MIGRATION AND SEASONAL HABITATS OF THE CASA DIABLO DEER HERD

CASA DIABLO DEER STUDY

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MIGRATION AND SEASONAL HABITATS OF THE CASA DIABLO DEER HERD

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ABSTRACT: One hundred and seventeen mule deer, Odocoileus hemionus hemionus, were captured on wintering areas from January-March 1986 and January-March 1987. Twenty-seven females and 1 adult male were radio-collared and monitored for two spring and two fall migrations in order to delineate migration routes and seasonal ranges. Timing of spring migration was similar during both years despite extremes in severity of winters. Two radio-collared does utilized different spring migration routes and wintering areas in consecutive years. Timing of fall migration was correlated with snowfall in 1987, but not in 1986. Deer remained on holding areas and delayed migration for up to 6 weeks during both spring and fall. Fifteen radio-collared deer occupied summer range on the east slope of the Sierra Nevada; 14 of these utilized aspen riparian habitats. Three radio-collared does crossed the Sierra crest to west side summer ranges. Those radio-collared does occupying summer range in Jeffrey pine (Pinus jeffreyi) habitat had larger home ranges than those in more diverse areas. All radio-collared deer exhibited strong fidelity to summer home ranges. Water was found to be the factor most limiting deer distribution and densities throughout portions of winter and summer ranges.

INTRODUCTION

The Rocky Mountain mule deer is the most adaptive and widespread western ungulate (Poole 1976). However, a decline of mule deer in the west has been a major concern of many state conservation agencies (Julander and Low 1976). A general statewide decline in California's deer herds has been occurring since the mid 1950's (Bertram and Rempel 1977, Dasmann 1981). Longhurst et al. (1976) concluded that the decline in California has resulted from a number of different causes including diminishing food supplies and loss of habitat resulting from changes in burning, logging, grazing practices, and other land use factors. On lower western slopes of the Sierra Nevada, increasing urbanization, recreational developments, construction of reservoirs and other land

uses have resulted in a serious decline in deer numbers (Dasmann 1981). Recent plans for recreational, urban, geothermal, and hydropower developments in areas of critical mule deer range on the east slope of the Sierra Nevada in Mono County have prompted the California Department of Fish and Game to conduct this study of the Casa Diablo deer herd.

The Casa Diablo herd, which consists of an estimated 1,500 animals, is the smallest of five migratory mule deer herds occurring in Mono County (Thomas 1984). Since this herd generally was known to occupy seasonal ranges throughout the southern and central portion of Mono County (where the majority of development is occurring) it was imperative that studies be conducted in order to delineate all critical habitats used by this herd. To effectively manage migratory deer in the Sierra it is crucial that migration routes and all seasonal habitats be delineated (Bertram and Rempel 1977). Prior to this study, little was known about specific locations of migration routes, holding and summering areas, and transitional ranges of the Casa Diablo herd.

The major objectives of this study, which was conducted from January 1986-January 1988, were to (i) delineate all critical habitats used by the Casa Diablo deer herd; (ii) analyze the quality and quantity of all critical habitats defined; (iii) assess the impacts of land uses, existing and proposed, on critical habitats; (iv) identify habitat factors limiting the herd; and (v) formulate recommendations to reduce the impacts of these factors.

STUDY AREA

The Casa Diablo deer herd occupies approximately 2,200 km^2 in Mono County, California. The herd winter range, located on the Inyo National Forest in southeastern Mono County (Figure 1), encompasses approximately 260 km^2, varying in elevation from 1,640-2,450 m. Winter range vegetation is a Great Basin sagebrush type, consisting mainly of big sagebrush (Artemisia tridentata), bitterbrush (Purshia tridentata), and rubber rabbitbrush (Chrysothamnus nauseosus). Singleleaf pinyon pine (Pinus monophylla) - western juniper (Juniperus occidentalis) woodland dominate vegetation between 1,950-2,450 m. Terrain is moderately sloping with soils consisting of an admixture of sandy loams which are generally shallow and rocky (Thomas 1984). Average annual precipitation, measured

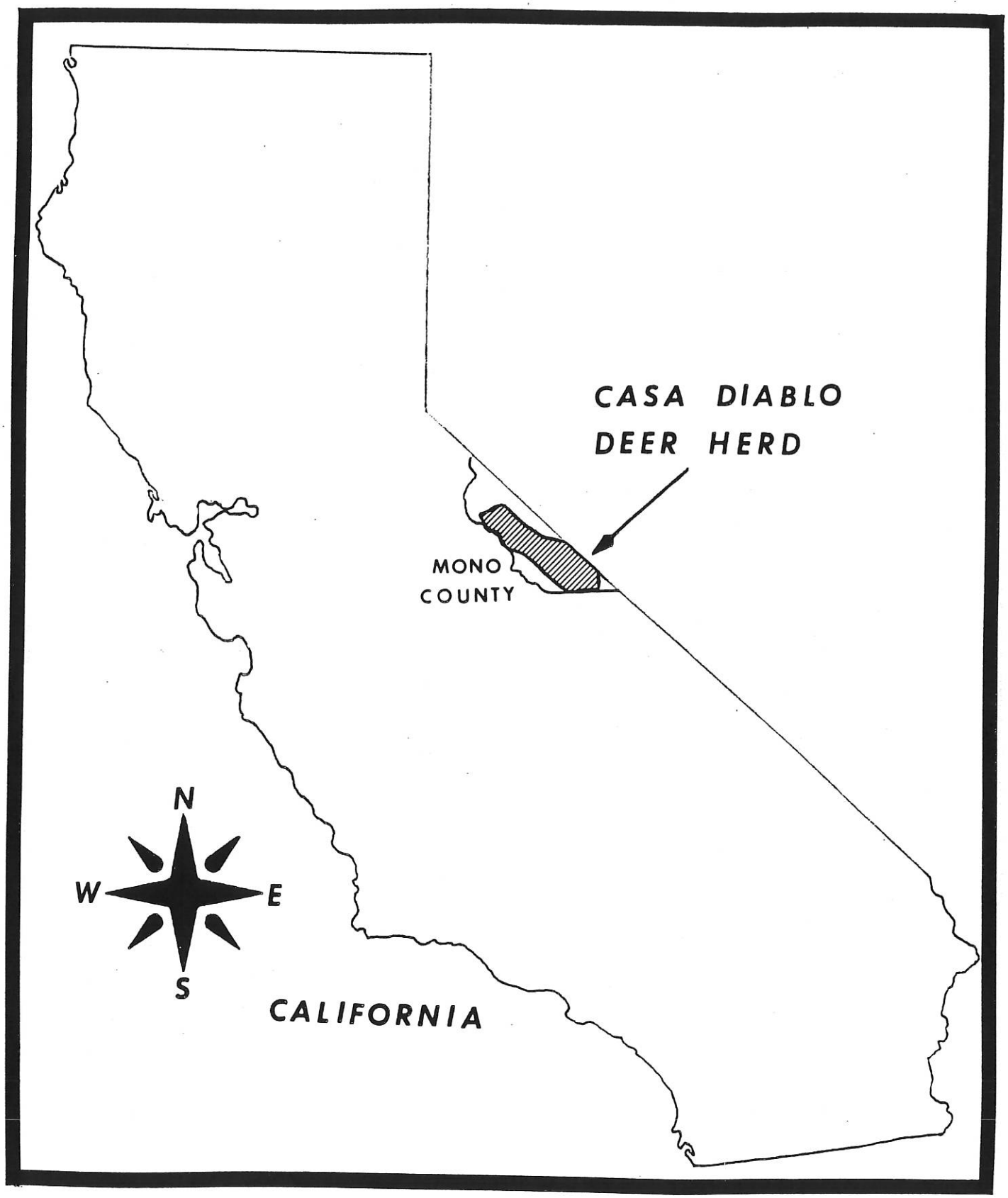

Figure 1. Location map, Casa Diablo deer herd.

at the Calif. Agric. Inspect. Sta. in Benton, California, is 150 mm, occurring mostly as snow in January and February.

The Casa Diablo winter range was divided into six subwintering areas based on major areas of deer concentration (Figure 2). From north to south these wintering areas include: Truman Meadows, located approximately 13 km north of Benton, California near the California-Nevada state line; Marble Creek, located approximately 7 km south of Benton at the base of the western escarpment of the White Mountain range and east of U.S. Hwy 6; The Blind Spring Hills area, located due west of Marble Creek and immediately west of Hwy 6 in the Benton Mountain Range; Chidago Flat, located approximately 21 km south of Benton and 14 km west of Hwy 6; Casa Diablo Mountain, located 29 km south of Benton and 14 km west of Hwy 6; and The Volcanic Tablelands, located 43 km south of Benton and 7 km north of Bishop, California.

Deer from the Casa Diablo herd occupy approximately 1,940 km^2 of summer range on the Inyo National Forest in west-central Mono County, mainly along the east slope of the Sierra Nevada (Figure 2). Portions of Madera County and Tuolumne counties on the west side of the Sierra are also used to a limited extent by summering deer. Nine major summer range habitat types, varying in elevation between 2,130-2,950 m were described in areas used by radio-collared and ear tagged deer (USDA 1981).

Singleleaf Pinyon Pine-Western Juniper----This type occurs mainly on dry south and east facing slopes of the Sierra Nevada and Glass Mountain ranges. Single-leaf pinyon pine is the dominant conifer species between approximately 2,070-2,600 m near Lee Vining and also dominates deer summer range on the west slope of the White Mountains. Associated understory species include curlleaf mountain mahogany (Cercocarpus ledifolius), big sagebrush, bitterbrush, and rabbitbrush.

Jeffrey Pine.----This type is open Jeffrey pine (Pinus jeffreyi) forest which occurs in large stands between elevations of approximately 2,200-2,450 m. Associated understory species include big sagebrush, bitterbrush, gooseberry (Ribes spp.), and mountain snowberry, (Symphoricarpos vaccinioides). This is also the dominant vegetation type found on all holding areas used by the Casa Diablo deer herd.

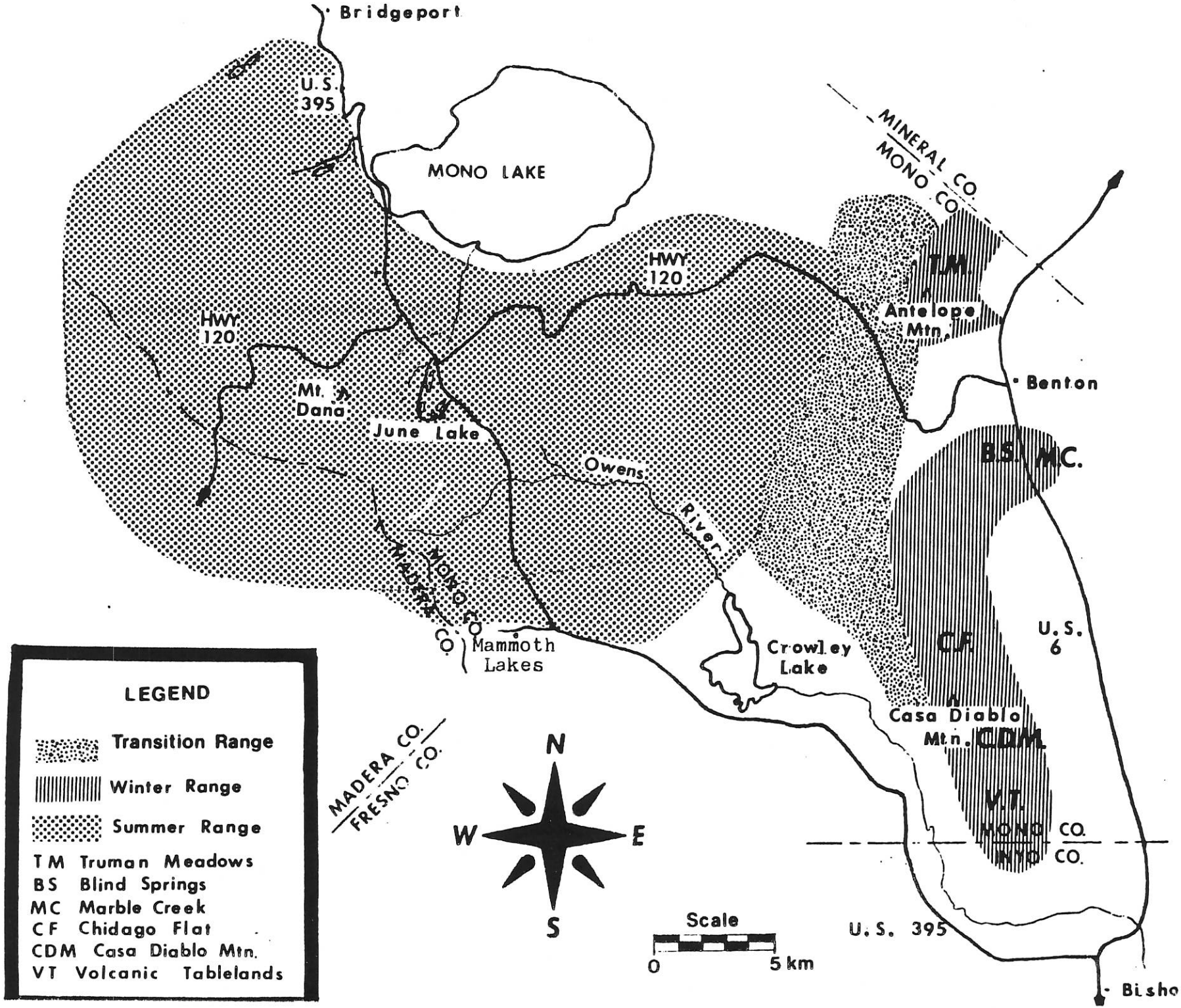

Figure 2. Location of Casa Diablo deer herd winter and summer ranges, Mono County, California.

Mixed Conifer Forest.----The codominants of this vegetation type occurring on the east slope of the Sierra Nevada between approximately 2,400 -2,600 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 and white fir often occurs in pure stands at lower elevations.

Quaking Aspen Riparian.----This dense cover type occurs within a few meters of most stream channels on the east slope of the Sierra Nevada and throughout the Glass Mountains and is dominated by quaking aspen (Populus tremuloides), willow (Salix spp.), wild rose (Rosa woodsii), gooseberry, and snowberry. Groves of quaking aspen, which provide critical fawning and fawn rearing habitat, also are indicators of moist conditions and are located mainly near high elevation meadows.

Lodgepole Pine Forest.----This forest type is found above the Mixed Conifer type on the east slope of the Sierra and north slope of the Glass Mountains at elevations between approximately 2,600-3,000 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 (Stipa comata), bluegrass (Poa pratensis), bromegrass (Bromus tectorum), lupine (Lupinus duranni), and pussy paws (Calyptridium caudiciferum)), dominate openings of poorly developed, dryer soils.

Montane Meadow.----This meadow type is found mainly at mid and upper elevations on the east slope of the Sierra and throughout the Glass Mountains and is composed primarily of sedges (Carex spp.), and rushes (Juncus spp.), and designates year long water availability. Perennial grasses, forbs, willows, quaking aspen, and lodgepole pine are associated with these meadows.

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.

Great Basin Sagebrush.----This type generally occurs on dry slopes and plains from 1,220-3,320 m, east of the Sierra Crest. Big sagebrush is dominant with bitterbrush often occurring as a codominant. This type often is found in association with Jeffrey pine.

Montane Chaparral.---This type occurs on open flats and rocky ridges from 2,135-3,050 m. Greenleaf manzanita (Arctostaphylos patula), mountain whitethorn (Ceanothus cordulatus), Chinquapin (Castanopsis sempervirens), and tobacco brush (Ceanothus velutinus), occur as codominants. This type often is found in association with Great Basin sagebrush.

METHODS

Deer were captured on the Casa Diablo winter range from January-February 1986 and January-February 1987 using Clover traps (Clover 1956), baited with alfalfa hay. Three to five trap sites were located throughout each area and prebaited for two weeks with alfalfa hay. Traps were operated on 2-3 days each week until late February, at which time bait acceptance became poor due to the presence of herbaceous growth.

On 26 and 27 February and 7 March 1986, deer were captured and marked on all six subwintering areas (Figure 2) using linear, nylon tangle nets (2 x 90 m) and a Bell Jet Ranger III helicopter (Beasom et al. 1980). Deer were hazed slowly by the helicopter into nets placed at strategic locations, usually preselected by the pilot through aerial reconnaissance. Net sites usually employed natural escape routes, such as ravines. Anywhere from 1-10 deer were captured on several successive drives until desired numbers were obtained for each wintering area.

All deer were physically restrained and marked with two large, plastic, consecutively numbered cattle ear tags (7.5 x 11.5 cm; Apollo Tag Systems), color coded to wintering area. Twenty-six adult females were fitted with radio collars. In addition, one adult male was instrumented with a radio transmitter mounted on an expandable collar to allow for neck swell during the rut. A single adult female was captured on its spring range by use of a tranquilizer dart carrying 3 cc of a Rompon-ketamine hydrochloride mixture, fitted with a radio-collar (.220) and released.

Adult radio collars (159.021-159.450 MHz; Telonics, Inc., Mesa, Arizona), weighed 260-270 g and had an operational life of 24-36 months at 35-75 pulses/minute. Thirteen radios were equipped with mortality sensors that doubled the pulse rate of the signal when an animal was stationary for 3-5 hours.

The locations of all radioed animals were obtained by triangulation

from the ground or from a fixed-wing aircraft during the course of the study. Deer were located from the ground at least 2-3 times weekly during the winter and summer months and 5-6 times weekly during spring and fall migrations. Initial ground locations were made from a vehicle equipped with a Telonics TR-2 receiver with an attached programmer/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, Arizona). Visual sightings of radio collared deer were made whenever possible. Radio locations and visual sightings were marked on U.S. Geological Survey 7.5 minute series topographic maps.

Fixed-wing flights were conducted once weekly, weather permitting, during spring and fall migration and once every 2-3 weeks during the winter and summer, usually between 0900 and 1100 hours. Flights were conducted in a Cessna 185 at air speeds of 120-180 km/hour.

Migration routes, holding areas, and winter and summer home ranges were identified and then delineated using radio telemetry. Winter and summer home ranges (Burt 1943), were determined using the Modified Minimum Area Method (Harvey and Barbour 1965). Each home range included a minimum of five relocation points determined from visual observations. Radio-collared deer were considered to show fidelity to a specific seasonal home range if ranges in consecutive years overlapped.

Holding areas were recognized as sites along migration corridors where deer remained for several days or more during migration (Bertram and Rempel 1977). All holding areas identified were designated a number as to the position in which they occur along the migration corridor, e.g., HA-I.

Post season deer composition counts were conducted over the entire winter range by use of a Bell Jet Ranger III helicopter during early January 1986, 1987, and 1988. Spring composition counts were conducted on foot in March and early April of 1986 and 1987 in more accessible portions of the winter range.

RESULTS

CAPTURE AND MARKING

A total of 117 deer (86 females and 31 males) were captured, marked, and released on all of the 6 subwintering areas of the Casa Diablo

deer herd (Table 1). Thirty-eight of these were fawns (24 males and 14 females), 72 adult females, and 7 adult males.

TABLE 1. Total Number and Composition of Deer Captured, Marked, and Released on each of the Casa Diablo Wintering Areas. January-March 1986, January-February 1987.

	ADULTS		FAWNS		
LOCATION	M	F	M	F	TOTAL
MC	4	30	11	8	53
BS	2	16	5	1	24
TM	0	6	3	2	11
TL	0	9	3	0	12
CD	0	3	0	0	3
CF	1	8	2	3	14
TOTAL	7	72	24	14	117

MIGRATION CORRIDORS AND HOLDING AREAS

During the two spring and fall periods studied, 22 of 27 radio-collared deer marked on the Casa Diablo winter range in 1986 and 1987 migrated to the west of their respective wintering areas. Five deer, all from the Marble Creek wintering area, migrated to the east, up the west slope of the White Mountains.

Beginning in early April, deer leave their respective wintering areas and move in a westerly direction along separate migration routes toward the Glass Mountains (Figure 3, Appendix Figure 1a). These routes merge at the east end of the Glass Mountains and continue westward along the south slope. The Glass Mountains extend in a westerly direction from Benton, California, and are bordered by Crowley Lake and the Owens River to the south and Hwy 120 to the north. They encompass approximately 256 sq. km with an elevational range of 2,134-3,216 m.

During the spring of 1986, 19 of the 22 radio-collared deer which summered west of the Casa Diablo winter range migrated along the base of the south slope of the Glass Mountains. Deer movements were concentrated between 2,135-2,285 m, along the interface of pinyon-juniper woodland and Great Basin sagebrush habitat types. Deer typically preferred to remain in the more open sagebrush-scrub vegetation while migrating, perhaps in order to avoid predators and to take advantage of herbaceous vegetation occurring there.

Eighteen of the 19 radio-collared deer which migrated along the south slope of the Glass Mountains in spring of 1986, utilized a large spring holding area at the west end of this range near the headwaters of the Owens River. In addition, 16 non-radioed, ear tagged deer were observed on this holding area during the spring and fall migrations of 1986 and 1987 (Appendix Figure 2). This holding area, designated (HA-I), is located 29 km north of the Casa Diablo winter range. The average vertical rise in elevation between HA-I and Casa Diablo deer herd wintering areas is approximately 300 m. HA-I encompasses 26 km^2, varying in elevation between 2,134-2,256 m. The major habitat type occurring there is a mixture of Jeffrey pine and Great Basin sagebrush vegetation. This area also contained one large wet meadow, known as Alpers meadow, where deer often concentrated in significant numbers during the evening and early morning hours.

Radio-collared deer spent an of average 11 days on HA-I in 1986 (range 1-45), and 4 days (range 1-34) in 1987. Radio-collared deer which migrated to the west of HA-I spent an average of 22 days longer there in 1986, and 15 days longer in 1987, than deer which migrated to the north.

During the spring migration of 1986, 13 of the 18 radio-collared deer which utilized HA-I summered to the north, and 4 to the west. One radio-collared doe was killed by a mountain lion (Felis concolor), on 26 April near Alpers meadow. Its radio-collar was put on another adult doe in the same area on 10 May. This deer never migrated further, eventually summering near Big Springs at the headwaters of the Owens River.

The main migration corridor used by deer summering to the north of HA-I, extends in a northwesterly direction, contouring around the southern end of the Mono Craters toward the Aeolian Buttes (Figure 3, Appendix Figure 1a). Deer were found to cross a two lane section of Hwy 395 near the Aeolian Buttes, before continuing west around the northern end of Grant Lake to another spring holding area (HA-II), located at the foot of the Parker Creek and Walker Creek drainages. HA-II encompasses approximately 5.2 km at elevations ranging from 2,195-2,439 m. The major habitat type occurring on HA-II is a mixture Jeffrey pine and Great Basin sagebrush which include dense pockets of 1-2 m high curlleaf mountain mahogany. HA-II also includes several wet meadows the largest of which is approximately 1 km . During the spring migration of 1986, 12 radio-collared deer, all of which spent some time on HA-I, utilized HA-II

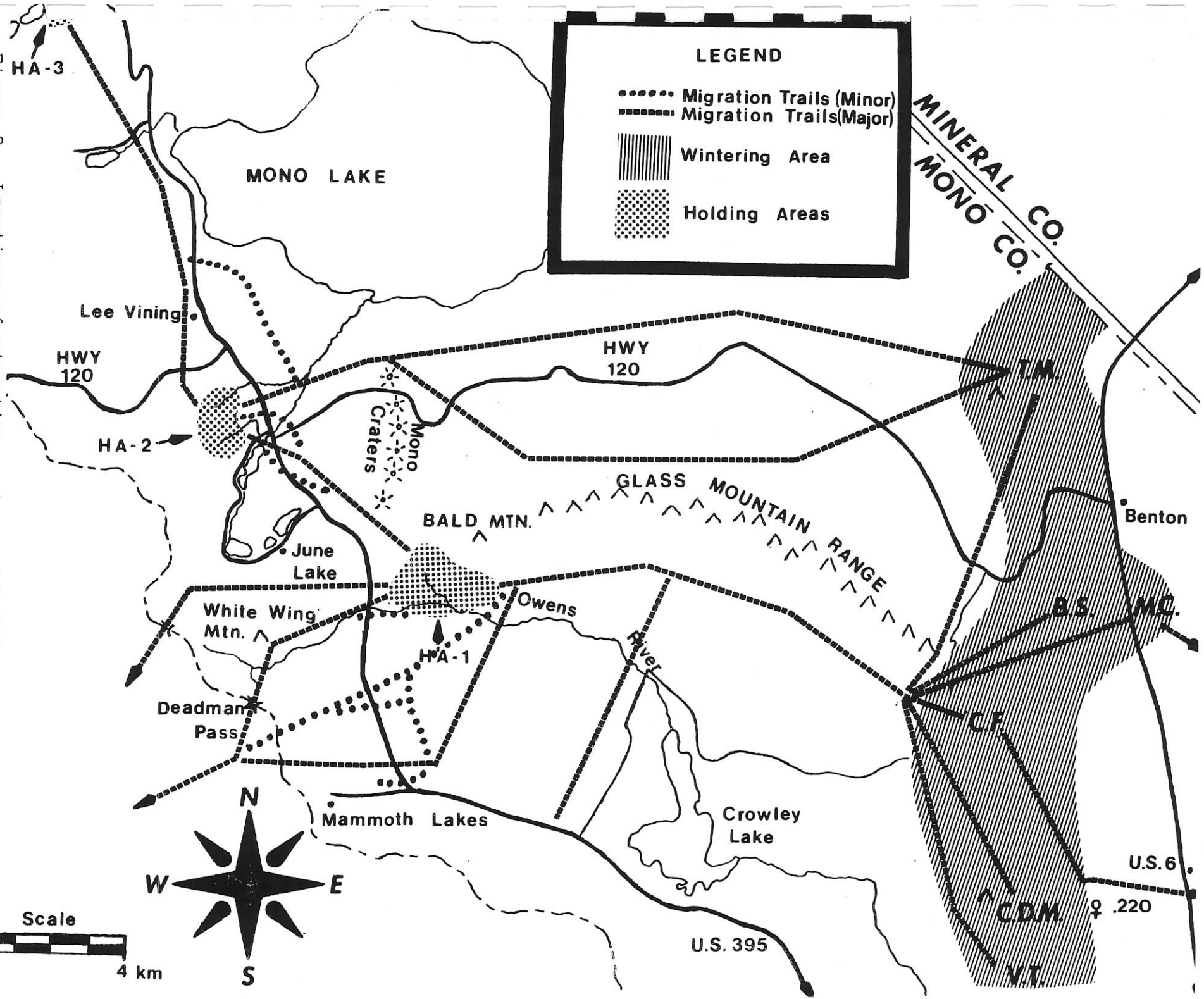

Figure 3. Locations of migration routes and holding areas of the Casa Diablo deer herd in Mono County, California.

from 1-47 days during April, May, and June. In addition, a total of 5 non-radioed, ear tagged deer were observed on HA-II during the spring migration of 1986 (Appendix Figure 2). Deer traveling to lower elevations did not use HA-II to the extent of those traveling to higher elevations.

One radio-collared doe was found to utilize HA-II during two different periods in the spring of 1986 before moving onto her summer range. This particular doe first arrived on HA-II on 12 April and remained there until 24 April after which time she traveled extensively to the north and west over an area encompassing 20 km at elevations between 2,320-2,750 m. She returned to HA-II for a second time on 2 May and remained there until 5 May, after which time she traveled to the south and east over much of the Reverse Peak area before finally settling down on her summer range on 10 May. Her movements appear to have been directly influenced by weather and its effects on plant phenology on her summer range, which was located within a steep canyon where limited sunlight and cool daytime ambient temperatures resulted in late development of forage.

In 1986, 6 radio-collared deer migrated north of HA-II, 4 of which summered in Lee Vining Canyon, 1 in Lundy Canyon, and 1 near lower Twin Lake. The radio-collared doe which summered near Lower Twin Lake was found to occupy another spring holding area (HA-III), located at the north end of Lower Twin Lake on Honeymoon Flat. She remained on HA-III for 5 days (12-17 June) in 1986, before moving 3 km east to her summer home range. HA-III encompasses 5 km^2 at elevations ranging from 2,120-2,200 m and, like other holding areas, is composed of a mixture of Jeffrey pine and Great Basin sagebrush vegetation (Appendix Figure 1b).

As mentioned previously, 4 radio-collared deer migrated to the west of HA-I (Figure 3, Appendix Figure 1). These deer departed HA-I between 24 and 28 May in 1986 and traveled in a southwesterly direction, crossing what was then a two lane section of Hwy 395 just north of the Crestview maintenance station. One radio-collared doe migrated up the Glass Creek drainage on the north side of White-Wing Mountain before crossing San Joaquin Ridge to the west side of the Sierra. The other 3 radio-collared does migrated around the south side of White-Wing Mountain, two of which crossed San Joaquin Ridge over Deadman Pass (elevation 3,163 m). The other stopped approximately 1 mile east of the ridge where it summered on the south slope of White-Wing Mountain.

Although the winter range of radio-collared female .220, marked on HA-I, was never located, a portion of her migration route was delineated. Her migration route heads in an easterly direction from her summer range, located near HA-I, first contouring along the south slope of the Glass Mountains. It then proceeds through the Chidago Flat area and across the Volcanic Tablelands, after which it crosses Hwy 6, just south of the town of Chalfant and continues into the Piute Creek area of the White Mountains. The remainder of the migration route, like her winter range, was never delineated.

Sixteen of 22 radio-collared deer which summered to the west of the Casa Diablo winter range were monitored for both the 1986 and 1987 spring periods, and all but 2 used the same migration routes. These 2 deer, both from the Truman Meadows wintering area, migrated along the south slope of the Glass Mountains in 1986 in order to reach their summer range destinations. However, in 1987, both of these deer migrated along the north side of the Glass Mountains (Figure 3, Appendix Figure 1a). Doe .450 totally bypassed HA-I which she used in 1986, and migrated directly to her summer range. Doe .315 migrated along the north side of the Glass Mountains to as far as Sagehen Meadow, before turning south to HA-I.

SPRING MIGRATION

A total of 11 radio telemetry flights were made during the spring periods of 1986 and 1987 to locate deer during migration. All monitored deer from the Casa Diablo deer herd were migratory with distinct winter and summer ranges. Despite extreme differences in the amount of snowfall recorded during the winters of 1985-86 and 1986-87, little variation occurred in the overall timing of migration (Figure 4). The winter of 1985-86 was one of the wettest on record in the eastern Sierra, with 745.2 cm of snowfall recorded at 2,378 m at Mammoth Lakes, Mono County (USFS, Unpubl.). In contrast, during the winter of 1986-87, 255.8 cm of snowfall was recorded at the same location.

Deer migrated approximately two weeks later in 1986 than in 1987. However, the overall timing of migration to the summer range between the two years was quite similar. In 1986, deer began leaving the winter range on 3 April, with 50% of all radio-collared deer having migrated by 20 April (Figure 4). By 15 May, all radio-collared deer had left the winter

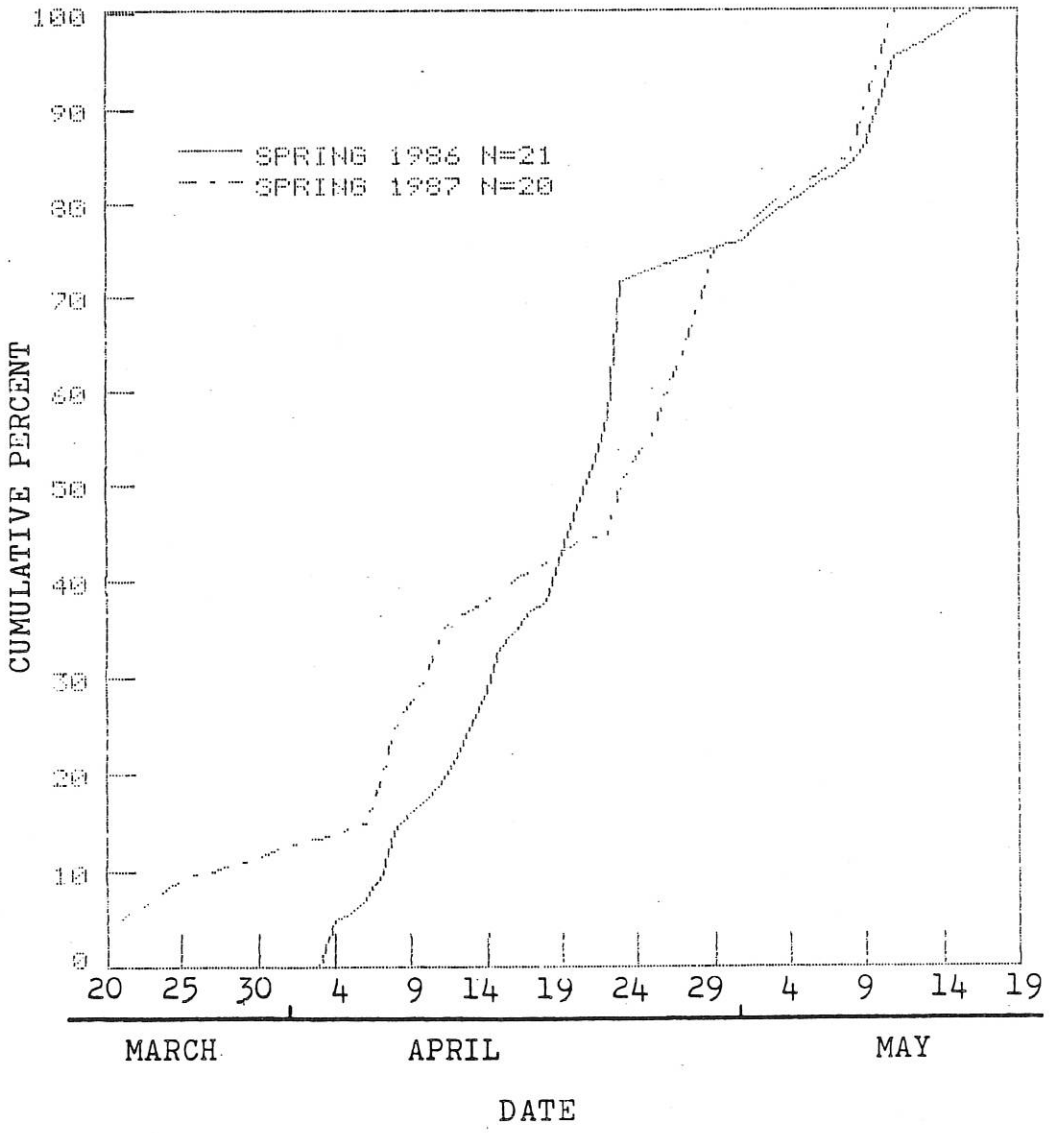

Figure 4. Cumulative percent of radio-collared deer migrating from the Casa Diablo winter range by date.

range.

In spring of 1987, 2 radio-colllared does migrated on 20 and 26 March. However, due to late development of spring green-up on the winter range, no other radio-collared deer were found to migrate until 6 April. By 22 April, 50% of all radio-collared deer had migrated and by 10 May, all had left the winter range. Migration from the winter range in spring of 1987 was more gradual than in 1986, with no peak periods of departure (Figure 4).

Deer that summered at higher elevations did not leave the winter range at a later date than those summering at lower elevations. However, deer which summered at higher elevations, or those having to cross the Sierra crest to gain access to west side summer ranges, did remain longer on spring holding areas. Changes in elevation between winter and summer ranges varied from 2,134-3,354 m. Distances traveled between winter and summer ranges varied from approximately 3.5 to 116 km.

Arrival dates of radio-collared deer on the summer range varied dramatically among some individuals during the two years studied and had no discernible pattern. Five deer arrived from 10-13 days later on their summer ranges in 1987 than in 1986. In contrast, five others arrived from 10-20 days earlier on their summer ranges in 1987 than in 1986.

FALL MIGRATION

Radio-collared deer were monitored for two consecutive fall seasons. Little variation exists in the timing of migration to the winter range between 1986 and 1987. However, migration to the winter range appeared to be less strongly correlated with weather in 1986 than in 1987. This mostly is due to the occurrence of only one minor storm in the fall of 1986, on 24 September. During the 1986 fall migration, 83% of radio-collared deer migrated between 3 October and 8 November (Figure 5). Two radio-collared does remained on their summer ranges until 3 January 1987, when the first significant winter storm occurred.

In 1987, the first radio-collared deer migrated from the summer range on 6 October. Eighty-two percent of radio-collared deer migrated in response to storms which occurred on 11-12, 22-23, and 27-28 October and 2-3 November.

Radio-collared does summering at higher elevations or west of the

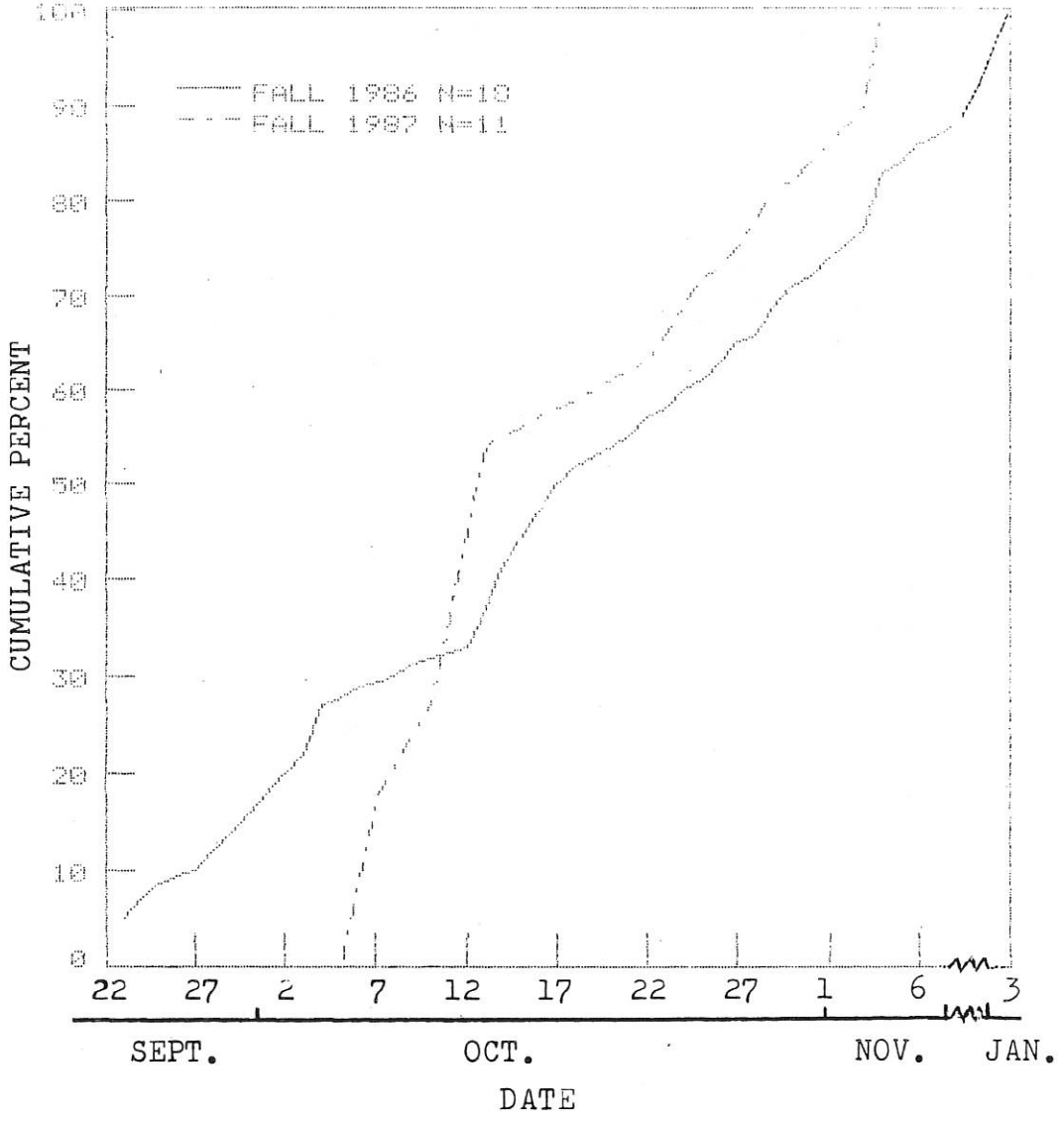

Figure 5. Cumulative percent of radio-collared deer migrating from summer range by date.

Sierra crest did not appear to migrate earlier than those summering at lower elevations. In both years, all deer known to migrate along the south slope of the Glass Mountains spent between 1 and 41 days on HA-I, remaining there until as late as mid-November before migrating further east. Here, a south-facing slope provided snow free areas of abundant browse. Once the deer left HA-I, movement generally was gradual, with deer taking as long as 15 days to reach wintering areas.

WINTER RANGE

Home range sizes for radio-collared deer on the winter range averaged 85 ha (range = 31-154 ha). During the dry winter of 1986-87, 19 of 22 radio-collared deer occupied higher elevation transition range west of their respective wintering areas. All utilized large stands of pinyon pine between 2,135-2,470 m, where they fed extensively on a large crop of pinyon nuts. Light to moderate snow conditions made pinyon nuts readily available throughout the entire winter. Home range sizes on transition range averaged 295 ha (range = 172-384 ha). Deer remained on transition range until approximately mid-March, after which time 16 radio-collared deer moved east an average of 11 km to lower portions of the winter range presumably in search of herbaceous spring forage.

During the winter of 1986-87, three radioed does, all of which were captured on Casa Diablo Mountain in January 1986, never returned to this wintering area (Figure 2). Two of these does spent the entire winter approximately 8 km northwest of Casa Diablo Mountain on transition range near the south end of Banner Ridge. These two does were the first radio-collared deer to migrate in spring 1987, on 20 and 26 March, departing directly from Banner Ridge. The other doe, which migrated along the north side of the Glass Mountains during the 1986 fall migration, traveled only as far as the Sagehen Meadow area where she spent the entire winter. In the spring of 1987, this doe migrated to her summer range directly from the Sagehen Meadow area on 7 April.

In fall of 1987, deer were monitored until 15 December. At this time, only 2 of 11 radio-collared deer had returned to the wintering areas where they were captured. The other 9 occupied transition range west of wintering areas, as they did during the winter of 1986-87.

SUMMER RANGE

Deer from the Casa Diablo herd occupied approximately 2,000 km of summer range throughout west central Mono County, primarily along the east slope of the Sierra Nevada (Figure 2). Fifteen of 22 radio-collared deer which migrated to the west of the Casa Diablo winter range summered on the east slope of the Sierra Nevada, from the Deadman Creek drainage north to lower Twin Lake (Figure 6, Appendix Figure 3). Twelve of these 15 deer summered within a 22 km area, from Grant Lake north to Lee Vining Canyon. A total of 22 non-radioed, ear tagged deer were observed along the east slope of the Sierra Nevada during the summers of 1986 and 1987 (1 June-1 October) (Appendix Figure 2). Radio-collared deer which summered on the east slope of the Sierra occupied home ranges located at an average elevation of 2,547 m (range = 2,135-2,960 m).

Four radio-collared deer summered east of Hwy 395 from the Mono Craters south to O'Harrel Canyon in the Glass Mountains at an average elevation of 2,515 m (range = 2,195-3,050 m). In addition, 10 non-radioed, ear tagged deer were observed east of Hwy 395 between 1 June and 1 October 1986 and 1 June and 1 October 1987 (Appendix Figure 2). Three radio-collared deer summered to the west of the Sierra crest, one in Madera County at Beasore Meadow near Chilkoot Lake, one in Yosemite National Park near Tuolumne Meadows, and one in the upper San Joaquin drainage near Shadow Lake (Appendix Figure 4). Four radio-collared deer, all from Marble Creek, summered on the west slope of the White Mountains directly above the winter range.

Marked deer from the same wintering area occupied portions of summer range in "family groups". This was most evident in deer from Chidago Flat in which 12 of 14 marked animals were found on the same summering area in Lee Vining Canyon. Conversely, marked deer from the same wintering area were also found to disperse to opposite ends of the summer range (Figure 6). For example, one doe from the Blind Spring Hills summered at the southern end of the herd range near the Deadman Creek drainage while another summered at the northern end of the range near lower Twin Lake. Gruell and Papez (1963), also found this to be true of deer in northeastern Nevada, where all deer wintering together did not summer together.

Marked deer from several different wintering areas were found to

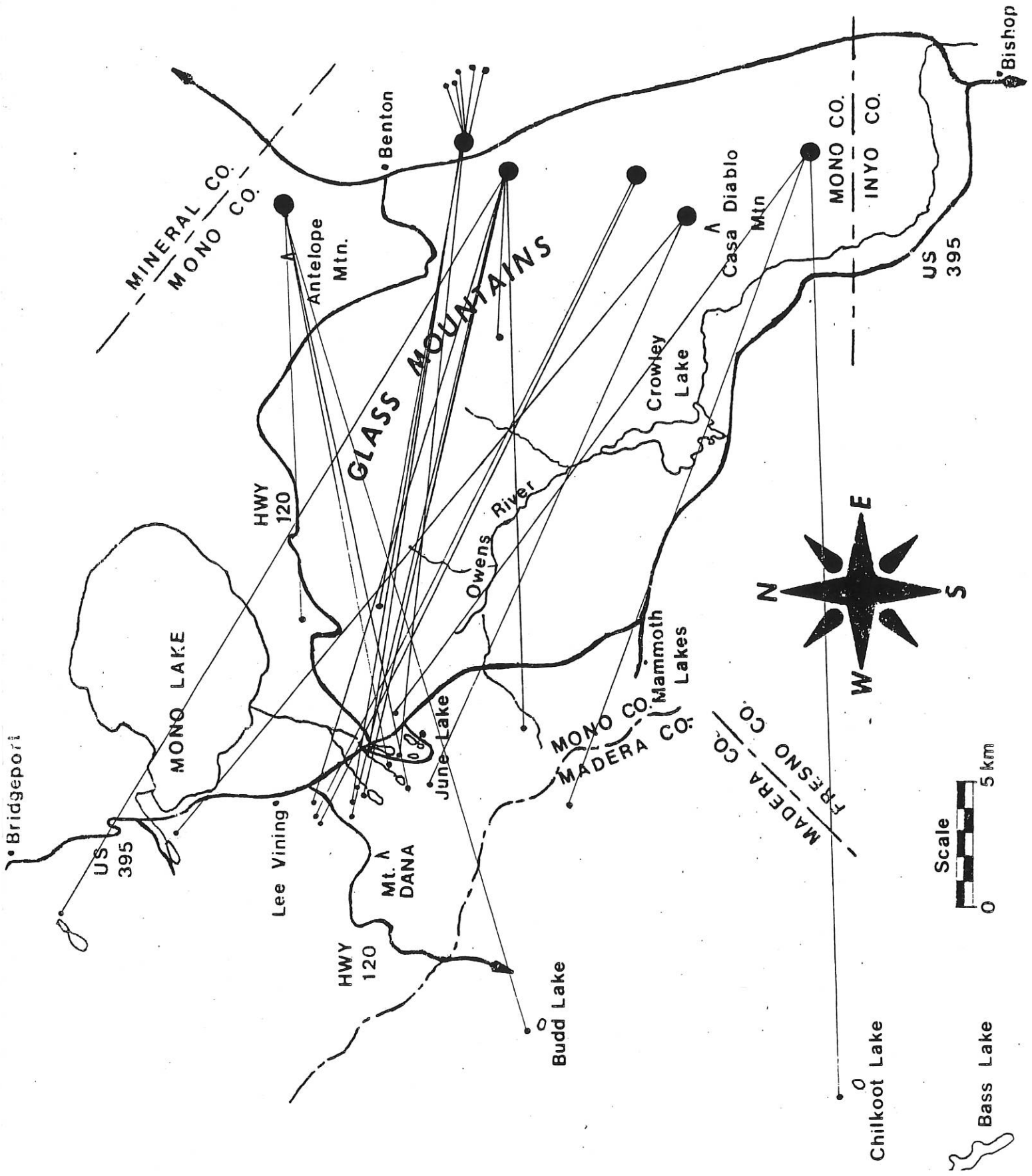

Figure 6. Movements of radio-collared deer marked on wintering areas (large circles) and subesquently found on summer ranges (small circles).

occupy summer range of close proximity and even to have overlapping home ranges. Three radio-collared does, two from Chidago Flat and one from Blind Springs, had overlapping home ranges of 34-111 ha in Lee Vining Canyon on the east slope of the Sierra. Two does, one from Marble Creek and one from Blind Springs, had overlapping home ranges in Bohler Canyon, also located on the east slope of the Sierra.

Many fawning areas or "population centers" were identified on the east slope of the Sierra (Figure 7, Appendix Figure 5). Population centers are described as an aggregation of propagation units where single pregnant does find adequate food, water, and cover to rear fawns (Bertram 1984).

All 16 radio-collared deer monitored for two successive years exhibited strong site fidelity to summer range areas by returning to the same summer range locations in 1987 as in 1986.

SUMMER HABITAT UTILIZATION

Home ranges for deer summering on the east slope of the Sierra Nevada averaged 100 ha (range = 34-167 ha). Quaking aspen riparian habitat was the major type most utilized by radio-collared deer from the Casa Diablo herd. Fourteen of the 15 monitored does which summered on the east slope of the Sierra Nevada mountains were found to have summer ranges typically consisting of a mosaic of different habitat types centered around some portion of a riparian area. Seven of these does utilized quaking aspen riparian vegetation occurring along stream channels winding through open areas of Great Basin sagebrush and montane chaparral. These riparian areas were an average of 25 m wide (range = 15-100 m). Deer most often selected portions of these riparian areas having from 80-405 aspen trees per ha within the 2.5-15 cm DBH size class and dense multilayered understory vegetation. These areas provide shade and thermal cover, but more importantly hiding cover, particularly for fawns. Understory vegetation typically consisted of several different grass species, aspen shoots, willow, snowberry, wild rose, and corn lily (Veratrum californicum). Willow and snowberry where the most abundant understory species making up 40 and 25 percent of understory vegetation respectively. The overstory canopy in these areas consisted of an average of 282 aspen trees per ha with an average DBH of 23 cm and average heights

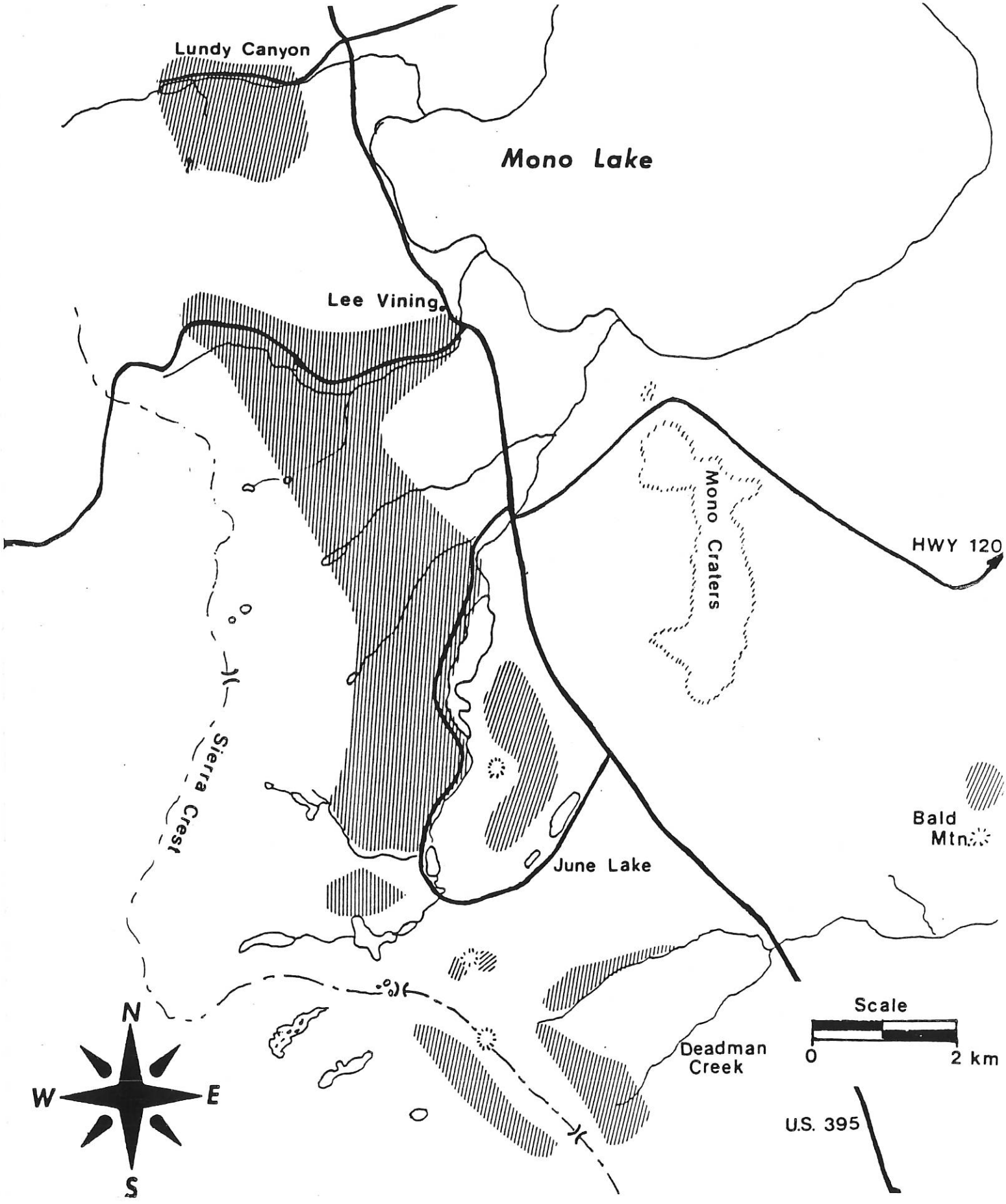

Figure 7. Locations of major fawning areas, Casa Diablo deer herd.

of 9 m.

Seven deer had home ranges including mixtures of both meadow and aspen riparian habitat types. Home ranges of these deer typically consisted of a portion of a large aspen grove and nearby associated meadows. All seven deer expanded their home ranges to include nearby Great Basin sagebrush and montane chaparral areas once meadow and aspen understory vegetation began to senesce, in late August of 1986 and in late June of 1987.

Three deer which summered east of Hwy 395 and south and east of Mono Lake had home ranges approximately 2 times larger than those that summered on the east slope of the Sierra Nevada. These does had summer home ranges averaging 384 ha in size which consisted primarily of Jeffrey pine and Great Basin sagebrush habitat types. Limited water distribution throughout the Jeffrey pine habitat type may have caused these does to range over a larger area. One doe, which summered east of Mono Mills (Figure 6), was observed drinking from a sheep watering trough 1.9 km west of the center of her home range. Another doe consistently was observed on her summer home range located approximately 2 km from the nearest water source. These does utilized large, open stands of Jeffrey pine consisting of an average of 243 trees per ha. Understory vegetation consisted primarily of 1-1.5 m high big sagebrush and bitterbrush.

MORTALITIES

Five of the original 23 radio-collared deer (22%) marked during January-March 1986 on the Casa Diablo winter range were killed by mountain lions (Figure 8, Appendix Figure 6). The first, from Truman Meadows, was killed on HA-I on 26 April 1986. Her carcass was found buried under about 5 cm of dirt and litter in a large opening of Great Basin sagebrush. Two does were killed by mountain lions on 29 January 1987 on pinyon-juniper transition range in the Banner Ridge area. Both carcasses, which were found approximately 8 km apart, were mostly consumed and buried at the base of pinyon trees. One doe was killed by a mountain lion on 20 March 1987 on the Blind Spring Hills wintering area. Her carcass, which was buried in a sandy draw, was found to be almost entirely eaten. A fifth doe was killed by a mountain lion while

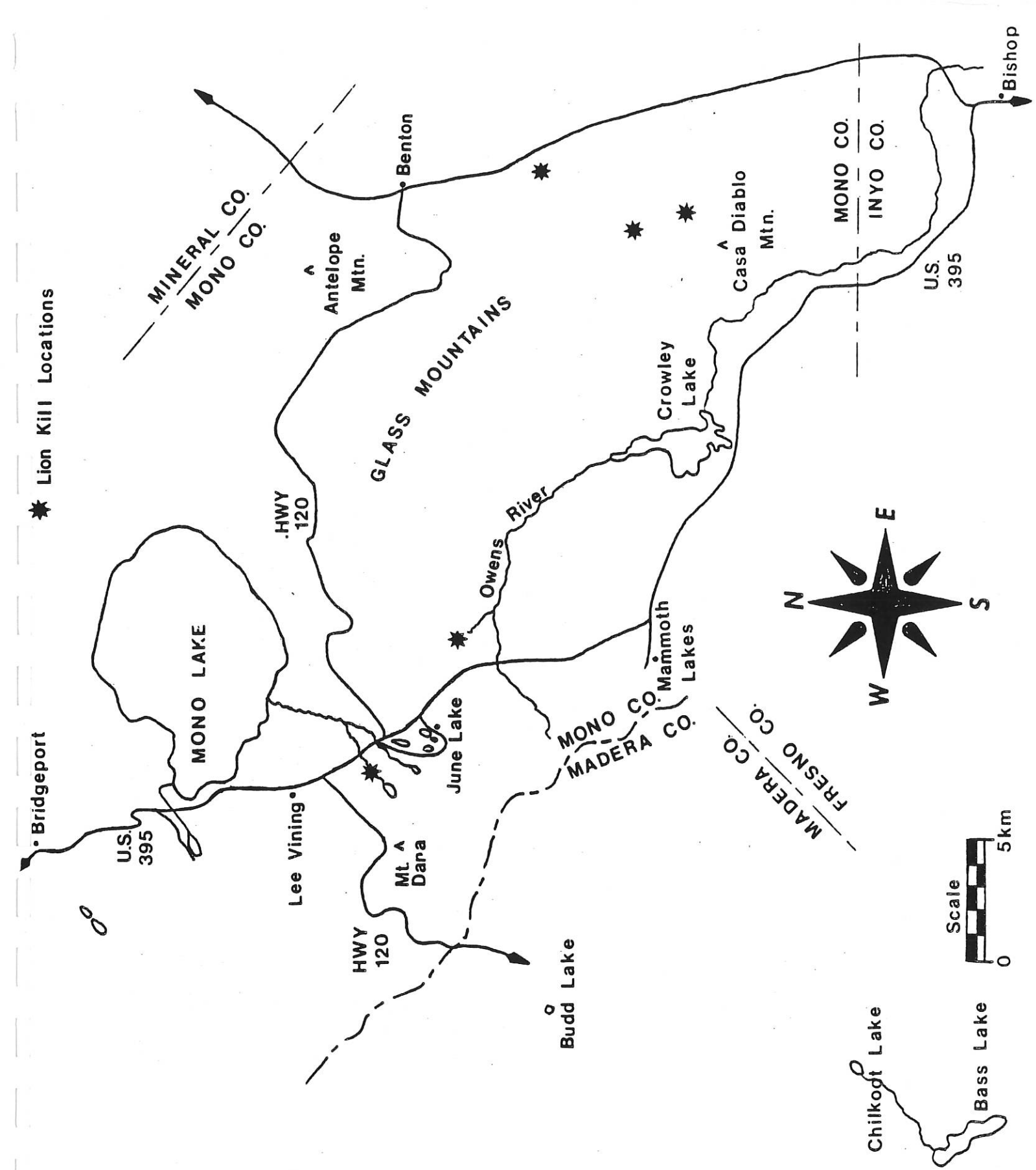

Figure 8. Locations of five radio-collared does killed by mountain lions.

on her summer range sometime during October 1987. Her carcass was found buried in willows on Parker Creek. Two additional does died while on their summer ranges; the cause of death was undetermined.

DEER HERD COMPOSITION COUNTS

Post season composition counts have been conducted over the last eight years on the Casa Diablo winter range. Fawn:doe ratios have averaged 49:100 and buck:doe ratios 9:100 (Table 2). During this study, post season composition counts were conducted on 7 January 1986, 6 January 1987, and 8 January 1988. In 1988, fawn:doe ratios were the lowest ever recorded (36:100).

Spring composition counts were conducted on the Casa Diablo winter range from the ground in April of 1986 and 1987. In 1986, fawn:doe ratios were 21:100 and 39:100 in 1987.

Deer herd size has been estimated at approximately 1,500 animals over the last several years using a ratio estimation method (Anderson et al. 1974), a technique utilizing annual buck harvest figures and herd composition data.

TABLE 2. Results of Casa Diablo Deer Herd Spring and Fall Composition Counts per 100 Does, 1980-1988

YR	Fall		Fall Sample	Spring	Spring Sample
	Bucks	Fawns		Fawns	
1980-81	13	58	---	47	---
1981-82	10	54	353	50	---
1982-83	7	41	403	28	---
1983-84	8	37	526	46	---
1984-85	7	43	366	42	191
1985-86	15	61	444	21	153
1986-87	6	60	293	39	602
1987-88	6	36	940	--	---

DISCUSSION

MIGRATION CORRIDORS

The Glass Mountains, which extend in a westerly direction from the center of the Casa Diablo winter range, provide a source of orientation

for deer as they migrate to and from wintering areas. Two major migration corridors, one along the north slope and one along the south slope of the the Glass Mountains were identified. Twenty-one of 27 radio-collared deer, representing all six subwintering areas, utilized the corridor on the south slope of the Glass Mountains during the spring and fall migrations of 1986 and 1987. It is believed that this corridor is used to such an extent because of its southerly aspect. South aspects typically are the first places to become snowfree in late winter (Garrott et al. 1987). Thus, snow does not appear to form an impediment to migration or to retard spring growth as it often does on the north slope of the Glass Mountains. In addition, this corridor was the shortest and the easiest way for most radio-collared deer to travel to and from wintering areas.

Two radio-collared does, both from the Truman Meadows wintering area, utilized different migration corridors during consecutive spring periods. In 1986, both does migrated along the south slope of the Glass Mountains, but in 1987 both used the north slope. Although the south slope is not the shortest route between winter and summer ranges for deer from Truman Meadows, it is the easiest route offering the most suitable conditions in years of above average snowfall (eg., 1986). In early April of 1986, due to snow free conditions, plant phenology was found to be much in advance and forage availability much greater along the south slope of the Glass Mountains than the north slope. Thus, in 1986 both does took advantage of these conditions by migrating along the south slope. In the dry year of 1987, snow cover on the north slope of the Glass Mountains was much lighter than normal in April, resulting in an earlier thaw and greater forage availability than in 1986. Hence, both does migrated along the north slope where they were able to take advantage of abundant forage while at the same time migrating a shorter distance to their summer ranges.

The fact that both radio-collared does have learned to utilize two migration corridors may be a form of opportunism (Geist 1982). In both cases, these animals were able to take advantage of abundant food sources brought about by ecological and climatic factors.

By traveling along the north slope of the Glass Mountains during the spring of 1987, these does were able to minimize expenditures of energy and nutrients on maintenance by migrating a shorter distance

while at the same time maximizing resources for reproduction (Geist 1982).

Radio-collared deer utilized two major migration corridors after departing HA-I. One of these extends to the west around the south slope of White Wing Mountain and over San Joaquin Ridge (Figure 3). Deer crossed San Joaquin Ridge using several passes with the majority of movement confined to Deadman Pass. These passes, located at elevations between 2,960-3,195 m, can be considered as the link between east and west side Sierra seasonal ranges. Assuming that the radioed sample of deer is representative of the entire population, about 200 deer from the Casa Diablo herd cross San Joaquin Ridge to gain access to west side summer ranges. Several hundred deer from another eastern Sierra herd (the Sherwin Grade herd) which winter in Round Valley about 14 km north of Bishop, are also known to cross San Joaquin Ridge to gain access to their west side summer ranges (Kucera, Unpubl.).

Migration between winter and summer ranges of individual radio-collared deer were quite variable. Deer summering west of the Sierra crest were found to migrate as far as 120 km between winter and summer ranges. Those deer summering in the White Mountains had up slope migrations between winter and summer ranges of 1-3 km.

HOLDING AREAS

Deer from the Casa Diablo herd utilized three major holding areas during the spring and fall migrations of 1986 and 1987. Elevational, topographical, and vegetative features of these holding areas are quite similar. All three holding areas are located at approximately the same elevation, between 2,134-2,439 m, and all generally are situated at the base of south and east facing slopes. Vegetative composition on all these holding areas consists of a mixture of Jeffrey pine and Great Basin sagebrush habitat types.

Deer generally occupied holding areas for a longer period during the spring than in the fall. Fourteen deer utilized both HA-I and HA-II in the spring of 1986, and one monitored doe was found to occupy all three holding areas.

Much of the land in which holding areas are located is administered by the United States Forest Service. Therefore, these

lands are managed for a variety of different uses including recreation, grazing, and logging. About 15% (4 km) of land in HA-I is in private ownership, most of which includes meadow areas along the Owens River that are used primarily for cattle grazing. A small portion of land at the northern corner of HA-III is also in private ownership where a small subdivision exists.

Winter logging of Jeffrey pine has been conducted over the last several years throughout the south and west portion of HA-I. Logging practices typically have included pre-and post-commercial thinning of trees < 20 cm DBH with an average spacing of 5 m between trees. Thus, many dense pockets of Jeffrey pine which provide the best hiding and escape cover for deer have been eliminated throughout this holding area. Several studies have identified the importance of dense hiding and escape cover for deer, especially during hunting season (Dasmann and Taber 1956, Sweeney et al. 1971). On fall holding areas of the North Kings herd, dense cover is a necessary and major component during hunting season (Bertram and Rempel 1977).

Conversely, thinning of dense stands of Jeffrey pine most likely has increased forage production within thinned areas. According to Ffolliott and Clary (1972), this is an acceptable generalization for most forest types. Other research has also indicated that use by deer commonly increases after logging (Wallmo et al. 1976).

No formal evaluation has been conducted concerning the effects of timber management practices on deer use within east side Sierra Jeffrey pine habitats. Therefore, it is difficult to postulate whether these practices have actually been of benefit to deer. According to Dasmann (1981), there can be too much cover as well as too little. HA-I already contains one large meadow area and vast open areas of Great Basin sagebrush habitat both of which typically provide an abundance of forage. Thus, since forage availability does not appear to be a limiting factor, perhaps it may be of greater benefit to deer if areas of dense Jeffrey pine are maintained.

Throughout most of the Jeffrey pine forest, roads, created primarily for timber harvest have reduced much of the effectiveness of hiding and escape cover by providing easy access to the public. Logging roads have been a major factor contributing to human disturbance on holding areas of the North Kings deer herd (Bertram 1984). Since

logging of harvestable timber is conducted only during the winter months, it does not directly conflict with deer use of Jeffrey pine habitats. However, public fuel wood gathering of logging slash and thinned trees are activities which normally coincide with the timing of fall and spring migrations.

SPRING MIGRATION

During the two spring periods studied, little overall variation was found in the overall timing of migration to the summer range (Figure 4). This is despite great extremes in total amounts of snowfall received during the winters of 1985-86 and 1986-87. Garrott et al. (1987) found that the timing of spring migration for deer in Colorado varied annually by as much as 1 month and was related to severity of winter, with deer migrating later after more severe winters. Bertram and Rempel (1977) found migration from the winter range in deer from the North Kings herd to be approximately two weeks earlier following dry winters than winters of normal to above normal precipitation.

In this study, I hypothesize that the consistency in the timing of migration between the two spring periods studied was related to the extreme difference in the severity of winters. Following the wet winter of 1985-86, a heavier than normal snowpack retarded spring growth along the south slope of the Glass Mountains, thus delaying spring migration until early April. After the very dry winter of 1986-87, spring green-up on the winter range did not occur until mid-March due to a lack of mid and late winter precipitation. This was reflected in the movements of 16 deer which moved during March from high elevation transition range to low lying wintering areas where the availability of spring forage was greatest. Deer remained on the winter range until early April when spring green-up at higher elevations along the migration corridor began to occur.

FALL MIGRATION

According to telemetry data, migration to the winter range in fall 1987 was in response to snow storms and the consequent accumulation of snow on the summer range. Snow was also found to be a cause of

found to occupy different summer home ranges during consecutive years. The observed behavior of these three Casa Diablo deer may best be explained by elevational, topographical, and vegetational similarities between the Casa Diablo Mountain wintering area and pinyon-juniper transition range. Why should deer expend extra energy by migrating a further distance to an area that offers similar or perhaps less forage quality and availability? This may be interpreted as another form of opportunism as throughout the winter of 1986-87 deer on transition range were found to feed extensively on an abundant crop of pinyon pine nuts which were made readily available because of below normal snow accumulations. Thus, deer were able to minimize energy expenditures on maintenance by remaining on transition range where resources were of higher density and quality (Geist 1981). As a result deer were able to maintain a high level of nutrition throughout the winter months. This in turn culminated in better animal condition, and thus higher pregnancy and fetal rates among adult does collected on transition ranges (Taylor, Unpubl.).

Throughout much of the Casa Diablo winter range, water appears to be a major factor limiting deer distribution during winter months when succulent forage or snow is unavailable. When available, succulent forage and snow can provide enough water to meet metabolic needs, but free water is required during other times (Wallmo 1981, Dasmann 1981). Portions of the Casa Diablo winter range having limited water availability, such as Chidago Flat and Black Rock, where found to have large areas of seemingly suitable habitat which where virtually devoid of deer.

Water and forage appear to be the primary factors governing the size of winter home ranges. Deer occupying pinyon-juniper transition range had home ranges 2 times larger than deer which utilized other habitat types on low lying wintering areas. On transition range free water was readily available from numerous streams and seeps and, therefore, provided increased opportunity for selective foraging. Thus, deer were able to forage throughout larger areas in search of pinyon nuts and other more desirable plant species. On the North Kings winter range deer occupying Foothill-Woodland types were found to have a slightly larger home range than deer in more diverse habitat types. However, this difference was attributed to cover distribution and its

Telemetry data also indicate that nearly 70% of the Casa Diablo deer herd, some 1,000 animals, summer north of the original administrative boundaries established for the herd by DFG. Therefore, since most all bucks are harvested on the summer range, it is likely that buck kill totals compiled each year for the Casa Diablo herd do not represent the actual number of bucks harvested from the herd. This is supported by the fact that four ear tagged bucks were killed by hunters within the administrative boundaries of the Mono Lake herd. Had these deer not been marked, they would have been included as part of the total kill for the Mono Lake herd. Since the Casa Diablo and Mono Lake herds are thought to share summer range together, it virtually is impossible to determine the true buck harvest for each herd. Consequently, herd size estimations based in part on buck harvest figures become questionable.

Recent changes in buck harvest management strategies in Mono County by DFG has resulted in the split of hunting zone X-9 into zones X-9a and X-9b. Prior to this split, three and possibly four herds in Mono County occupied summer range within the boundaries designated for zone X-9. From telemetry data, it was possible to delineate distinct summer range boundaries for the Casa Diablo herd which were recognizable from those of the Sherwin herd to the south and the East Walker herd to the north. These delineations were used for the purpose of demarcating new zone boundaries which now allow DFG to manage the Casa Diablo and Mono Lake herds as one in zone X-9a.

Radio-collared deer exhibited strong fidelity to individual summer ranges. All occupied the same summer home range in 1987 as in 1986. Others, (Ashcraft 1961, Gruell and Papez 1963, Robinette 1963, Schneegas and Franklin 1972, Bertram 1984, Loft et al. 1984, Garrott et al. 1987), have also reported that deer consistently use the same specific summer range, winter range, and migration routes.

One radio-collared doe was found to shift home ranges after her original one was subjected to heavy use by domestic sheep. The summer home range of this particular doe originally was centered on a small riparian strip near the lower north end of Parker Bench. She arrived on this summer range on 1 May 1987 and was observed several times there until sheep entered the area on 2 July. She immediately abandoned this home range and moved approximately one mile west to an adjacent riparian strip where she remained for the rest of the summer. Similar shifts of home

range resulting from destruction of food and cover have also been documented by Robinette (1966).

One other monitored doe which summered in Jeffrey pine habitat was found to shift her home range during early August for two consecutive years. She moved from her original summer home range, which was located in Jeffrey pine forest, to an area devoid of trees that consisted mainly of 1-1.5 m high bitterbrush and sagebrush. This dispersal was apparently done in order to establish a new home range with closer proximity to water and perhaps more adequate fawn hiding cover (Robinette (1966).

Deer occupying summer range in Jeffrey pine habitat had home ranges slightly larger than deer in other habitats. Again, this may be related to water and its proximity to forage and cover. Pumice soils associated with Jeffrey pine forest on the east side of the Sierra generally hold very little water. This is especially true of areas immediately south and east of Mono Lake, where two monitored does summered. These deer were observed to travel several km on a daily basis between feeding and resting, and watering locations.

Water is very likely a factor limiting deer distribution and numbers throughout much of the Jeffrey pine habitat type, especially after spring growth has desiccated. It also may influence fawn survivability since fawns, which have a greater relative metabolic rate, probably are more sensitive to water deprivation and consequently succumb more quickly to this form of stress than do adult deer (Short 1981).

Undoubtedly, the major reason for deer from the Casa Diablo herd showing such affinity for the east slope of the Sierra Nevada is that it offers the best suitable habitat and conditions for fawning.
Aspen-riparian habitat was the type most often utilized by radio-collared does summering on the east slope of the Sierra. This type is preferred because dense understory vegetation provides important thermal and hiding cover, especially for fawns (Reynolds 1969, Loft et al. 1987). It also is preferred because of its close proximity to water and the succulent forage which it provides (Kauffman and Krueger 1984, Loft et al. 1986).

It is estimated that riparian habitats encompass approximately 14,974 ha or 2% of all lands on the Inyo National Forest. Seventy percent of these riparian habitats (10,522 ha) are comprised of wet meadows above 2,440 m (USDA 1987). The fact that 93% of all radio-collared deer summering on the east slope of the Sierra utilized this habitat type, one

which comprises a relatively small portion of the total summer range, may indicate that this type is actively selected for by deer.

Livestock grazing occurs on an annual basis throughout most state and federal lands on the east side of the Sierra. Sheep grazing is particularly prevalent throughout most east side summer range habitats occupied by the Casa Diablo deer herd. This is especially true of lands owned by the Los Angeles Department of Water and Power, which mostly are comprised of meadow and aspen-riparian habitats. Direct conflicts in the timing of sheep and deer use occur during both spring and summer periods in many aspen-riparian areas, especially on HA-II and other lands located on the east slope of the Sierra. In those aspen-riparian habitats that have received heavy sheep use on an annual basis, much of the understory vegetation has been severely reduced from grazing and trampling. This, in turn, has affected regeneration and survival of young trees (Loft et al. 1987).

RECOMMENDATIONS

Since seasonal habitats and migration routes utilized by the Casa Diablo deer herd have now been delineated, it is important to maintain and enhance, if possible, the quality of these areas in order to achieve herd management objectives outlined in the Casa Diablo Herd Management Plan (Thomas 1984). Therefore, to assist wildlife and habitat managers in this endeavor some general recommendations regarding habitat maintenance and manipulation of critical use areas are in order.

Holding areas are utilized for up to 6 weeks during both spring and fall migration and therefore efforts should be made to attain adequate high quality forage and cover during these times. Livestock grazing occurs on on all holding areas identified and the location and use periods of some allotments suggest the probability of conflict with deer, especially during spring migration. Thus, the timing and intensity of livestock grazing should be evaluated and provisions made which minimize competition for available forage.

Timber harvest and thinning can have beneficial effects on deer forage production by opening the canopy and stimulating herbaceous growth and browse production. However, thinning of Jeffrey pine forest has eliminated valuable hiding and escape cover, which appear to be of

particular importance during the fall. Therefore, it is essential that dense stands of Jeffrey pine be maintained especially on fall holding areas where deer are dependent on this habitat type for cover.

A dense network of logging roads throughout most of the Jeffrey pine forest has reduced much of the effectiveness of this habitat type as hiding and escape cover by increasing accessibility and disturbance to deer. Thus, a program of road closure and rehabilitation is needed to improve habitat conditions and reduce human disturbance throughout areas impacted by past timber harvests.

Water is scarce and poorly distributed throughout much of the Casa Diablo winter range and portions of the summer range, especially in Jeffrey pine and Great Basin sagebrush habitats to the south and east of Mono Lake. As a result, deer use generally is restricted to favorable habitats near permanent water sources. In order to increase deer densities on a herd wide basis, a major management objective of the Casa Diablo herd, it is essential that permanent water sources be developed in unwatered areas. This can be achieved by improving existing water sources and establishing windmills and rainwater collectors, or "guzzlers" (Appendix Figures 7a, 7b, and 8).

Three radio-collared deer occupied summer range on the west side of the Sierra Nevada. These animals were provided access to their west side summer ranges by a migration corridor extending around the south slope of White-Wing Mountain and over San Joaquin Ridge. White Wing Mountain and San Joaquin Ridge have been proposed for nordic ski development in phases IV and V of the Mammoth-June Mountain Ski Area Development Plan. It is essential, if ski development is allowed to occur, that development be intelligently planned when considering the placement of proposed facilities within this migration corridor. Thus, it will be necessary to design studies that would gather more site-specific information regarding deer migration and summer use within areas of proposed ski development. It also is imperative that mitigation be designed that will limit human disturbances associated with such developments during migration periods. For example, this may entail reduction or complete cessation of ski area construction and maintenance activities until migration has been completed. It may also include stringent laws that help to prevent free roaming dogs, a typical problem associated with such developments, from harassing migrating deer.

Other areas of the Casa Diablo deer herd range are the subject of land use proposals which may impact deer habitat. A major geothermal power plant has been proposed near the Inyo Craters. One such plant exists and several others are proposed for the Casa Diablo Hot Springs area. In addition, there is a proposal for a major resort complex on Doe Ridge near the Mammoth-June Lake Airport. Several hydropower projects exist or are proposed on drainages between June Lake and Bridgeport, some in critical deer habitat. This study has revealed that deer from the Casa Diablo herd use these areas as migration and summer habitats. The effects of these or other projects will depend on the number developed, and where and how they are developed. Therefore, in order to insure the welfare of the Casa Diablo herd it is imperative to evaluate the effects of land use projects on an individual and a cumulative basis.

Since the Casa Diablo and Mono Lake herds essentially have overlapping summer ranges, it may be biologically and administratively sound to designate these herds as one, e.g., the Mono Lake herd. Future telemetry research of the Mono Lake herd will further clarify this issue.

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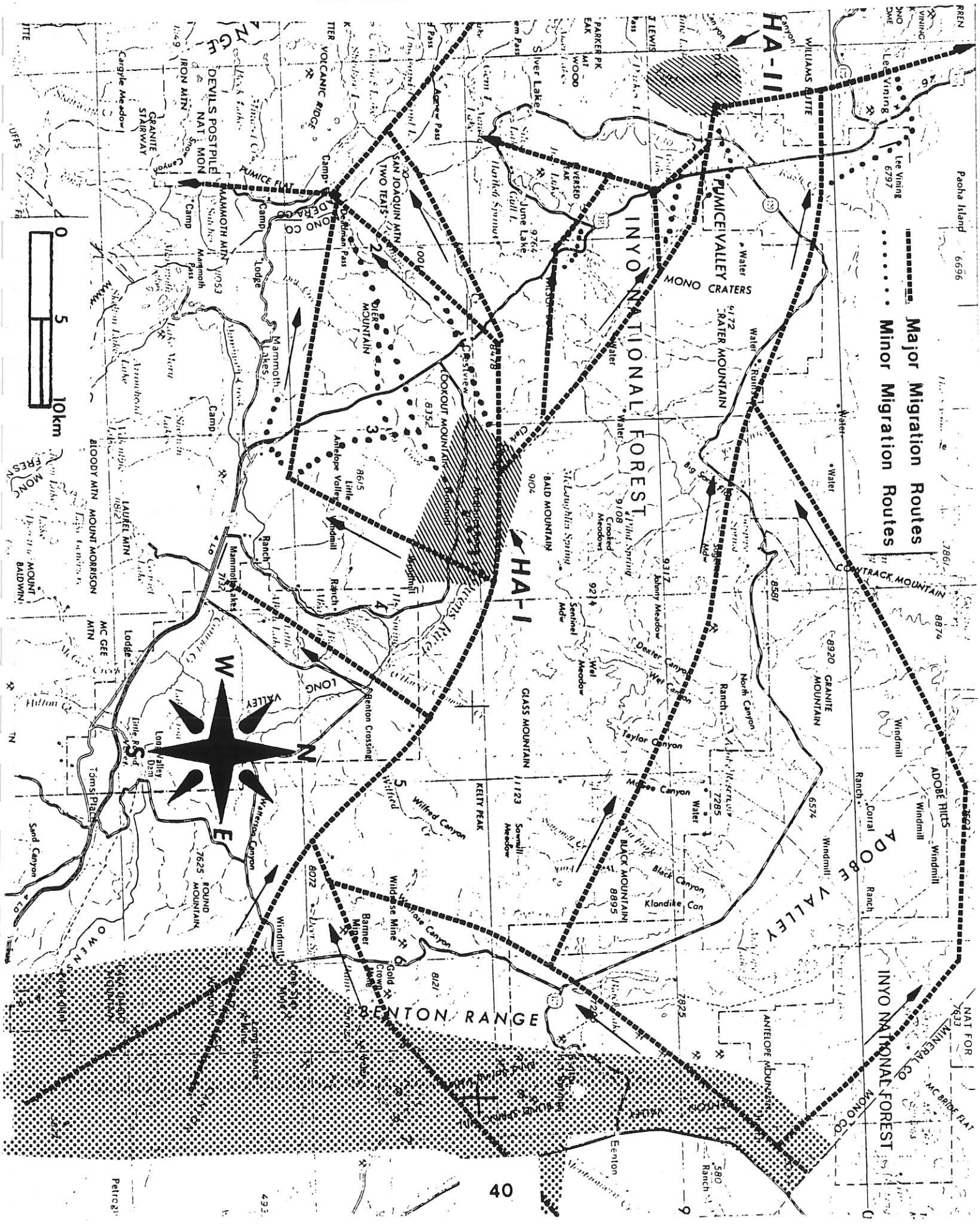
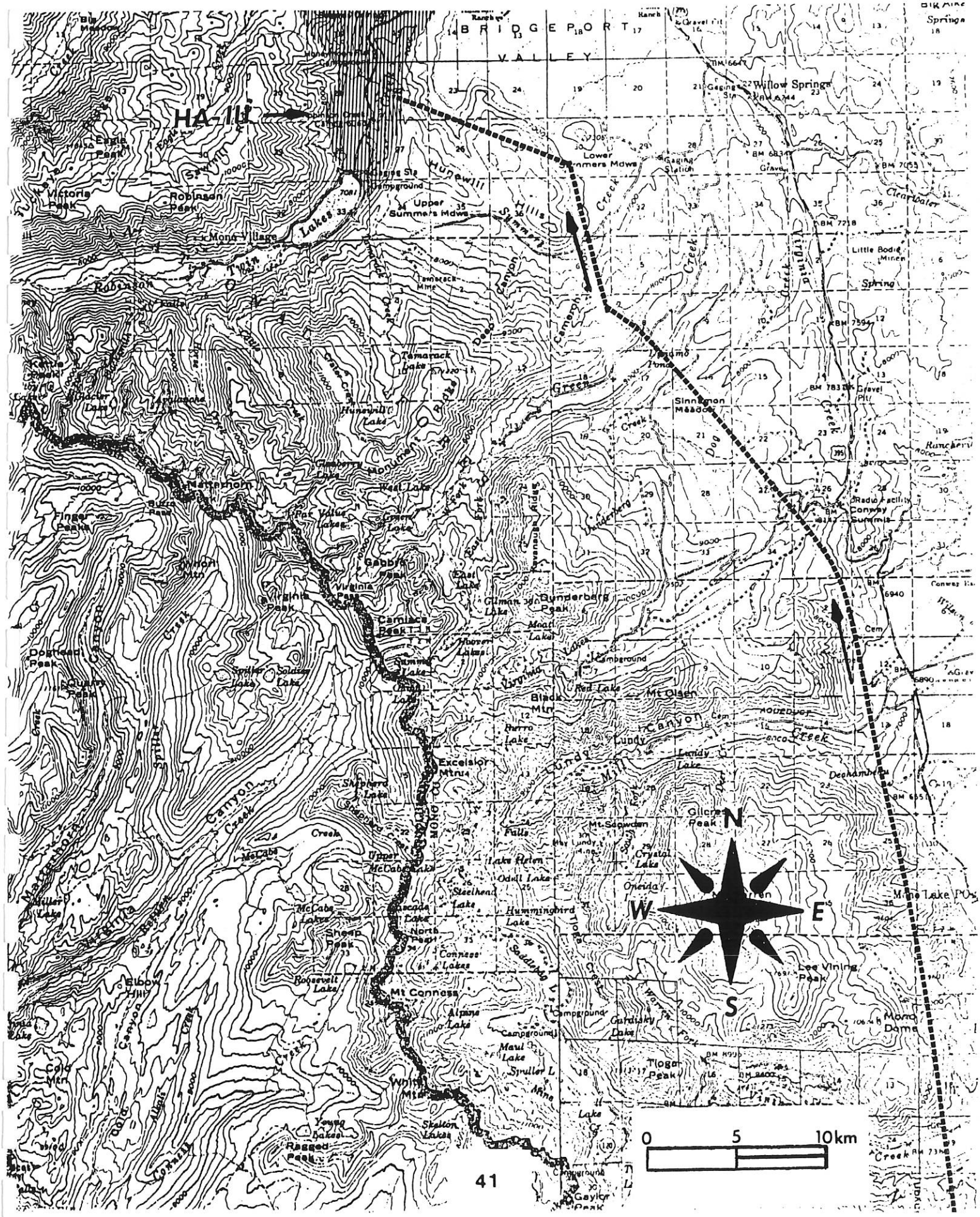
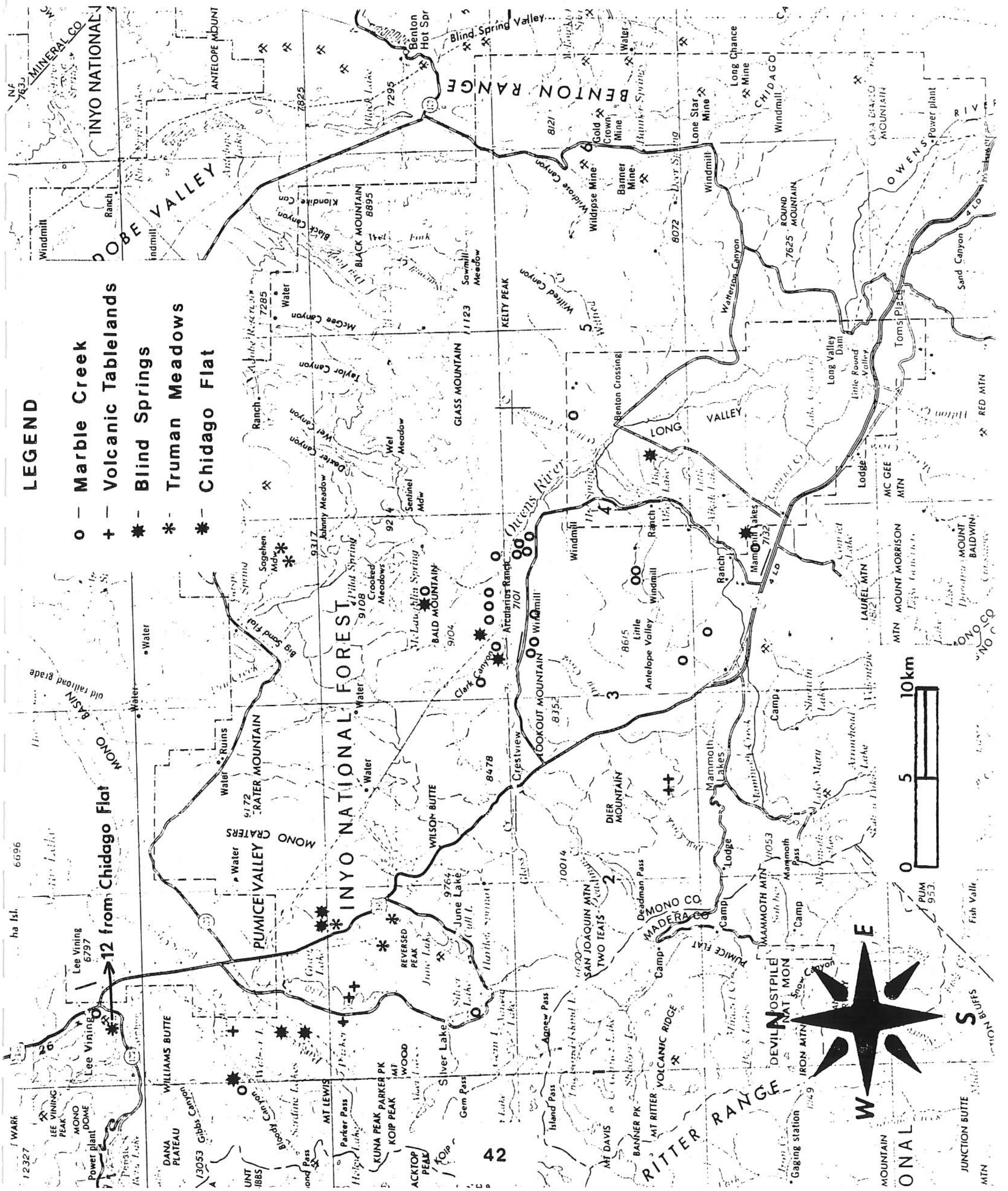
Appendix Figure 1a Locations of migration routes and holding areas of the Casa Diablo deer herd.



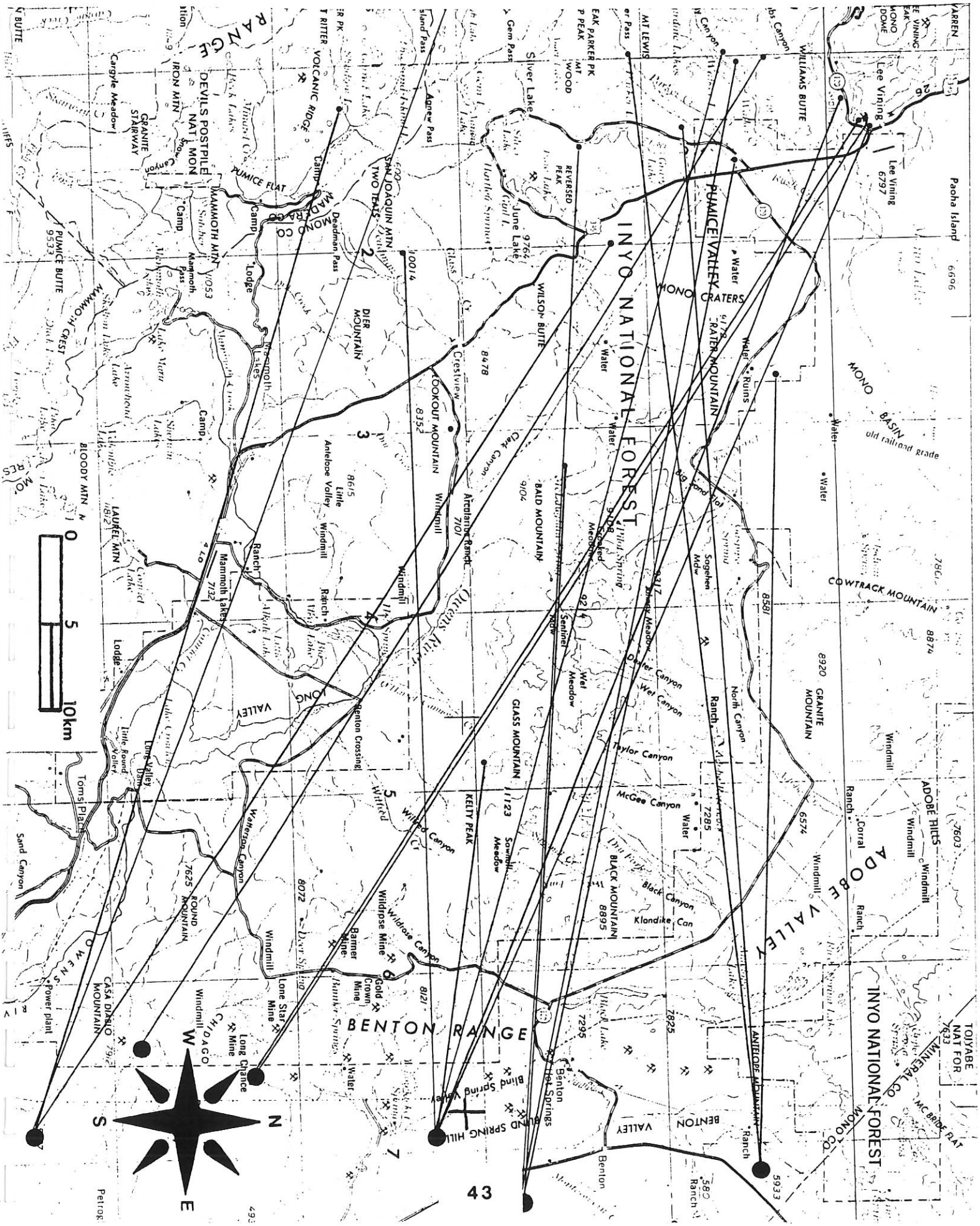
Appendix Figure 1b Locations of migration routes and holding areas of the Casa Diablo deer herd.

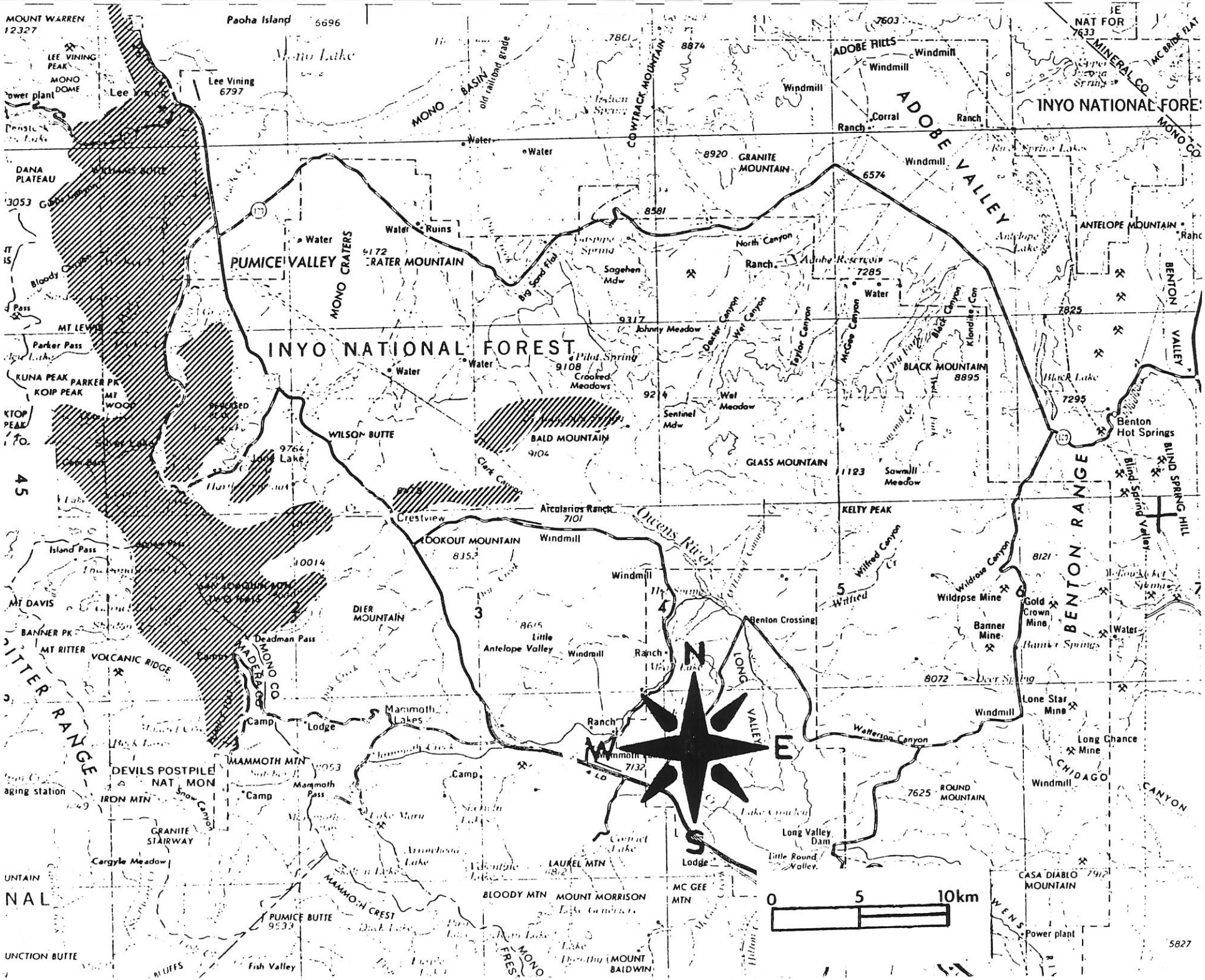


Appendix Figure 2   Locations of non-radioed, ear tagged deer observed west of the Casa Diablo winter range during the spring and fall migrations of 1986 and 1987, and the summers of 1986 and 1987



Appendix Figure 3 Movements of radio-collared deer marked on wintering areas (large circles) and subsequently located on the summer range (small circles).

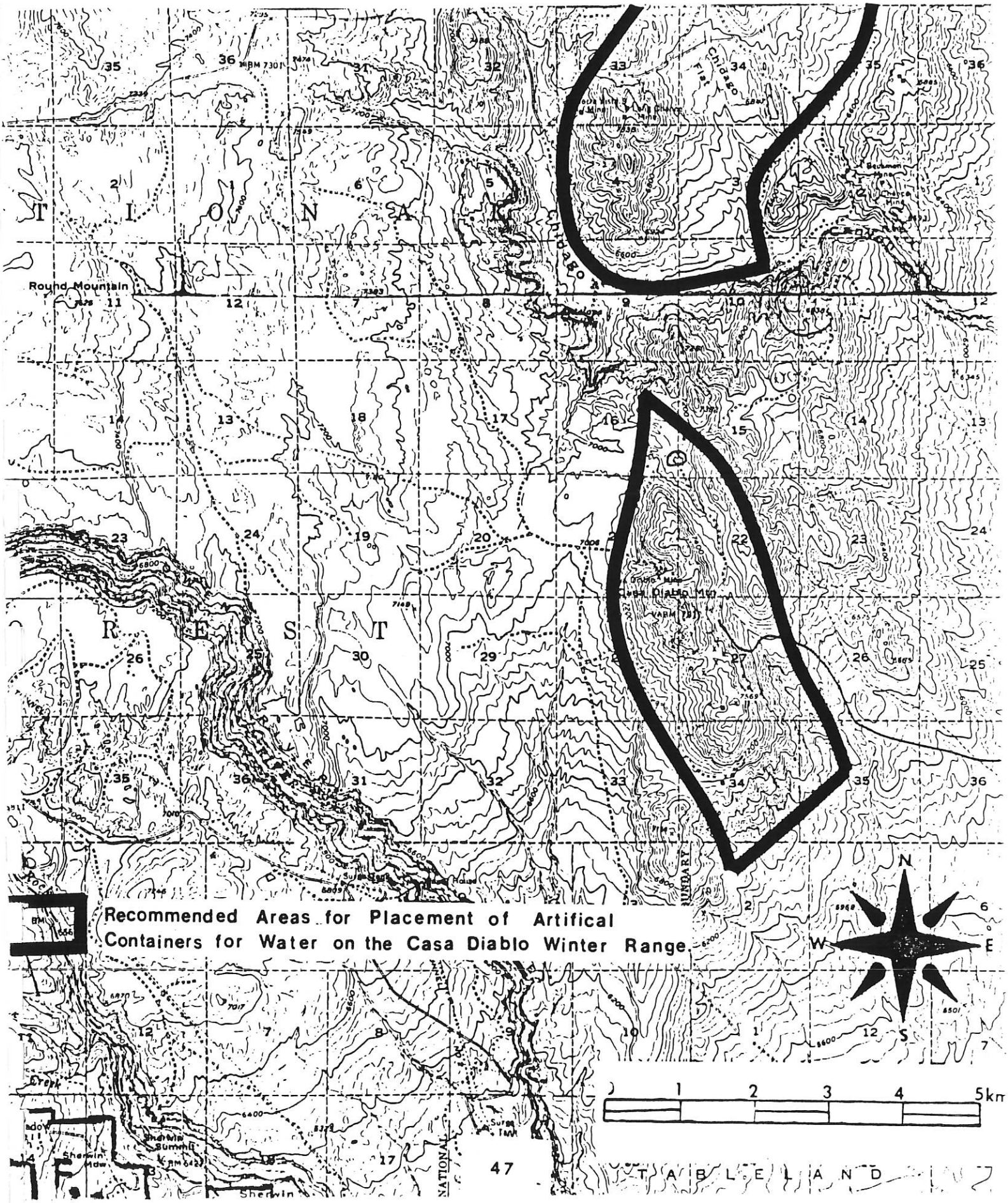




Appendix Figure 5 Locations of deer fawning areas, Casa Diablo deer herd.

Appendix Figure 6 Locations of 5 radio-collared deer killed by mountain lions, Casa Diablo deer herd.

Appendix Figure 7a Recommended areas on the Casa Diablo winter range for establishment of rainwater collectors and guzzlers necessary for providing permanent water.



Appendix Figure 8 Recommended areas on the Casa Diablo summer range for establishment of rainwater collectors and guzzlers necessary for providing permanent water.