MIN	MAX	AVE	MIN	MAX	% KFI	% FMF	CONINDEX SCORE
EW	3.5	104.0	100	1.00	1.93	1.96	108	95	115	237	170	250	25.0	67.9	77.5
ML	4.6	110.0	100	1.14	1.88	1.88	109	95	125	224	190	225	33.9	77.9	96.1

structure of adult does stratified by herd is presented in Figure 6-1.

REPRODUCTION

Reproductive Potential.--Pregnancy rates among 32 adult does examined (32 reproductive tracts) from both herds was 100%. Pregnancy rates among 3 yearling EW does was 33%; pregnancy rates among 2 ML yearlings was 50%. Adult fetal rates, 1.93 fetuses/adult doe and 1.88 fetuses/adult doe for the EW and ML herds, respectively, were not significantly different among herds. Tables 6-2a and 6-2b present age specific data by year class for the EW and ML herds. For adult does from the EW herd, 28 CLP resulted in 28 viable, implanted fetuses (100% pregnancy rate). For ML does, 39 CLP resulted in 35 implanted fetuses for an overall pregnancy rate of 89.7%. Two does, one from each herd, were pregnant with triplets.

Fetal Sex Ratios.--The combined fetal sex ratio of EW does was 50% males versus 37% males in ML does (Table 6-3). Examination of pooled data (EW and ML) for individual age classes revealed 7, 7, and 4 male and 9, 7, and 4 female fetuses for the 2, 3 and 4 year classes, respectively; for the 5, 6 and 7+ year classes, there were 4, 0 and 4 male and 2, 4 and 10 female fetuses, respectively.

Breeding and Fawning Seasons.--There was no significant difference in mean fetal size between herds. Back-dated ages

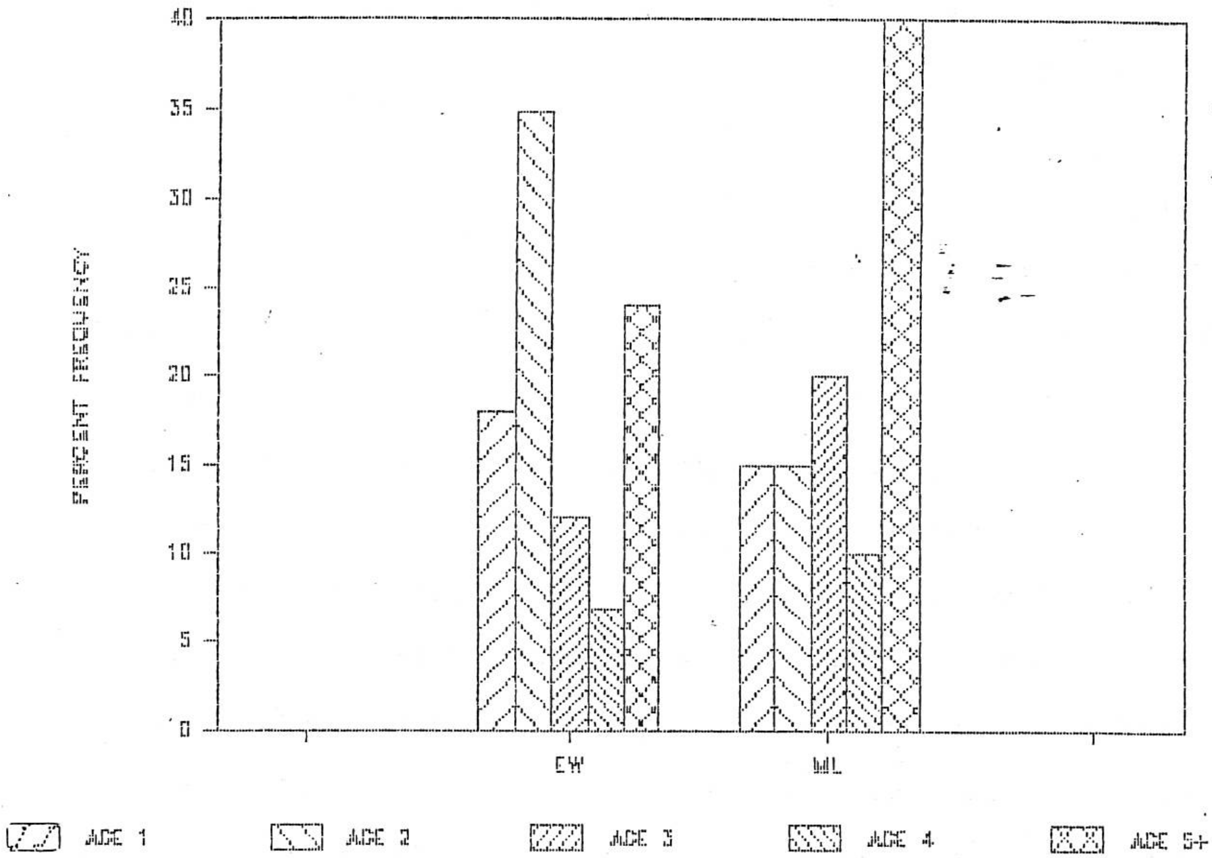

Figure 6-1. Age structure of does collected from the East Walker and Mono Lake deer herd winter ranges, Lyon and Mineral Counties, Nevada. March 1990.

Table 6-2a. Frequency of occurrence of fetuses in East Walker does by age class.

YEAR CLASS	NUMBER OF FETUSES 0 %	0 No	1 %	1 No	2 %	2 No	3 %	3 No	TOTAL NUMBER OF FETUSES	TOTAL NUMBER OF DOES	% AND TOTAL NUMBER OF PREGNANT DOES %	No.	FETUSES PER DOE	FETUSES PER PREGNANT DOE
1	66	2	33	1	0	0	0	0	1	3	33	1	.33	1.00
2	0	0	33	2	66	4	0	0	10	6	100	6	1.60	1.60
3	0	0	0	0	66	2	33	1	7	3	100	3	2.33	2.33
4	0	0	0	0	100	1	0	0	2	1	100	1	2.00	2.00
5+	0	0	0	0	100	4	0	0	8	4	100	4	2.00	2.00
SUM	12	2	18	3	65	11	5	1	28	17	88	15	1.64	1.86

Table 6-2b. Frequency of occurrence of fetuses in Mono Lake does by age class

YEAR CLASS	NUMBER OF FETUSES 0 %	0 No	1 %	1 No	2 %	2 No	3 %	3 No	TOTAL NUMBER OF FETUSES	TOTAL NUMBER OF DOES	% AND TOTAL NUMBER OF PREGNANT DOES %	No.	FETUSES PER DOE	FETUSES PER PREGNANT DOE
1	50	1	50	1	0	0	0	0	1	2	50	1	.50	1.00
2	0	0	0	0	100	3	0	0	6	3	100	3	2.00	2.00
3	0	0	25	1	75	3	0	0	7	4	100	4	1.75	1.75
4	0	0	0	0	50	1	50	1	5	2	100	2	1.66	1.66
5+	0	0	22	2	78	7	0	0	16	9	100	9	1.77	1.77
SUM	5	1	20	4	70	14	5	1	35	20	95	19	1.75	1.84

Table 6-3. Sex of fetuses in 4 maternal age classes of mule deer from the East Walker and Mono Lake deer herds, Mineral and Lyon Counties, Nevada.

Maternal age class (yr)	Mono Lake			East Walker		
	No. M	No. F	% M	No. M	No. F	% M
1-2	6	5	55.4	3	4	42.9
3-4	6	3	66.0	4	8	33.3
5-6	1	3	25.0	3	3	50.0
≤ 7	1	3	25.0	3	7	30.0

of fetuses from 32 females collected from both herds between 21-23 March suggest that breeding occurred between 23 November and 28 December with a median date of 2 December. Of the 32, 11 (34%) bred between 1 and 5 December; 5 (16%) between 21 and 25 December; and 4 (12.5%) between 25 and 30 November, 11 and 15 November and 16 and 20 November.

Assuming a period of gestation of about 204 days (Anderson 1981), parturition occurred from mid-June to mid-July with a median date of about 23 June.

CONDITION

I found no differences in condition indices between herds (Table 6-1). Although not statistically significant, fat indices averaged slightly higher in ML does than the alternative. Mean KFI's for ML and EW herds were 34% and 25%, respectively. There was no difference in KFI among ML age classes ($F=1.12$, $P=0.05$); no differences in KFI were detected among EW age classes ($F=3.98$, $P=0.05$). The KFI of 2 year old ML does was significantly greater ($P < 0.05$) than that of 2 year old EW does. For all deer ($N = 38$), highest mean KFI's occurred among 3 year old does (35%), followed by 2 year olds (34%) and 4-5 year olds (28%). Yearling and older does $\geq$ 6 years exhibited the lowest mean KFI's, 24% and 26%, respectively.

There was no difference between herds in percent FMF ($P \geq 0.05$). Percent FMF for EW does ranged from 15.6%-88.9%;

percent FMF for ML does ranged from 13.6%-53.5%. No differences were detected in FMF among ML age classes (F=2.5, P=0.05) and EW age classes (F=1.4, P=0.05). Highest mean FMF in EW and ML does was among 2 year olds (85%), followed by 4-5 year olds (79.5%), and yearlings (76.5%). Six year and older does had a combined FMF of 53%.

I found no difference between herds (P > 0.05) in mean CONINDEX ratings. Highest mean CONINDEX ratings occurred among 4-5 year olds (108), followed by 2 year olds (98) and 3 year olds (96). Older does and yearlings showed the lowest mean ratings of 64 and 75, respectively. There was no difference in average BCW between herds (P > 0.05).

DISCUSSION

Unfortunately, funding constraints within DFG prevented conducting animal and fecal pellet collections during the same year or for more than a single year, thus precluding direct comparative analysis of indicators of diet quality (FN and DAPA) with measures of animal reproduction and condition (pregnancy rates, KFI, etc.).

Reproductive potential was comparable between the EW and ML herds. All adult does from the EW and ML herds were pregnant (Table 6-1). Mean fetal rates among adult does from the EW and ML herds were 1.93 and 1.88, respectively, slightly higher than the majority of those reported by Anderson (1981, pp. 44-47) for other mule deer populations throughout the west. A similar investigation conducted in

1987 and 1988 of another eastern Sierra deer herd, the Casa Diablo herd, reported a mean fetal rate of 1.83 fetuses/doe and a 100% pregnancy rate among 35 females collected from winter range near Benton, California (Taylor 1988b). Kucera (1988) reported a fetal rate of 1.88 fetuses/doe and 100% pregnancy rate for does collected in 1984 from the Round Valley winter range near Bishop, California.

Comparatively high reproductive rates for both yearling and older females in this study suggests an adequate level of maternal nutrition in deer from the EW and ML herds in the winter of 1990. Pronounced effects of a reduced nutritional plane on reproduction have been documented for free-ranging and confined populations of mule and white-tailed deer (Cheatum and Severinghaus 1950, Robinette 1955, Teer et al. 1965, Kie et al. 1980). Julander et al. (1961) reported rates of 1.9 and 1.2 fetuses per doe in two mule deer populations residing on summer range of high and low carrying capacity, respectively, following poor nutrition and hard winters. The productivity of whitetail does fed a good ration was nearly twice that of those on a restricted diet (Verme 1967).

In the eastern Sierra, Kucera (1988) associated declining reproductive rates, body weights and fetal sizes in deer from the Buttermilk herd with decreasing precipitation and forage. However, direct measures of reproduction and condition did not correlate well with indicators of diet quality (FN and DAPA). In the present study, reproduction/condition and diet/nutrition data were collected in different years. Consequently, it was not possible to examine relationships between indicators of diet quality and measures of reproduction and condition.

According to Riney (1955) and Kie et al. (1984), KFI is a valuable indicator of nutrition between two populations. Although not statistically significant, mean KFI's, FMF and CONINDEX scores for deer in the ML herd were comparatively greater than in deer from EW herd. Mean KFI's for the ML herd were 34% versus 25% for the EW herd. KFI's for the Casa Diablo herd averaged 39% (Taylor 1988b), and Kucera (1988) reported mean KFI's as high as 70% and as low as 10% in deer collected near Bishop, California.

There were large variations in fat indices within and between individual EW and ML age classes. KFI's ranged from 13.6-55.9% and 13.6-74.3% for the EW and ML herds, respectively. KFI's below approximately 15% indicate essentially no kidney fat, and is the level at which a deer begins to use femur marrow fat (Harris 1945, Riney 1955). Once deer begin mobilization of femur marrow fat, KFI may not be a good indicator of condition (Connolly 1981). Therefore, a more subjective method (CONINDEX) which combines KFI and FMF measures was used to rate the physical condition of deer.

Differences in condition among individuals of the same age class suggests that these animals occupied summer ranges with varying degrees of habitat quality. Deer with comparatively low fat measurements may be from summer ranges of poorer quality than deer with higher levels of body fat. If deer cannot obtain adequate amounts of quality foods on the summer and intermediate ranges in early autumn, production of body fat will be diminished (Short 1981). Does with lower fat levels, e.g., 6+ age class, may also have been animals that reared fawns the preceding summer, devoting much of their stored energy to lactation demands.

Although not statistically different, yearling and older does ($\geq$ 6 years) exhibited the lowest mean KFI's and CONINDEX scores. Therefore, the relatively low KFI's obtained for this study may partially be due to the large percentage of young deer and older adults in the sample. Connolly (1981) suggested that lower productivity in young and old does may be an indication that they are less healthy, on the average, than does of prime age. However, pregnancy rates and fetal rates among does 6 years and older in this study were 100% and 2.00 fetuses/doe, respectively, indicating a high reproductive potential and an adequate nutritional plane among older age classes. According to Ozaga and Verme (1986), a (white-tailed) doe's fawn rearing skills improve with age; older mothers are more successful than younger ones, especially when predation seriously impacts neonatal survival. The above findings suggest that the productive contribution of older does in the subject herds may be significant. Additionally, the fact that nearly half the yearlings collected were pregnant would suggest a higher level of nutrition than would normally be expected among individuals of this age class.

Adequate maternal nutrition among all age classes is also indicated by the fact that there were no observed differences in fetal sizes, estimated fetal ages or conception dates. According to Verme (1965) and Mansell (1974), maternal nutrition can influence the onset of estrous. Verme (1967) found that yearling whitetail does will not conceive fawns if summer and fall nutrition is inadequate. Short (1981) reported that marginal range conditions, owing to overgrazing or seasonal drought, can adversely affect the nutrition of does and the reproductive success of mule deer. In other words, if nutrition is suitable only for maintenance, then productive functions suffer.

For the ML herd, fetal sex ratios strongly favored females (59 M:100 F), another indication of adequate maternal nutrition as previously indicated by fetal rates and fetal sizes. Robinette et al. (1957), found that males comprised 42 percent of the fetuses produced by mule deer living on comparatively good range. In contrast, males comprised 65% of fetuses carried by does on poor range. On Michigan's George Reserve, McCullough (1979) found that more male fetuses were conceived in years when higher population densities created a suboptimal nutritional plane. According to Verme (1969), adult white-tailed does which fed on a poor diet prior to breeding produced 72% males, while does that fed on good diets produced 43% males.

In Utah, the fetal rates of yearlings on poor range was greater after a mild winter than after a severe one (Robinette et al. 1955). This mostly applied to yearlings that occupied good versus poor summer range.

In this study, apparent contradictions between poor diet quality and high fetal rates may be partially due to mild winter conditions which occurred during this study. This collection took place after a fourth successive winter of drought, when lack of snowfall at higher elevations allowed deer to remain on summer and transition ranges until late January 1990 (Chapter 4). This suggests that during mild winters, deer can reduce intraspecific competition for forage by exploiting food resources on both transition and winter ranges that are normally not available because of deep snow. At least four radio-collared deer from the present study remained on transition ranges to the west of Bridgeport until early February. One radioed doe from the EW herd remained on her summer range in the Bodie Hills until late February, after which she migrated to a lower elevation secondary winter range offering an abundance of succulent forage.

Because of the comparatively high reproductive potential of the EW and ML populations, it is logical to assume that poor fawn recruitment is largely a function of neonatal losses and perhaps, prenatal mortality in the third trimester of pregnancy. Neonatal losses may in turn contribute to higher reproductive rates since does are relived of the strain of lactation, enabling them to meet their metabolic requirements during the summer and autumn. They enter the autumn breeding season in good condition and are able to conceive and maintain a higher level of maternal nutrition during the winter months. This results in lower prenatal mortality and a higher reproductive potential. Ransom (1967) found that winter stressed whitetails in Manitoba exhibited a high gross productivity that was probably related to increased fecundity of nonlactating does that had suffered natal fawn losses.

CHAPTER 7. MORTALITY

The principal causes of mortality identified among deer from the EW and ML herds were hunting, predation, causes related to malnutrition, and automobiles.

Hunting.--Deer from the EW and ML herds summer primarily within California hunting Zone X-12 and within the northern end of Zone X-9A. Prior to this investigation, the number of bucks harvested from Zone X-12 were reported by "herd unit" based on the best available knowledge of EW and ML deer herd habitats. However, radio-telemetry data collected during this study has revealed that EW and ML deer share summer ranges along the east slope of the Sierra. Thus, for the purposes of buck only hunting in California's Zone X-12, the number of bucks harvested from the EW and ML herd summer range are now considered and reported as one by DFG.

In 1986, the number of tags issued for Zone X-12 was reduced from 3,000 to 1,500 tags. In 1989, the quota was further reduced to 1,000 tags; the quota in 1990 was increased to 1250 tags. This overall decrease in buck only hunting tags was imposed by DFG in attempt to increase buck ratios while at the same time providing participating hunters with a greater opportunity for success. Another desirable outcome of this strategy is to increase the number of older bucks in the population so that eventually these older individuals will represent a larger proportion of the annual harvest. The logic behind this strategy is that the average age of animals killed is related inversely to the size of the harvest (Connolly 1981). Gross (1975) and Anderson et al. (1974) have shown a decline in trophy quality with an increase in harvest using computer modeling. Therefore, in theory, a reduction in deer tags in Zone X-12 will result in increased buck ratios, increased hunter success and an increase in the number of trophy quality bucks in the harvest. Whether or not the current quota is low enough to obtain the latter objective remains to be seen.

Traffic-related Mortality.--According to radio-telemetry information, the majority of deer from the EW and ML herds cross Route 395 at least twice a year as they move between winter ranges in western Nevada and summer range on the east slope of the Sierra Nevada mountains in California. Route 395 is a major State highway which connects southern California with the Reno and Lake Tahoe areas and resort communities along the east slope of the Sierra. Due to increases in human population throughout California and particularly in southern California, traffic-volumes on Route 395 are increasing on an annual basis (Tom Dayak, Caltrans, pers. comm.). Consequently, hundreds of deer are killed by vehicles on Route 395 each year.

The California Department of Transportation (Caltrans) is planning to construct passing lanes at four separate sections of Route 395 within Zone X-12. These four expansion areas, which range in length from 1.9-4.0 km, are located between the junction of Route 167 and the Swauger Creek Road. Two of these passing lane expansions are proposed for areas where historically, high numbers of deer-kills have been documented. Highway expansion at these "critical" deer kill or "hot spot" areas has created concern among DFG and Caltrans officials because of the potential for additional deer-vehicle collisions.

Throughout the United States, vehicular collisions with deer (Odocoileus spp.) and attempts by motorists to avoid collisions constitute an important cause of highway accidents, resulting in human injury and death, extensive automobile damage and loss of wildlife. According to Arnold (1978), a reported 63,184 deer-vehicle collisions occurred in Michigan from 1972-1976, resulting in 3,289 (5%) motorist injuries and 17 deaths. Thompson (1965) reported one human casualty for every 41 deer-vehicle collisions which occurred in California. In Colorado, it was estimated that 5,000-6,000 deer-vehicle collisions resulted in an annual property damage of 1.6 million dollars (Pojar et al. 1972). Hansen (1983) estimated that the mean cost of a deer-vehicle accident was about $650.

In 1974, a reported 146,229 deer carcasses were removed from roadways across the United States (Rue 1978). In Pennsylvania, a reported 24,183 deer were killed by motorists in 1976, exceeding the number of deer harvested by recreational hunting in thirty-five other states (Wolfe 1978). Hansen and Wolfe (1983) reported that highway deaths of deer exceed 20,000 annually in New York and Michigan and Longhurst et al. (1976) estimated that 20,000 deer were killed on California roadways in 1974.

The number of deer killed annually on Route 395 in Mono County was recorded with varying intensity by Caltrans from 1966-1976 and 1989-1990. A total of 1,876 road-killed deer were recorded in Mono County between 1965 and 1976. Because of DFG concerns regarding the potential impact of proposed expansions of Route 395 on migratory deer, Caltrans made a moderate effort in 1989 and a more intensive effort in 1990 to document road kills on all Mono County highways. As a result, a total of 161 and 486 road killed deer were recorded in 1989 and 1990, respectively (Caltrans files).

Highway kill data has been useful in identifying "hot spot" areas along portions of Route 395 in Mono County. However, little has been done, except for the installment of driver warning signs, to remedy the deer kill problem. According to Ford (1980), a similar deer kill problem on Route 395 in southeastern Lassen County and northeastern Sierra County was alleviated by installment of highway underpass structures. These structures have proven to be effective in providing migratory deer safe passage across highway corridors.

Due to the apparent adverse impact of Route 395 on Mono County deer herds and the potential to increase this impact, Caltrans with cooperation of DFG, expanded the present investigation to include a study of the four sections of Route 395 which are proposed for expansion from 2 to 4 lanes. The objective of this study was to describe and quantify the amount, timing and specific locations of migratory mule deer use of each of the four proposed expansion areas. The goal was to provide information which will allow informed decisions to be made with respect to each project and enable mitigation designed to reduce the number of deer-vehicle collisions to be incorporated into those projects developed.

METHODS

Automobiles

Route 395 Expansion Areas.--The relative number of deer crossing Route 395 within each of the four expansion areas was determined from radio-telemetry studies, ground surveys of highway right-of-ways, track count surveys, interviews with knowledgeable individuals, and highway kill records obtained from 1969-1976 and 1989-1990. A detailed description of each of these methodologies is provided in

Taylor (1990a).

The four sections of Route 395 proposed for expansion from 2-4 lanes within Zone X-12 include:

(1) Cemetery Road - Located from 0.1 miles south of Cemetery Road to 0.1 miles south of the junction of Route 167; Post Mile (PM) 55.6-58.1 (Figure 7-1).

(2) Conway Summit - Located from 0.4-1.6 miles north of the Virginia Lakes Road; PM 63.9-65.1 (Figure 7-1).

(3) Buckeye - Located from 1.1 miles south to 0.4 miles north of the Bridgeport Ranger Station Road; PM 79.5-PM 81.0 (Figure 7-1).

(4) Rattlesnake - Located from 1.4-2.5 miles south of the Swauger Canyon Road; PM 84.6-86.7 (Figure 7-1).

Topographic and vegetative descriptions of each of these expansion areas is provided in Taylor (1990a).

Traffic-related Mortality.--In 1990, Caltrans personnel made diligent efforts to record deer kills on Mono County highways. This information, although not 100 percent efficient, yielded information which enabled DFG to calculate what was felt to be a "realistic minimum estimate of the number of deer killed on Mono County highways in 1990" (Thomas, Unpubl. data). This estimate was deemed necessary by DFG in order to determine the overall magnitude of the road kill problem in Mono County.

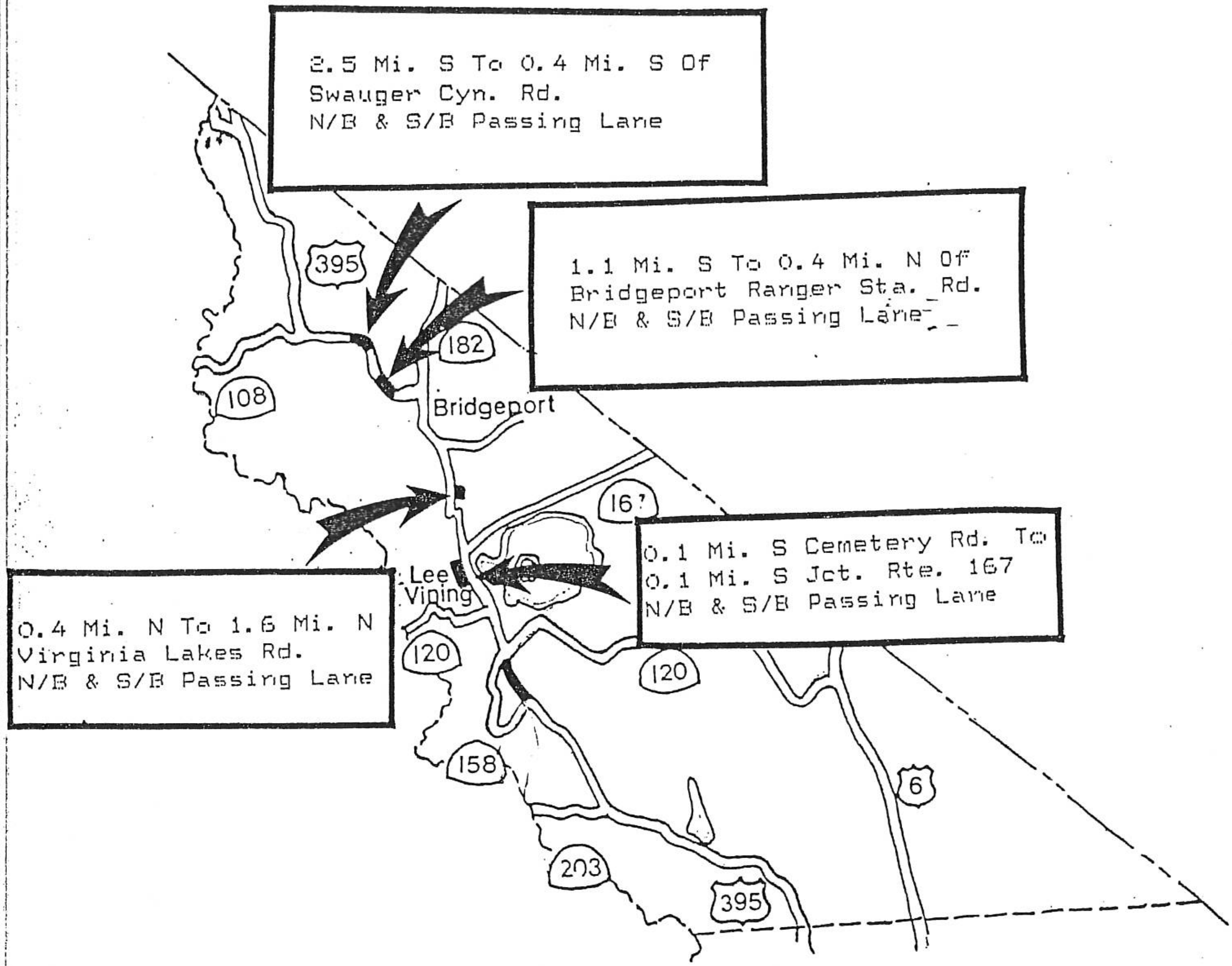

Figure 7-1. Location of four proposed Route 395 expansion areas in Zone X-12, Mono County, California.

The estimate derived by DFG was based on consultations with persons experienced in the road kill issue, i.e., Caltrans personnel, highway patrol personnel, and contract researchers. During interviews with local highway patrol officers, DFG was told that only at about one-third of deer-vehicle accidents are the animals found on the roadway after the accident. Animals which are not detected after a collision are those that either leave the roadway after the collision or those that are removed from the roadway by members of the public. An unknown percentage of animals which leave the roadway are able to survive, but DFG felt it reasonable to assume that the majority of these deer eventually succumb to their injuries or other ultimate causes of death such as predation (Thomas, Unpubl. data). From additional interviews conducted with local Caltrans officials, DFG concluded that some carcasses picked up by maintenance personnel are not reported. In addition, deer killed on some California and all Nevada roadways are also not reported.

For these reasons, DFG used a factor of 2 to estimate a conservative minimum number of road-killed deer from known minimum figures obtained from Caltrans in 1990.

RESULTS

Between March 1988 and January 1990, 21 of 61 (34%) radio-collared deer from the EW and ML herds died from various causes. Fifteen deer died during the first year of the study (March 1988-March 1989); 4 deer died between March 1988 and March 1989; and 2 deer died between March 1989 and March 1990. Twelve of these deer (9 females and 3 males) were from the ML herd; 9 deer (5 males and 4 females) were from the EW herd. Of the 21 confirmed deaths of radio-collared deer, 11 (52%) occurred during the fall, 4 (19%) during the summer, 3 (5%) during the spring, and 3 (5%) during the winter (Table 7-1).

NATURAL MORTALITY

Predation

During the first year of this study (March 1988-February 1989), 8 of 38 radio-collared deer marked on the EW and ML winter ranges in March 1988 were killed by mountain lions. Mountain lions killed 3 deer during the second year of this study (March 1988-February 1989) and 2 deer during the third year (March 1989-March 1990). Eight of the lion killed deer were from the EW herd; 5 were from the ML herd. Therefore, 13 of 61 (21%) deer radio-collared on EW and ML winter ranges in 1988-1990 were killed by lions during the course of this 39 month investigation.

Table 7-1. Number of confirmed deaths of radio-collared deer from the East Walker and Mono Lake herds by season and age class, 1988-1990.

Sex and Age (Yrs)	No. at Start	Total Deaths	Season: Summer	Fall	Winter	Spring
			EAST WALKER			
Female						
2	3	0				
3	3	0				
4	9	2		2L		
5+	8	2	1L	1L		
Total	23	4	1	3		
Male						
2	3	2		1L, 1H		
4	2	2		1H		1L
5+	3	2			2L	
Total	8	6		2 1	2	1
			MONO LAKE			
Female						
1	1	0				
2	8	4		2L	2L	
3	6	3	1L, 1U	1M		
4	5	1	1M			
5+	5	1				1M
Total	22	9	2, 1	3	2	1
Male						
2	1	1		1H		
3	2	1		1H		
4	2	0				
5+	1	0				
Total	6	2		2		

H = Hunter kill, L = Lion kill, M = Malnutrition, U = Unknown

Of the 13 deer killed by lions, 4 were adult bucks and 9 were adult does. Four deer were killed on the winter range (2 on EW and 2 on ML), 5 on transition range, and 4 on the summer range.

When found, 4 of the carcasses were partially covered and hidden in thick brush; 6 carcasses were either completely or partially buried near the base of trees; and 3 carcasses, which had initially been buried by lions, were uncovered, entirely consumed and dismembered by coyotes. Additional mountain lion sign including tracks, scat, scratches and drag marks, was found in the vicinity of each carcass, thus confirming the cause of death.

It appeared that carcasses of deer killed during the cooler winter months were not buried or hidden as well as carcasses of deer killed during periods of warmer weather. Five of the 13 carcasses had bite marks on the nape of the neck; 1 had bite marks in nasopharyngeal region; and 1 had bite marks near the trachea.

Of the 13 lion-killed deer, 6 were killed on the summer range, 3 on the winter range and 4 on transition ranges. Nine of the 13 lion kills occurred on summer and transition ranges in California; 4 occurred on Nevada winter ranges.

Malnutrition

Three radio-collared deer (.205, .236 and .430), all from the ML herd, appear to have died from causes related to malnutrition as indicated by their generally poor body condition and the red, gelatinous nature of their bone marrow (Cheatum 1949). Female #236, a 3 year old, died on the Buckeye holding area in mid-December 1988; female #430, a 7 year old, died on transition range in the Bodie Hills in March 1989 during spring migration; and female #205, a 2 year old, died in mid-July 1989 on her summer range in the Bodie Hills.

Hunting Mortality

Radio-collared deer.--Five radio-collared bucks were shot by hunters during the 1988-1990 California and Nevada State hunting seasons. One of these (#286) was taken on 11 September 1988 on his summer range on the north side of Kavanaugh Ridge. Another (#345) was crippled and lost on his summer range near Summers Meadow. A third radioed buck (#445) was crippled and lost in November 1988 in the Rough Creek drainage during the Nevada State rifle season. Buck #355 from the EW herd was taken on his summer range on Bush Mountain on 9 September 1989. A fifth buck, #355, was crippled and lost by an archer on Bush Mountain in late-August 1990. In addition, 3 non-radioed ear-tagged bucks were also taken during the 1988 California rifle season on their summer ranges located in the Bodie Hills. On 30

November, a non-radioed ear-tagged doe was shot on the ML herd winter range during a Nevada State antlerless hunt.

General Buck Harvest.--Over the last 5 years, the number of bucks harvested on EW and ML herd summer ranges in California has ranged from a high of 682 in 1985 to a low of 242 in 1990 (DFG files) (Table 7-2). The high harvest figure reported for 1985 reflects an early migration. During that year deer migrated during the hunting season in response to a severe fall snow storm. Consequently, bucks were more vulnerable to hunters as they moved between summer and winter ranges.

Automobiles

Route 395 Expansion Areas.--According to estimates obtained from track count surveys and radio-telemetry data collected from 1988-1990, approximately one-half of the EW herd, about 1500 animals, crosses Route 395 within the limits of the Buckeye expansion area. An additional 15% of the EW herd, some 450 deer, crosses through the proposed Rattlesnake expansion area. About 175 deer from the ML herd cross Route 395 through the Cemetery Road expansion area and approximately 100 ML deer cross through the Conway expansion area (Taylor 1990a).

Site factors common to all expansion areas which are

Table 7-2. Number of bucks harvested in Mono County Zone X-12 and Nevada winter ranges from 1980-1990 and number of does harvested from Nevada winter ranges from 1986-1990.

	California Zone X-12		Nevada	
	East Walker	Mono Lake	Bucks	Does
1980	352	258	77	
1981	502	374	94	
1982	205	202	63	
1983	226	213	26	
1984	348	378	74	
1985	319	363	123	83
1986	280	259	76	43
1987	164	135	133	52
1988	205	67*	72	36
1989	165	107	42	23
East Walker and Mono Lake Herds				
1990	242**		41	140

* This marked decline is partially due to altered allocations of kills to the Casa Diablo herd based on knowledge of seasonal ranges based on telemetry data.

** Hunting kill of deer in the EW and ML herd units was reported as one, since, based on telemetry research data, these two herds are known to be homogeneous on the summer range where hunting occurs in California.

believed to contribute to the road kill problem on Route 395 include right-of-way fencing, steep cut banks, topography, the availability of water and desirable forages along the right-of-way, and vegetation along the right-of-way which decreases visibility for deer and motorist.

Traffic-related Mortality.--The number of deer reported killed by vehicles on Route 395 and other Mono County highways in 1990 was 486. Of the 486 documented road-kills, 356 occurred on highways in Zone X-12. The 356 road-kills accounts for all animals recorded by Caltrans on Route 395 between Conway Summit and the Nevada State line and other State roads in Zone X-12, including Route 270, Route 182 and Route 108. These would be deer from the EW and ML herds and deer from the West Walker herd. The West Walker herd is recognized as occupying seasonal habitats primarily to the north of EW and ML herd ranges (Thomas 1984). The remaining 130 deer were killed on highways in Zone X-9A which includes the Sherwin Grade, Buttermilk and Casa Diablo deer herds. The ML herd also occupies summer range in the northern end of X-9A, from Lundy Canyon, north to Virginia Creek (Figure 7-2).

In order to extrapolate a more realistic estimate of the number deer killed on Mono County highways in 1990, Thomas (Unpubl. data) multiplied the 356 documented road kills recorded in Zone X-12 by 2 to derive a conservative estimate of 712 road-killed deer in Zone X-12 during 1990. For Zone X-9A, the 130 documented road-kills were multiplied by 2 to derive an estimate of 260 road-killed deer.

From Figure 7-2 it can be seen that the majority of road-kills on Route 395 within Zone X-12 occur to the north of Bridgeport, from the junction of Route 108, north to Walker. Telemetry data indicates that the majority of deer from the ML herd cross Route 395 between the junction of Route 167 and the junction of Route 108. Therefore, the high number of road-kills in the vicinity of Walker are deer from the West Walker herd, which are known to occupy winter and spring ranges immediately adjacent to Route 395.

Using this information, roughly 125 of the 356 documented roads-kills in Zone X-12 can be attributed to the EW and ML herds. Thus, multiplying 125 by 2 yields an estimate of 250 road-killed deer from the EW and ML herds in 1990. Since the EW and ML herds are estimated to have a combined population of around 6,000 deer, it can be estimated from this method that approximately 4 percent of the population was killed by vehicles in 1990.

DISCUSSION

Thirteen of 61 (21%) of radio-collared deer were documented to have been killed by mountain lions during the course of this 39 month investigation. Several researchers have provided estimates of the number of deer killed by an adult mountain lion on an annual basis. Hornocker (1970) estimated that each adult lion killed 14-20 adult deer per year in the Idaho primitive area. Connolly (1949) and Grinnel et al. (1937) estimated that an adult mountain lion killed one deer every 7-10 days. The number of deer killed by individual lions will obviously differ between areas due to the presence of alternate prey species. For example, in northwest Arizona, Shaw (1977) reported that of 62 lion kills, 37 were mule deer, 23 were cattle, 1 was a pronghorn, and 1 was a cottontail.

Feral horses and domestic cattle are abundant on EW and ML winter ranges in western Nevada, while cattle and domestic sheep are abundant on summer ranges in the eastern Sierra. In addition to wild horses and livestock, pronghorn antelope (*Antilocapra americana*) occur in the Bodie Hills and white-tailed jackrabbits (*Lepus townsendii*), black-tailed jackrabbits (*Lepus californicus*), cottontails (*Sylvilagus* spp.) and other small mammals are prevalent on all herd seasonal ranges. Mountain lions have also been reported to take coyotes which are common on all herd ranges. In a USFS study of coyotes near Mono Lake, California, 3 of 5 radio-collared coyotes were killed by mountain lions (Tom Murphy, USFS, pers. comm.). Of the 13 deer killed by mountain lions, 9 were taken on summer and transition ranges in California; only 4 were taken on winter ranges in Nevada. Why would the level of predation by mountain lions be greater on summer and transition ranges where deer are dispersed over a much larger area? There may be two reasons for this difference. First, mountain lions are hunted in Nevada and not in California. The mountain lion season in Nevada typically runs from 1 October-30 April and therefore coincides with the wintering period of the EW and ML herds. Within the vicinity of the EW and ML winter ranges (Nevada management units 201, 202 and 204) 12 permits to pursue and take lions were issued to hunters in 1988-89. The resultant hunting pressure may act to reduce mountain lion densities on these winter ranges by pressuring some lions to spend the winter months in California where they are not hunted.

A second possible explanation for this difference relates to high lion density. Evidence of high lion density is provided by the increase in lion sightings reported by the public, an increase in the number of depredation permits issued to ranchers and members of the public, and an increase in the number of lions hit by vehicles on roads in Mono County. I suggest that even though deer are more concentrated on the EW and ML winter ranges, the smaller cumulative area of wintering habitats preclude high lion density because of increased competition among territorial individuals. This results in some lions adapting to a nonmigratory seasonal use pattern where they remain on summer or transition ranges year-round. This pattern is perpetuated by the abundance and diversity of other prey species (e.g., coyotes, rabbits, etc.) on summer and transition ranges. Neal et al. (1987) suggested that the nonmigratory seasonal use pattern of some mountain lions on the North Kings deer herd range was the result of a low primary prey population and the high competition for it. Hornocker (1969) described this behavior as "mutual avoidance", where a lion will move in an effort to avoid a shared portion of its home range with another lion. The high level of lion predation on radioed deer indicates a high density of mountain lions throughout northern Mono County, or at least a high mountain lion to deer ratio. Therefore, depending on the relative densities of mountain lions and deer and the amount of buffering the EW and ML herds receive from other prey species, mountain lions could be exerting a significant effect on the EW and ML herds. Coyotes are commonly observed and abundant on all herd seasonal ranges. Thus, it is logical to assume that substantial predation of deer by coyotes did occur during this investigation.

Deaths related to malnutrition are likely an indirect result of a prolonged drought, and in some cases overgrazing by livestock, which both appear to have adversely affected range conditions during the course of this investigation. According to Menke (1977), weather conditions influence range forage and production from year to year, creating annual variations in carrying capacity for all species utilizing the range resource. This would be especially true of more xeric areas like the Excelsior Mountains and the Bodie Hills which are of paramount importance to deer from the ML herd.

Weather effects can intensify existing competition between deer and livestock (Menke 1977). When range conditions become marginal from drought and overgrazing, severe competition for desirable forage may exist between deer and livestock (Short 1981).

Evidence of competition between deer and livestock is provided by movement data collected for doe #205 during the spring and summer of 1989. Doe #205 summered in Bridgeport Canyon located at the southwest end of the Bodie Hills. Her summer home range was composed of several small groves of Populus tremuloides and a wet meadow, all surrounded by Sagebrush Scrub vegetation. Intensive domestic sheep grazing within the summer home range of doe #205 began in late May, immediately subsequent to her arrival from the winter range. In mid-June, #205 left her original summer home range and moved to more marginal habitat located in drier Sagebrush Scrub vegetation approximately 4 km to the south and east.

It is suspected that #205 left her original summer home range because of the direct disturbance caused by the physical presence of sheep, herders and dogs, and the destruction of most of the desirable forage and hiding cover associated with the aspen groves. During research conducted on the North Kings herd, Ashcraft (1978) found that deer had little tolerance of livestock and were easily forced out of favorable habitats to marginal habitats by the more aggressive domestic animals.

In mid July, #205 died of causes related to malnutrition likely induced by poor forage conditions in these marginal habitats. According to Short (1981) animals from poor quality intermediate and summer ranges will deplete fat reserves and die from malnutrition when sufficient energy is no longer present for maintaining bodily functions. Ashcraft (1978) found that does and fawns are subjected to nutritional stress and presumably increased predation when forced to use marginal habitats.

Diet composition data indicates that during the winter of 1988-89 deer were eating primarily browse (Chapter 5). However, because of poor range conditions resulting from prolonged drought, the quality and availability of forages such as bitterbrush (*Purshia tridentata*) appear to have been limited. Consequently, winter diets consisted largely of less nutritional forages such as sagebrush (*Artemisia tridentata*) and evergreens, mainly singleleaf pinyon pine

(*Pinus monophylla*). In fact, amounts of sagebrush in the winter diets of EW and ML deer exceeded 50% for some months. Excessive use of sagebrush has been associated with physical deterioration in tame deer (Carpenter 1974), extreme nutritional stress (Kucera 1988), and heavy mortality in wild deer (Longhurst et al. 1968).

In 1990, an estimated 250 deer from the EW and ML herds were killed by vehicles on Route 395 in Mono County. The majority of these deer were killed in the Buckeye and Rattlesnake expansion areas and in the vicinity of Sonora Junction (Route 108). The high number of deer-kills within the Rattlesnake and Buckeye expansion areas and the Sonora Junction area may be directly related to deer densities. Reed (1969) found that the frequency of deer-vehicle collisions in Colorado was directly related to deer density.

Additional factors identified in the Caltrans investigation that likely contribute to the deer-kill problem on Route 395 include topography, steep cut banks, right-of-way fencing, the availability of forage and water along the right-of-way, and vegetation along the right-of-way which decreases driver visibility. These factors are extrinsic in nature and subject to manipulation. However, other factors such as vehicle speed, increased traffic volume, and the locations of major deer crossings are less manageable. Taylor (1990a) provides a detailed analysis of those habitat and highway factors believed to contribute to the road-kill problem in each of the four Route 395 expansion areas. Recommendations to help alleviate the road-kill problem within the Buckeye and Rattlesnake expansion areas and elsewhere on Route 395 in Mono County are provided in Chapter 8.

CHAPTER 8. MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Increases over the last decade in multiple commercial, residential and recreational uses of public and private lands in Mono County have raised concerns among wildlife managers regarding the cumulative impact of these land uses on local deer herds. Public lands have been subject to increased demands for recreational, mining and energy development, while remaining private lands are being used for commercial, residential and recreational development; both are often used for intensive livestock grazing. There is no quantitative information available regarding the cumulative effect of these land uses on deer range. However, considering the locations and habitat types desirable for development, it is logical to conclude that the cumulative impact of development and other land uses on deer ranges is adversely affecting Mono County deer herds.

For the most part, seasonal ranges of the EW and ML herds are located on public lands managed by the USFS and BLM. However, there are a number of large private parcels scattered throughout herd ranges that include meadow and riparian areas, habitats which are most often preferred by both man and deer. Although these areas of private land comprise only a fraction of the total range, their locations and composition make them critically important to the EW and ML herds. A good example of this is the Rosachi Ranch, which comprises a major portion of secondary winter range occupied by the EW herd. The Rosachi Ranch is located on the East Walker River and consists of irrigated pasture land which is maintained for cattle grazing. However, diet composition and radio-telemetry data suggest that irrigated pasture land on the Rosachi Ranch is critical to the nutritional well-being of the EW herd. These pasture lands provide deer with succulent herbaceous forage beginning early in the growing season which is needed to rapidly reverse the negative energy balance acquired over the winter. Fortunately, because of a sympathetic land owner, there appears to be little immediate risk that EW deer will be denied use of pasture land on the Rosachi Ranch.

Another example of a large private parcel which is critically important to deer is the Conway Ranch, an 880 acre meadow area located within the migration corridor of the ML herd. The Mono County Board of Supervisors recently granted approval for the development of a resort complex on the Conway Ranch. A pre-project deer study (Taylor 1988) funded by the proponent of this development indicates that the Conway Ranch area is a critical portion of the migration corridor, serving as a spring holding area for deer from the ML herd. The study revealed that a large number of deer use the northern perimeter of the meadow for the water and herbaceous forage which it provides. This work predicted that without appropriate mitigation, development of Conway Ranch could adversely affect the ML herd. Fortunately, mitigation designed to reduce the impact of the development on migratory deer was incorporated into the final project design.

The Conway Ranch project proposal demonstrates the importance of obtaining site-specific information to determine patterns of deer use on areas of deer range that are subject to development. Thus, wildlife professionals who manage deer herds should attempt to obtain site-specific data wherever they have evidence that a proposed project will adversely affect deer range.

In addition to residential developments, mining and highway developments are also proposed within EW and ML herd ranges. Bodie Consolidated Mining Company is seeking approval to develop a large scale gold mine within the vicinity of Bodie Bluff in the Bodie Hills. A deer migration study (Taylor 1990b) conducted within the project area during the fall of 1990 revealed that the project will not present a barrier to deer migration, but impacts to a small number of migrant and summer resident deer will likely be unavoidable.

Recommendations to offset the impacts of this development on migrant and resident deer included: i) revegetation of disturbed sites with a grass/forb/legume mix that is compatible with the diets of ML deer; ii) development of free water sources away from the project vicinity; iii) curtailment of blasting and other mining activities during the migration season; and iv) reducing the impact of human presence, vehicles, noise and nighttime mining activities. Such recommendations should be formulated and applied to future mining proposals and other projects in efforts to reduce project related impacts.

Any development project, i.e., recreation, housing, mining, etc., which usurps critical fall and winter range habitats, should be required as mitigation to increase the quality of forages on reclaimed disturbed sites and on ranges adjacent to development. Revegetation or habitat improvement should include a mix of shrubs, forbs, and grasses to allow deer to select the most favorable nutritional regime. Diversifying forages on winter and fall ranges will help assure that some species are available under all winter conditions.

The California Department of Transportation is currently planning to expand 4 sections of Route 395 from 2 to 4 lanes within subject herd range. Expansion of these sections of highway have raised concerns among DFG biologists because of the potential for additional deer-vehicle collisions. In 1990 alone, an estimated 700 deer were killed on Route 395 in Zone X-12. Therefore, in order to determine the potential impact of highway expansion on migratory deer, each of these four areas were investigated as part of a Caltrans funded study.

Several factors were identified in the Caltrans study which likely contribute to the road-kill problem on Route 395. Some of these include: topography, steep cut banks, reduced driver visibility due to vegetation along the right-of-way, the availability of water and forage near the right-of-way, and right-of-way fencing.

Recommendations to reduce the effects of these factors include: i) filling ditches and reducing vegetation along the right-of-way in order to increase visibility for motorists and deer; ii) eliminating steep cut banks and right-of-way fencing from current and future expansion plans at critical deer crossings; iii) eliminating preferred deer forage, i.e., Purshia, from the right-of-way; iv) relocating water sources away from the highway; v) construction of highway underpasses in conjunction with deer proof-fencing where appropriate, especially at the Buckeye and Rattlesnake project areas; and vi) implement pre-and post-project monitoring to assess the impacts of highway expansion on migratory deer and evaluate mitigation effectiveness (Taylor 1990a). Such monitoring of mitigation effectiveness is required by California State law under PRC 21081.6.

There are other factors which are believed to limit EW and ML herds. Such factors include: livestock grazing, predation, drought, off-road vehicles, and fuel wood cutting.

Although further study is needed, present indications (high pregnancy and fetal rates and relatively good maternal condition) suggest that prenatal losses are low and that high neonatal losses may be the principal cause of poor fawn recruitment in the EW and ML populations. Therefore, future management work should focus on determining the magnitude of neonatal mortality within these populations and the extent to which these losses are nutritionally or habitat related. This could be achieved through a late spring collection or necropsies of vehicle killed does in order to assess reproductive performance during the third trimester of pregnancy.

Smith and Lecount (1979) reported that survival of fawns was influenced by vegetation because increased cover reduced predation. Accordingly, it is recommended to conduct intensive habitat assessment surveys of critical summer range areas identified in the present study. Summer habitats should be surveyed in conjunction with USFS and BLM personnel in order to assess the effects of grazing on fawn hiding cover and summer forage availability.

Due to the apparent difference in the sizes of summer home ranges on grazed versus ungrazed habitats, and implications regarding deer populations and densities (Loft et al. 1987), it appears that critical ranges could be improved through livestock grazing reductions.

Therefore, recommended options for immediately reducing the impacts of livestock grazing on deer habitats include: 1) defer livestock use of summer habitats recognized as propagation units and population centers (Bertram and Remple 1977) until after the fawning period (25 July); 2) construct fences or barriers using native materials to reduce livestock use of riparian and other key wildlife habitats, especially deer fawning sites; 3) through the allotment planning process reduce total allotment numbers; and 4) regulate livestock presence on the winter range when deer are under nutritional stress.

It may be prudent for deer managers to assess the quality of spring holding areas in order to determine if these areas are sufficient to maintain the nutritional requirements of does in their third trimester of pregnancy. Verme (1962) identified a close relationship between neonatal mortality and maternal nutrition during the third trimester of pregnancy. Bertram and Remple (1977) found some holding areas used by deer from the North Kings herd were generally deficient in forage and cover. Deer apparently left the winter range after the spring green-up period in good condition, but fell off to poor condition during the spring migration. It was postulated that this loss of condition in does in their third trimester of pregnancy contributed to the birth of weak fawns, of which there was a high loss on the summer range within 30 days after birth. Therefore, it is recommended that adequate high quality forage on secondary winter ranges and spring and fall holding areas be maintained by reducing competition with livestock (Bertram 1984).

The prolonged drought which has plagued California for the last 5 years has caused deteriorating winter range conditions and may be contributing to reduced productivity among the EW and ML herds. Although weather patterns are beyonds man's influence, it is possible to improve forage and cover conditions on critical habitats through regulated livestock grazing.

Current legislation prevents sport hunting of mountain lions in California. Therefore, with the exception of the current limited Nevada hunt, there is virtually no control of lion numbers on EW and ML herd ranges. Balancing of deer and lion numbers through controlled lion hunts is needed to stabilize this predator-prey relationship and preserve deer herds at viable levels.

To reduce the effects of OHV's on critical seasonal habitats, it is recommended that existing roads that are not needed be closed and that construction of new roads be discouraged. Strict Federal enforcement of OHV regulations is vital.

LITERATURE CITED

Ascraft, G.C. 1978. Observations of meadow use by deer. North Kings Deer Herd Comparative Management Project. Fresno: Calif. Dept. of Fish and Game, Sierra National Forest. 18pp.

Anderson, A.E., D.E. Medin and D.C. Bowden. 1972. Indices of carcass fat in a Colorado mule deer population. J. Wildl. Manage. 36:689-97.

______. 1981. Morphological and physiological characteristics. Pp. 27-97 in Wallmo, O.C. (ed.) Mule and black-tailed deer of North America. Lincoln: University of Nebraska Press. 605pp.

______, D. E., Medin and D. C. Bowden. 1974. Growth and morphometry of the carcass, selected bones, organs, and glands of mule deer. Wildl. Monogr. no. 39. 122pp.

Allredge, W. A., J. F. Lipscomb, and F. W. Wicker. 1974. Forage intake rates of mule deer estimated with fallout ceisum-137. J. Wildl. Manage. 38:508-16.

Arnold, D. A. 1978. Characteristics and cost of highway deer kills. Pages 92-101 In C. M. Kirkpatrick, ed. Proc. John S. Wright For. Conf.

Ashcraft, G. C., Jr. 1961. Deer movements of the McCloud Flats herds. Calif. Fish and Game 47:145-152.

Bartmann, R.M. 1983. Composition and quality of mule deer diets on Pinyon-Juniper winter range, Colorado. J. Range Manage. 36(4):534-41.

Beasom, S.L., W. Evans and L. Temple. 1980. The drive net for capturing western big game. J. Wildl. Manage. 44(2):478-480.

Bertram, R.C., and R.D. Remple. 1977. Migration of the North Kings deer herd. Calif. Fish and Game 63:157-179.

______, 1984. North Kings deer herd study. Calif. Dept. of Fish and Game. 203 pp.

Bissell, H.D., B. Harris, H. Story, and F. James. 1955. The digestibility of certain natural and artificial foods eaten by deer in California. Calif. Fish and Game 41:57-78.

Bormann, F. H. 1976. An inseparable linkage; Conservation of natural ecosystems and the conservation of fossil energy. Bioscience 26:754-60.

Britton, W. E. 1971. Biological Unit Management Plan West Walker deer herd; USDA Forest Service, Toiyabe National Forest.

Burrell, G.C. 1982. Winter diets of mule deer in relation to bitterbrush abundance. J. Range Manage. 35:508-510.

Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24:346-352.

Carhart, A.H. 1943. Fallacies in winter feeding of deer. Trans. N. Amer. Wildl. Conf. 8:333-57.

Carpenter, L.H. 1976. Nitrogen-herbicide effects on sagebrush deer range. Ph.D. thesis, Colorado State University, Fort Collins. 159 pp.

______. 1974. Middle Park deer study: Range fertilization. In Game research report, July 1974, part 2, pp.183-95. Denver: Colorado Division of Wildlife. 398 pp.

Cheatum, E.L. 1949. The use of corpora lutea for determining ovulation incidence and variations in the fertility of white-tailed deer. Cornell Vet. 39:282-91.

______, and C.W. Severinghaus. 1950. Variations in fertility of white-tailed deer related to range conditions. Trans. N. Amer. Wildl. Conf. 15:170-190.

Connolly, G.E. 1981. Limiting factors and population regulation., pp 245-286 in O.C. Wallmo ed., Mule and black-tailed deer of North America. Univ. of Nebraska Press, Lincoln. 605 pp.

______, G.E. 1981. Assessing populations. Pp. 287-345 in Wallmo, O.C. (ed) Mule and Black-tailed deer of North America. Lincoln: University of Nebraska Press. 605pp.

Dasmann, R. F. 1952. Methods for estimating deer populations from kill data. Calif. Fish and Game 38:225-33.

______, and J.A. Blaisdell. 1954. Deer and forage relationships on the Lassen-Washoe interstate winter deer range. Calif. Fish and Game 40:206-212.

______, and R.D. Taber. 1956. Behavior of Columbian black-tailed in Wisconsin. Wisconsin Conserv. Dept. Tech. Bull. 14. 282 pp.

Dietz, D. 1972. Native value of shrubs. USDA For. Serv. Gen. Tech. Rpt. INT-1, Intermt. For. and Range Exp. Stn., Odgen, Utah.

Dimeo, A. 1977. An investigation of equipment for rejuvenating browse. ED&T 7080, USDA For. Serv. Equipment Development Center, Missoula, Montana. 19 pp.

Ellisor, J. E. 1969. Mortality of white-tailed deer in south Texas. J. Wildl. Manage. 33(1):220-222.

Ford, S.G. 1980. Evaluation of highway deer kill mitigation on SIE/LAS-395. Division of Transp. Environmental Planning Research Report. Final Report NO. FHWA/CA/TP-80/01. 23 pp.

Garrott, R. A., G. C. White, R. M. Bartmann, L. H. Carpenter, and A. W. Alldredge. 1987. Movements of female mule deer in northwest Colorado. J. Wildl. Manage. 51:634-643.

Geduldig, H.L. 1981. Summer home range of mule deer fawns. J. Wild. Manage. 45(3):726-728.

Gilbert, P. F., O. C. Wallmo, and R. B. Gill. 1970. Effect of snow depths on mule deer in Middle Park, Colorado. J. Wildl. Manage. 34:15-23.

Gill, R.B., and O.C. Wallmo. 1973. Middle Park deer study: Physical characteristics and food habits. In Game research report, July 1973, part 2, pp. 81-103. Denver: Colorado Division of Wildlife. 275 pp.

Grinnel, J., J. S. Dixon, and J.M. Lindsdale. 1937. Furbearing Mammals of California. Univ. Calif. Press, Berkeley, 2 Vols. 777 p.

Gruell, G. E., and N. J. Papez. 1963. Movements of mule deer in northeastern Nevada. J. Wildl. Manage. 27:414-422.

Halls, L. K., editor. 1984. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pa. 870 pp.

Hansen, C.S. 1983. Costs of deer-vehicle accidents in Michigan. Wildl. Soc. Bull. 11:161-164.

______, and A.C. Wolfe. 1983. Costs of deer-related automobile accidents. Univ. Mich. Transp. Res. Rec. 913:19-22.

Harris, D. 1945. Symptoms of malnutrition in deer. J. Wildl. Manage. 9:319-22.

Harvey, J.J., and R.W. Barbour. 1965. Home ranges of <u>Microtus ochrogaster</u> as determined by a modified minimum area method. J. Mammal. 46:398-402.

Hobbs, N.T., D.L. Baker, J. E. Ellis, and D. M. Swift. 1981. Composition and quality of elk winter diets in Colorado. J. Wildl. Manage. 45:156-171.

Hornocker, M.C. 1970. An Analysis of Mountain Lion Predation on Mule Deer and Elk in the Idaho Primitive Area. Wildlife Monograph 21. 39 p.

Howery, L.D., and J.A. Pfister. 1990. Dietary and fecal concentrations of nitrogen and phosphorus in penned white-tailed deer does. J. Wildl. Manage. 54(3):383-389.

-----. 1987. Fecal indices to dietary quality: a critique. J. Wildl. Manage. 51:317-320.

Jobman, W.G. 1972. Consumption of juniper by deer and inhibition of rumen microorganisms by volatile oils of juniper. M.S. thesis, Colorado State University, Fort Collins. 51 pp.

Jordon, P. A. 1967. Ecology of migratory deer in the San Joaquin River drainage. Ph.D. thesis, Univ. California Berkeley. 278pp.

Julander, O., and J.B. Low. 1976. A historical account and present status of mule deer in the west. Pages 3-19 in G.W. Workman and J.B. Low, eds. Mule deer decline in the west. A symposium. Utah State Univ., Agric. Exp. Stn., Logan.

______, W.L. Robinette and D.A. Jones. 1961. Relation of summer range condition to mule deer productivity. J. Wildl. Manage. 25:54-60.

Kelsall, J.P. 1969. Structural adapatation of moose and deer for snow. J. Mammal. 50(2):302-310.

Kie, J.G. 1987. Measures of ungulate performance: population density and condition of individuals. Presented at Symposium on Monitoring Animal Performance and Production at Society for Range Management Meeting, Boise, Idaho. Pp 23-36.

______, D.L. Drawe, and G. Scott. 1980. Changes in diet and nutrition with increased herd size in Texas white-tailed deer. J. Range. Manage. 33:28-34.

_____, and T.S. Burton. 1984. Dietary quality, fecal nitrogen, and 2.6 diaminopimelic acid in black-tailed deer in Northern California. U.S. For. Serv, Res. Note PSW-364. Berkeley, Calif. 3pp.

Klein, D.R. 1970. Food selection by North American deer and their response to over-utilization of preferred plant species. Pages 25-46 in D.B. Watson, ed. Animal populations in response to their food resources. Blackwell Scientific Publications, Oxford, England.

Kucera, T.E. 1988. Ecology and population dynamics of mule deer in the Eastern Sierra Nevada, California. Ph.D. thesis, University of California Berkeley. 205pp.

Kufeld, R.C., O.C. Wallmo, and C. Feddema. 1973. Foods of the Rocky Mountain mule deer. U.S. For. Serv., Rocky Mountain For. and Range Exp. Stn. Pap. RM-111. 31pp.

Larson, J.S.. and R.D. Taber. 1980. Criteria of sex and age. Pp. 143 in Schemmnitz, S.S. (ed.) Wildlife management techniques manual. Washington, D.C.: The Wildlife Society. 686pp.

Leach, H. 1956. Food habits of Great Basin deer herds of California. Calif. Fish and Game 42:243-308.

Leopold, A. S., T. Riney, R. McCain, and L. Tevis, Jr. 1951. The Jawbone deer herd. Calif. Dep. Fish and Game, Game Bull. no. 4. 139pp.

Leslie, D. M., Jr., E. E. Starkey, and M. Vavra. 1984. Elk and deer diets in old-growth forests in western Washington. J. Wildl. Manage. 48:762-775.

_____, and _____. 1987. Fecal indices to dietary quality: a reply. J. Wildl. Manage. 51:321-325.

_____, J. A. Jenks, M. Chilelli, and G. R. Lavigne. 1989. Nitrogen and diaminopimelic acid in deer and moose feces. J. Wildl. Manage. 53(1):216-218.

Loft, E. R., J. W. Menke, and T. S. Burton. 1984. Seasonal movements and summer habitats of female black-tailed deer. J. Wildl. Manage. 48(4):1317-1326.

_____, J.W. Menke, J.G. Kie, and R.C. Bertram. 1987. Influence of cattle stocking rate on the structural profile of deer hiding cover. J. Wildl. Manage. 51(3):655-664.

______, R.C. Bertram and D.L. Bowman. 1989. Migration patterns of mule deer in the central Sierra Nevada. Calif. Fish and Game. 75(1):11-19.

Longhurst, W. M., H. K. Oh, M. B. Jones, and R. E. Kepner. 1968. A basis for the palability of deer forage plants. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 33:181-189.

______, and E.O. Garton, H.F. Heady and G.E. Connolly. 1976. The California deer decline and possibilities for restoration. Annu. Meet. West. Sect. Wildl. Soc. (Fresno, Ca.) 1976:74-103.

Loveless, C. M. 1974. Some relationships between wintering mule deer and the physical environment. Trans. N. Amer. Wildl. Conf. 29:415-431.

Mansell, W.D. 1974. Productivity of white-tailed deer on the Bruce Peninsula, Ontario, J. Wildl. Manage. 38:808-814.

Marchinton, R.L., and A.K. Jeter. 1967. Telemetric study of deer movement-ecology in the southeast. Proc. Ann. Conf. Southeast. Assoc. Game and Fish Comm. 20:189-206.

Mattfeld, G.F. 1973. The effect of snow on the energy expenditure of walking white-tailed deer. Proc. NE Fish and Wildl. Conf. 30:327-43.

McCullough, D.R. 1979. The George Reserve deer herd. Ann Arbor: The University of Michigan Press. 271pp.

Menke, J.W. 1977. Livestock and wild ungulates. In Proc. of the workshop on livestock and wildlife-fisheries relationships in the Great Basin, Sparks, Nev., May 3-5 1977. pp. 42-64.

Michael, E. D. 1965. Movements of white-tailed deer on the Welder Wildlife Refuge. J. Wildl. Manage. 28(1):44-52.

Moen, A. N. 1973. Wildlife ecology: An analytical approach. San Francisco: W. H. Freeman. 458 pp.

Moore, H. 1981. Early explorations of the San Joaquin Sierra. The Journal of the Fresno City and Historical Society. Vol. 23, No. 2, Summer 1981. 2-9.

Mould, E.D., and C.T. Robbins. 1981. Nitrogen metabolism in elk. J. Wildl. Manage. 45:323-334.

Munz, P. A., and D. D. Keck. 1959. A California flora. Univ. California Press, Berkeley. 1681pp.

Nagy, J.G., H. W. Steinhoff, and G. M., Ward. 1964. Effects of essential oils of sagebrush on deer rumen microbial function. J. Wildl. Manage. 28:785-790.

Neal, D.L., G.N. Steger and R.C. Bertram. 1987. Mountain lions: Preliminary findings on home-range use and density in the Central Sierra Nevada. Res. Note PSW-392. Berkeley, Ca: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Dept. of Agriculture; 1987 6 p.

Nelson, J. R. and B. B. Davitt. 1984. A regional cooperative DAPA research and development program. Pages 148-163 in R. W. Nelson, ed. Proc. of the 1984 western states and provinces elk workshop. Alta. Fish and Wildl. Dep., Edmonton.

______, ______, and T. Hodgman. 1986. FY1986 progress report - DAPA cooperative research and development program. Washington State University, Pullman, Washington. 38pp.

______, and T. A. Leege. 1982. Nutritional requirements and food habits. Pages 323-363 In J. W. Thomas and D. E. Toweill ed., Elk of North America-Ecology and Management. Stackpole Books. 870pp.

Olson, H.F. 1939. Deer tagging and population studies in Minnesota. Trans. N. Amer. Wildl. Conf. 3:280-286.

Ozaga, J.J., and L.J. Verme. 1982. Physical and reproductive characteristics of a supplementally-fed white-tailed deer herd. J. Wildl. Manage. 46:281-301.

______, ______. 1986. Relation of maternal age to fawn rearing success in white-tailed deer. J. Wildl. Manage. 50:480-486.

Pac, H. I., W. F. Kasworm, L. R. Irby, and R. J. Mackie. 1988. Ecology of mule deer (Odocoileus hemionus) along the east front of the Rocky Mountains, Montana. Canadian Field-Naturalist 102(2):227-236.

Pojar, T.M., D.F. Reed and T.C. Reseigh. 1972. Highway construstion - motorist and deer safety. Joint Publication, Colorado Division of Wildlife and Colorado Division of Highways. 4 pp.

Poole, D.A. 1976. An overview of big game management. Pages 70-76 in G.W. Workman and J.B. Low, eds. Mule deer decline in the west. A Symposium. Utah State Univ., Agric. Exp. Stn., Logan.

Ransom. A.B. 1967. Reproductive biology of white-tailed deer in Manitoba. J. Wildl. Manage. 31(1):114-123.

Reed, D.F. 1969. Techniques for determining potentially critical deer highway crossings. Colorado Division of Game, Fish and Parks. Outdoor Facts No. 73. 3pp.

Regelin, W. L., O. C. Wallmo, J. Nagy, and D. R. Deitz. 1974. Effect of logging on forage values for deer in Colorado. J. For. 72:282-85.

Riney, T. 1955. Evaluating condition of free-ranging red deer (Cervus elaphus), with special reference to New Zealand. New Zealand. J. Sci. and Technol. 36 (Section B):429-63.

Robinette, L. R. 1966. Mule deer home range and dispersal in Utah. J. Wildl. Manage. 30(2):335-348.

Robinette, W.L., J.S. Gashwiler, D.A. Jones and H.S. Crane. 1955. Fertility of mule deer in Utah. J. Wildl. Manage. 19:115-36.

______, J.S. Gashwiler, D.A. Jones and J.B. Low. 1957. Differential mortality by sex and age among mule deer, J. Wildl. Manage. 21:1-16.

______, W.L., C.H. Baer, R.E. Fillmore and C.E. Knittle. 1973. Effects of nutritional change on captive mule deer. J. Wildl. Manage. 37:312-26.

Rue, L.L. III. 1978. The deer of North America. Outdoor Life Books, Crown Publ. Co., New York, N.Y. 462 pp.

Russell, C. P. 1932. Seasonal migration of mule deer. Ecol. monogr. 2:1-46.

Sanderson, G.C. 1966. The study of mammal movements-a review. J. Wildl. Manage. 30(1):215-235.

Schwartz, C. C., J. G. Nagy, and W. L. Regelin. 1979. Effects of volatile oils of juniper om mule deer. I. Volatile oil yield, terpenoid concentration and antimicrobial effects in vitro. J. Wildl. Manage.

Shaw, H.G. 1977. Impacts of mountain lion (Felis concolor azteca) on mule deer and cattle in Northwestern Arizona. In Proceedings of the 1975 Predator Symposium, ed. R.L. Phillips and C. Jonkel, pp. 17-32. Missoula: Montana Forest and Conservation Experiment Station, Univ. of Montana. 268 pp.

Short, H.L. 1981, Nutrition and metabolism. Pp 99-127 in Wallmo, O.C. ed. Mule and black-tailed deer of North America. Lincoln: University of Nebraska Press. 605pp.

Smith, D. O., and M. Conner. 1989. The distribution of winter mule deer use around homesites. Trans. Western Sec. of the Wildl. Society. 15 pp.

Smith, R.H., and A. Lecount. 1979. Some factors affecting survival of desert mule deer fawns. J. Wildl. Manage. 43:657-665.

Sparks, D. R., and J. C. Malechek. 1968. Estimating percentage of dry weight in diets using a microscope technique. J. Range Manage. 21:264-265.

Stewart, D. R. M. 1971. Comparative food preferences of five East African ungulates at different seasons. Pages 351-365 in E. Duffey and A. S. Watt, eds. The scientific management of animal and plant communities. Blackwell Sci. Publ., Oxford, U.K.

Storer, T. I., and R. L. Usinger. 1968. Sierra Nevada natural history. Univ. Calif. Press, Berkeley. 374pp.

Swift, R. W. 1948. Deer select the most nutritious forage. J. Wildl. Manage. 12:109-101.

Taylor, T. J. 1990a. Deer migration study: Highway 395 expansion projects, Mono County, Calif. Final Report--Typescript. 106pp.

______. 1990b. Bodie Consolidated Mining Company deer migration study: Fall 1990. Typescript. 52 pp.

______. 1988a. Migration and seasonal habitats of the Casa Diablo deer herd. The Casa Diablo deer herd study. Calif. Dept. of Fish and Game, Bishop, Calif. 49pp.

______. 1988b. Conway Ranch Resort development project: deer migration and sage grouse study. Typescript. 31pp.

Teer, J.G., J.W. Thomas and E.A. Walker. 1965. Ecology and Management of white-tailed deer in the LLano Basin of Texas. Wildl. Monogr. 15. Washington, D.C. The Wildlife Society. 62pp.

Theureu, C. B., A. L. Lesperance and J. D. Wallace. Botanical composition of the diet of livestock grazing native ranges. Univ. Arizona Technol Bull. 233. 19pp.

Thomas, R. 1984. The West Walker deer herd management plan. Calif. Dept. Fish and Game. 95pp.

______. 1985a. The East Walker deer management plan. 1984. Calif. Dept. Fish and Game. 70pp.

______. 1985b. The Mono Lake deer herd management plan. Calif. Dept. of Fish and Game. 54 pp.

Thompson, F.A. 1965. Deer on highways. New Mexico Dept. of Fish and Game. 11 pp.

U.S.D.A. Forest Service 1981. A classification of California vegetation. U.S. For. Serv., Regional Ecology Group, San Francisco, Calif. 168pp.

Verme, L.J. 1962. Mortality of white-tailed deer fawns in relation to nutrition. Proc. Nat. White-tailed Deer Dis. Symp. 1:15-38.

-----.1965. Reproduction studies of penned white-tailed deer. J. Wildl. Manage. 29(1):74-79.

-----.1967. Influence of experimental diets in white-tailed deer reproduction. Trans. N. Amer. Wildl. and Natur. Resour. Conf. 32.405-420.

-----.1969. Reproductive patterns of white-tailed deer related to nutritional plane. J. Wildl. Manage. 33(4)881-887.

Wallmo, O. C., and W. L. Regelin. 1981. Rocky Mountain and intermountain habitats. Pages 387-421 In O. C. Wallmo (ed.) Mule and black-tailed deer of North America. Univ. of Nebraska Press, Lincoln. 605 pp.

______, D. F. Reed, and L. H. Carpenter, 1976. Alteration, agriculture and housing developments. Pages 37-46 In Mule deer decline in the west symposium, Utah State Univ., College of Natl. Resour., Utah State Agric. Exp. Stn., Logan.

Wilkens, B. T. 1957. Range use, food habits, and agricultural relationships of mule deer, Bridger Mountains, Montana. J. Wildl. Manage. 21:159-169.

Wolfe, M.L. 1978. Habitat changes and management. In Big Game of North America : Ecology and management, ed. J.L. Schmidt and D.L. Gilbert. Harrisburg, Pa.: Stackpole Books. 494 pp.

This study was funded primarily through the California Deer Herd Management Plan Implementation Program under Contract FG-7027. Additional support was also provided by the Inyo and Mono Counties Fish and Game Fines Committee, California Department of Transportation, and the Bureau of Land Management.