SNOWCREEK SKI AREA DEER STUDY
1994 SPRING AND FALL MIGRATION STUDY

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Chapter 1. Introduction and Methods

INTRODUCTION

In June 1994, Dempsey Construction Corporation (DCC) of Mammoth Lakes, California, completed preparation of a Deer Herd Monitoring Plan (DHMP) (Raedeke Associates 1994) for the proposed Snowcreek Ski Area (SSA). The Final Environmental Impact Statement (FEIS) for the SSA specified that the DHMP be developed in order to assess the effectiveness of mitigation measures designed to minimize impacts of the SSA on migratory mule deer, and to determine the overall effect of the SSA development on the Round Valley deer herd, formerly known as the Sherwin Grade and Buttermilk deer herds.

The SSA is located immediately south of the Town of Mammoth Lakes (TML) on approximately 3,100 acres of public land managed by the U.S. Forest Service (USFS). The proposed ski area and surrounding vicinity is regarded as important transition range for mule deer (*Odocoileus hemionus hemionus*) from the Round Valley herd, which migrate through the area during annual spring and fall migrations.

Throughout the past decade, the California Department of Fish and Game (CDFG) has been collecting data on the Round Valley deer population with emphasis on factors affecting population size and trend and habitat use relationships. During the same period, DCC has collected site-specific data on the timing and locations of deer use patterns in the proposed SSA permit area and surrounding vicinity. The DHMP was designed to expand on this existing information and to furnish data required by the SSA-FEIS for the analysis of potential impacts to migratory mule deer (Raedeke Associates 1994).

This report summarizes field studies completed by DCC during the 1994 spring and fall migrations. Specific objectives of the spring work were to: 1) determine, through the use of radio telemetry and infrared sensor equipment, the amount, timing, and specific locations of migratory deer use in the SSA and surrounding lands during the 1994 spring and fall migrations; 2) census the Sherwin Holding Area (SHA) using deer population estimates based on mark-recapture techniques using radio-collared deer; 3) develop a "sightablity index" to estimate the number of deer in the holding area based on the number of deer observed during a given census; and 4) determine habitat use patterns by radio-collared deer that use the Snowcreek Ski Area and surrounding lands. Objectives of the fall work were to determine the amount and timing of fall migratory deer use and the specific locations of deer migration routes.

The information presented in this report can be used to augment existing preconstruction data and to further expand the volume of scientific information that currently exists for the Round Valley herd. Moreover, this information can be used to develop and refine the data sampling techniques outlined in the DHMP that will be used to evaluate the effectiveness of project mitigation measures on the Round Valley deer herd.

PERMIT AREA

The proposed Snowcreek Ski Area, hereafter designated the permit area, is situated within the TML in Sections 2, 3, 9-15, 23, and 24 of T. 4 S., R. 27 E., in the Mammoth Ranger District, Inyo National Forest, California (Figure 1-1). It comprises approximately 3,100 acres of steep, generally north-facing, mountainous terrain at elevations ranging from 7,960 to 11,730 feet. The site is bordered on the southwest by the Sherwin crest, which includes Pyramid Peak, Red Peak, and Fingers Peak; on the east by the Sherwin Creek drainage; and on the north by the U.S. Forest Service Mammoth meadows and the Dempsey Construction Corporation's Snowcreek development (SSA-Master Development Plan (SSA-MDP, pages 2-1 to 2-4).

Vegetation within the proposed permit area is comprised of eight major plant communities including: barren or fellfield, whitebark pine, mixed conifer, mixed brush, quaking aspen, riparian, wetland, possible wetland, and late-seral mixed conifer (old growth). A complete description of these plant communities and their locations within the project area was provided in the FEIS (page III 17-20) and the SSA-MDP (Page 2-15).

METHODS

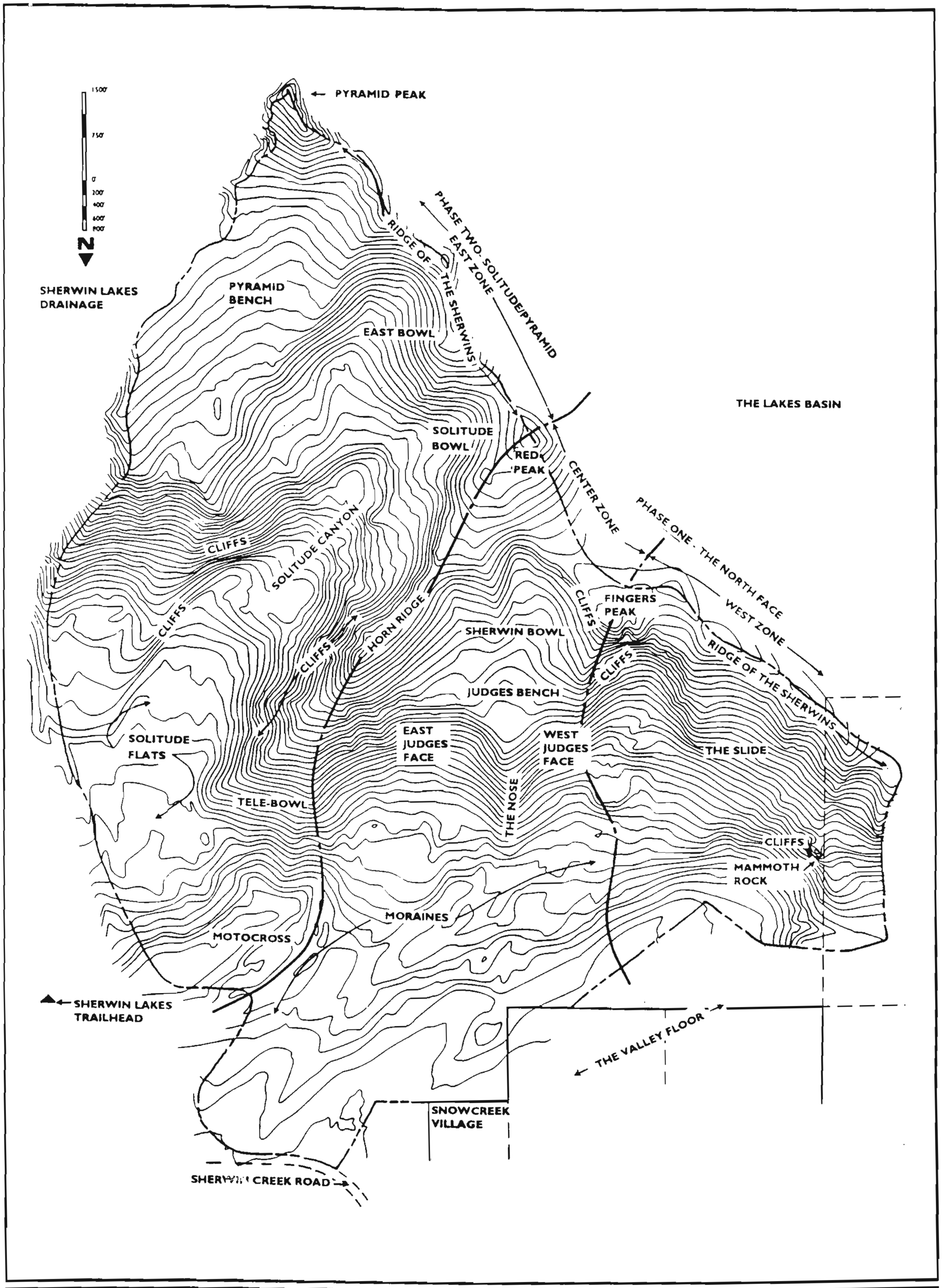
Section 2.0 of the Draft Deer Herd Monitoring Plan (Raedeke Associates 1994) described specific tasks that would be used to achieve the objectives outlined above. These tasks are to be conducted in different stages, related to development of the SSA. The following sections describe the methodologies used to complete specific tasks performed during 1994 spring and fall preconstruction surveys.

Radio-telemetry Studies

Radio-tracking of Deer

Ground based radio-tracking of radio-collared deer was accomplished by a non-triangulation method or "homing-in" on the animal (Raedeke Associates 1994). Initial relocations were made from a vehicle equipped with a Telonics® TR-2 receiver and an attached program/scanner (TS-1) and a truck-mounted, omni-directional antenna. A hand-held directional antenna was then used to determine the general direction of the collared deer. The precise location of the deer was determined by using a spotting scope from a vehicle or moving toward the signal until the deer was visually located.

Deer were located two-three times/week during daylight hours. Activity, cover type, aspect, elevation, and association with other animals was recorded for each radio-location. All deer relocations were plotted in the field on U.S. Geological Survey 7.5 minute topographic maps and the Universal Transverse Mecator (UTM) coordinates for the positions were recorded to the nearest 100 meters.



SNOWCREEK SKI AREA
SNOWCREEK RESORT
at Mammoth Lakes, California

MASTER DEVELOPMENT PLAN

PERMIT BOUNDARY AND TOPOGRAPHY

Land Plan Services

FIGURE: 1-1

If a deer's location could not be verified visually with a reasonable amount of effort and without potential for disturbance of the deer, its location was determined by triangulation using a hand-held 2-element antenna and a compass. To reduce the size of the error polygon, triangulation was accomplished by 2 observers obtaining simultaneous bearings or 1 observer obtaining ≥ 3 bearings from as close to the animal as practical. We assessed telemetry accuracy by comparing known transmitter locations (transmitters placed by another observer) with those determined by triangulation.

We used the program CALHOME (Kie et al. 1994) to estimate home-range sizes of radio-collared deer. Program CALHOME performs utilization, distribution, or home-range estimates based on data sets consisting of X and Y coordinates for successive locations of a single animal. CALHOME provides home range estimates using several different methods. For comparative purpose, we selected the minimum convex polygon (MCP) (Mohr 1947) and the adaptive kernel (ADK) (Worton 1989) methods. Because of small sample sizes we pooled data for all individuals to reduce the sample size bias associated with these methods and to delineate a composite home range (Andelt and Andelt 1981, Jenkins and Starkey 1984). Areas of concentrated deer use within composite home ranges were defined as core areas (Samuel et al. 1985). Core areas were identified as the largest areas within the composite home range where observed use (based on ADK values) exceeded a uniform distribution (Samuel and Green 1988).

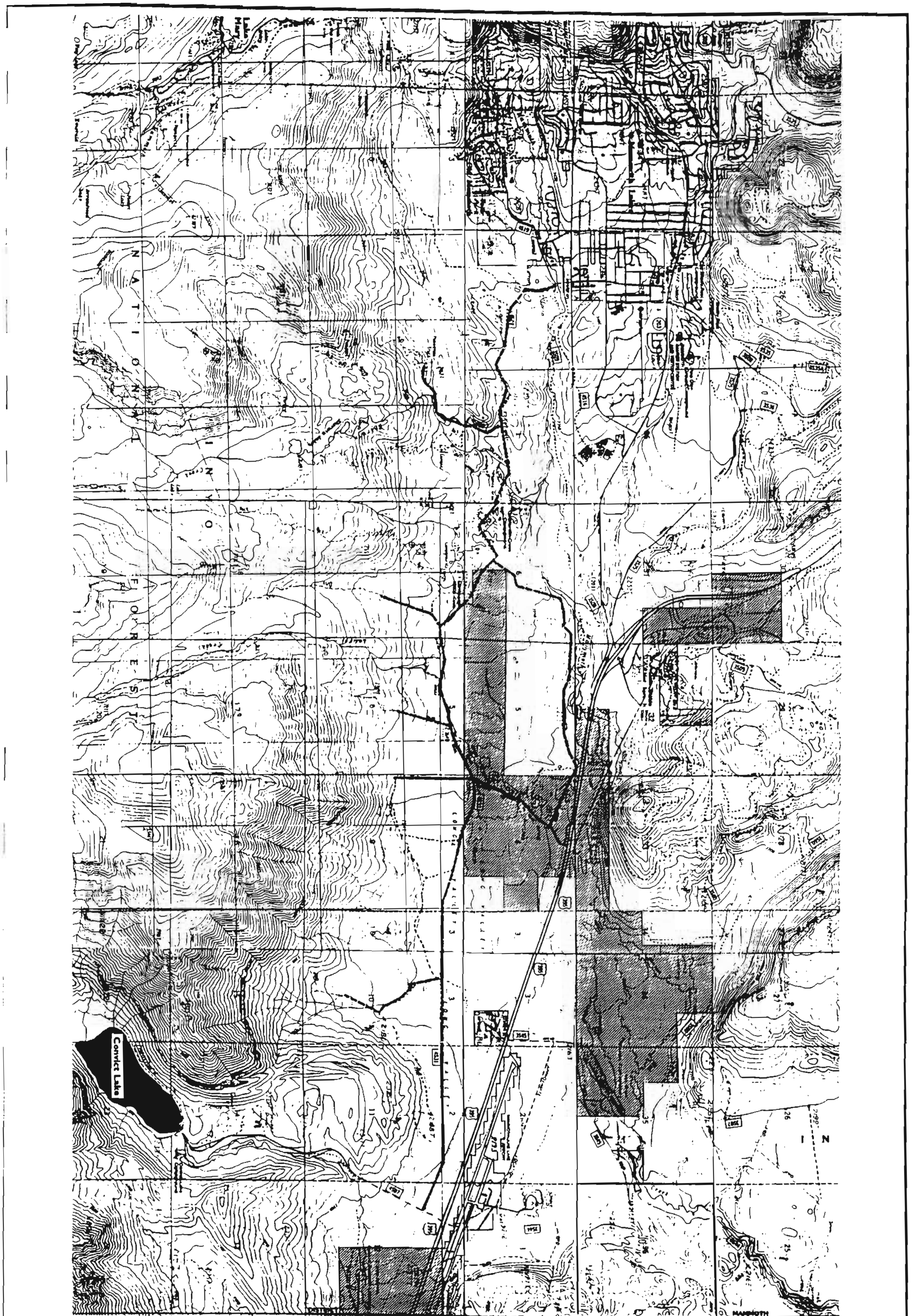
Major migration routes between winter and summer ranges were ascertained by tracking radioed deer closely once they departed the winter range. The locations of these routes were mapped on U.S. Geological Survey 7.5 minute maps and the proportions of radio-collared deer using each route was recorded. If a deer's migration route could not be ascertained from radio-telemetry, then the summer range location of the animal and data from Kucera (1988) was used to determine its migration route.

The summer range locations of radio-collared deer were determined by CDFG from a fixed-wing aircraft during monthly flights conducted from June-September. The locations of summer deer use in the project area was determined during field work conducted from June 15 to June 30.

Holding Area Studies

Deer Count Surveys

Deer were counted once weekly from a slow moving vehicle along a fixed route located on dirt roads within the SHA (Figure 1-2). Observations were made from both sides of the vehicle, usually by 2 observers using 10 x 50 binoculars. All counts began as soon as light was sufficient to discern deer; this ranged from 0530 in April to 0510 in June. Distance to observed groups of deer ranged from approximately 25 to 2,000 m. Data recorded included group size, group composition, number of marked deer, vegetation type, slope, aspect, activity, and time. In addition, the location of each group



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SNOWCREEK RESORT
at Mammoth Lakes, California

DEER COUNT SURVEY ROUTE

FIGURE: I-2

was plotted on a 7.5 minute topographic map of the area. The presence of man-made physical features (e.g., roads, fencelines, borrow pits) and natural landscape markers (e.g., rock piles, tree stands, abrupt changes in topography) were used as reference points when plotting deer locations.

We estimated population size (N) for each deer count survey using Chapman's (1951) estimator, where radio-collared deer were used as the sample of marked deer. Critical assumptions of this mark-resighting method were: 1) marked animals were randomly distributed throughout the population; 2) the probability of sighting marked and unmarked animals was the same; 3) catchability was the same in marked and unmarked animals; 4) each animal had an identical, but independent probability of being resighted; 5) the number of marked animals in the population was known and therefore, all markers that were lost were accounted; and 6) there was no immigration, emigration, recruitment or mortality (Davis and Winstead 1980).

Raedeke Associates (1994) suggested that mark-resighting could potentially be a reliable method of estimating deer population size on the SHA. Therefore, radio-collared deer from this and future studies observed during weekly dawn deer counts will be used to develop a "sightability index" during Phases I and II of the DHMP. The "sightability index" will be used in Phase III of the DHMP to estimate the number of deer actually on the holding area based on the number of deer observed during a given census.

Habitat Use Studies

We analyzed habitat use in relation to its availability using simultaneous interval estimates (Neu et al. 1974). Chi-square tests of independence were used to test hypotheses that habitats used by deer clusters observed during weekly counts were similar among years. Chi-square goodness-of-fit tests were used to test hypotheses that habitat use in the holding area was proportional to availability of the habitat classes. If the null hypothesis was rejected ($P < 0.05$), we calculated confidence intervals using the Bonferroni Z-statistic (Neu et al. 1974, Marcum and Loftsgaarden 1980, Byers et al. 1984) to test which habitat classes were used more or less than expected.

Chi-square Goodness-of-fit tests were used to test hypotheses that habitat use by radio-collared deer in the SHA was similar to expected use. Boniferroni confidence intervals were used to determine which habitats in the SHA deviated from expected use. We set the level of statistical significance at $\alpha = 0.05$.

Migration Corridor Counts

Infrared Sensor Equipment

Trailmaster 1500 units (Goodson and Assoc., Lenexa, KS) were used to determine the amount, timing and specific locations of deer migration through Solitude Canyon. The Trailmaster 1500 operates with an invisible infrared light beam that automatically records an event each time the infrared beam is broken. Each event is stored by date and by time (to-the-minute) and can be instantly recalled. By positioning the beam at a certain height and setting the length of time that the beam of light is broken, the Trailmaster can be used to monitor the activities of deer, as opposed to other wildlife species.

Ten Trailmaster counting stations were established at Solitude Pass during the spring 1994 surveys. Each station consisted of two units, a transmitter and a receiver, both of which were fastened to 2 x 4 inch posts. The units were spaced approximately 60 feet apart, with the infrared beam aligned at 24 inches above ground. The 10 stations were oriented back-to-back in a continuous straight line that spanned the entire width of Solitude Pass.

The Trailmaster units at each station were calibrated from direct observations of deer crossing through the infrared beam and by a comparison of event data with radio-telemetry data. These two techniques can be used to determine a correction factor for each station, to account for individual deer that are not counted as some deer pass the counting stations in groups, or for deer that go around the counting stations.

Habitat Mapping

Habitats occurring within the SHA were classified according to the Wildlife Habitat Relationships (WHR) System (Mayer and Laudenslayer 1988). Color aerial photographs (1:24,000 scale) provided by the U.S. Forest Service, Mammoth Ranger District, were used to make determinations on appropriate habitat classification. Habitats were then delineated on a 7.5 minute series topographic map and their boundaries verified in the field.

Weather Data

Daily weather data (maximum and minimum temperatures and precipitation) was provided by the U.S. Forest Service, Mammoth Ranger District.

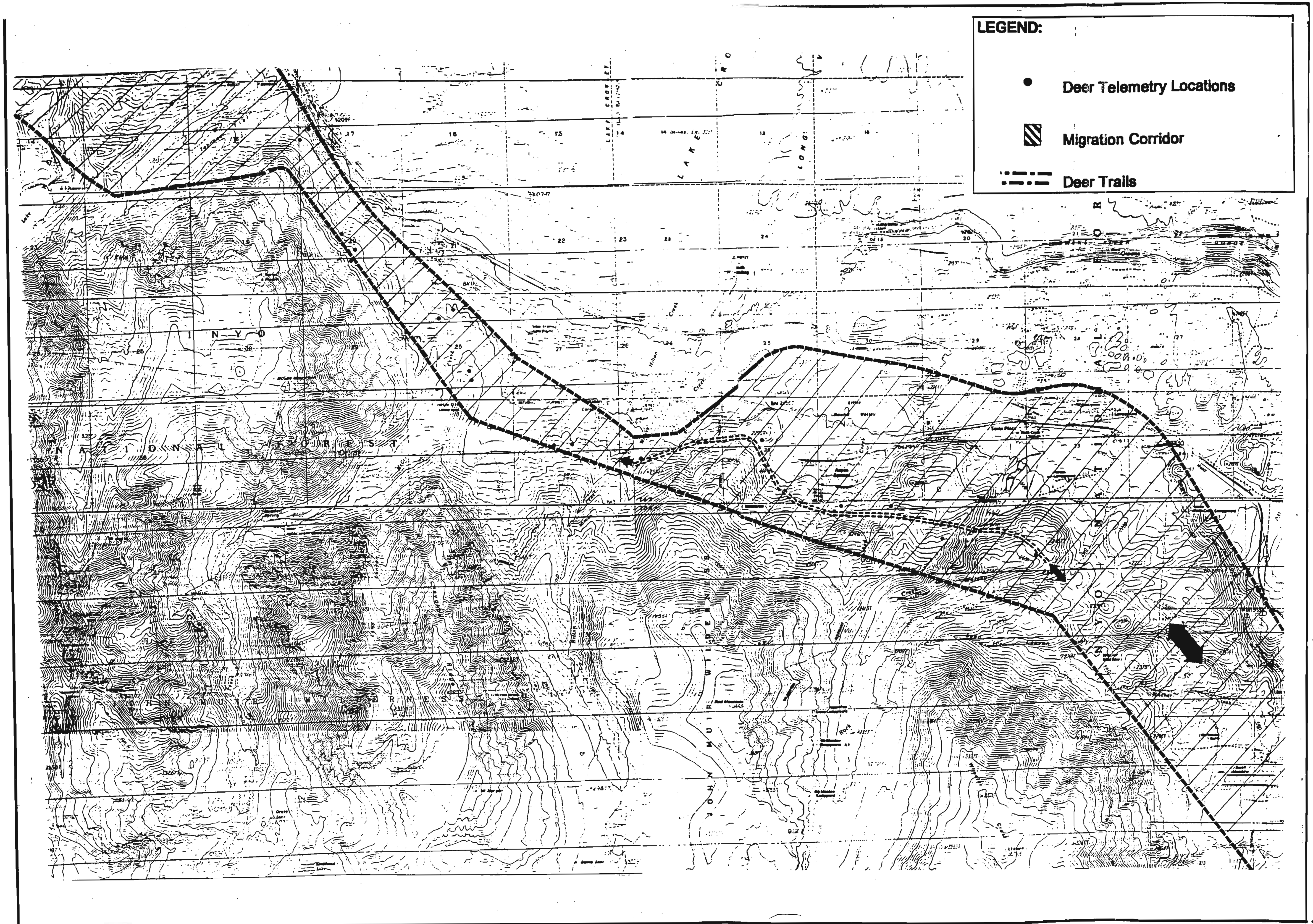

FIGURE: 2-1

LOCATIONS OF DEER MIGRATION ROUTES BETWEEN THE ROUND VALLEY WINTER RANGE AND THE SHERWIN HOLDING AREA DURING SPRING 1994

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SNOWCREEK RESORT
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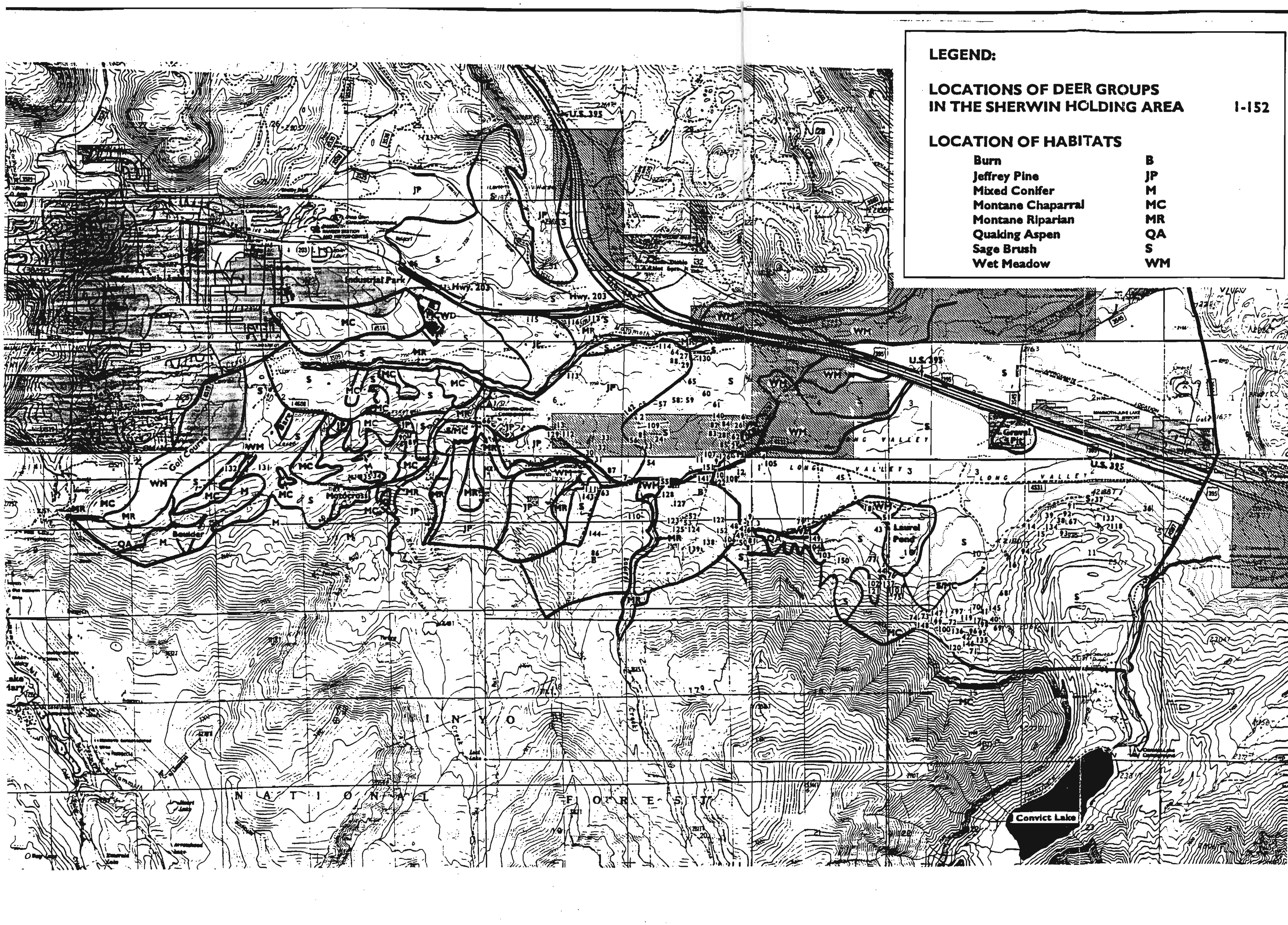
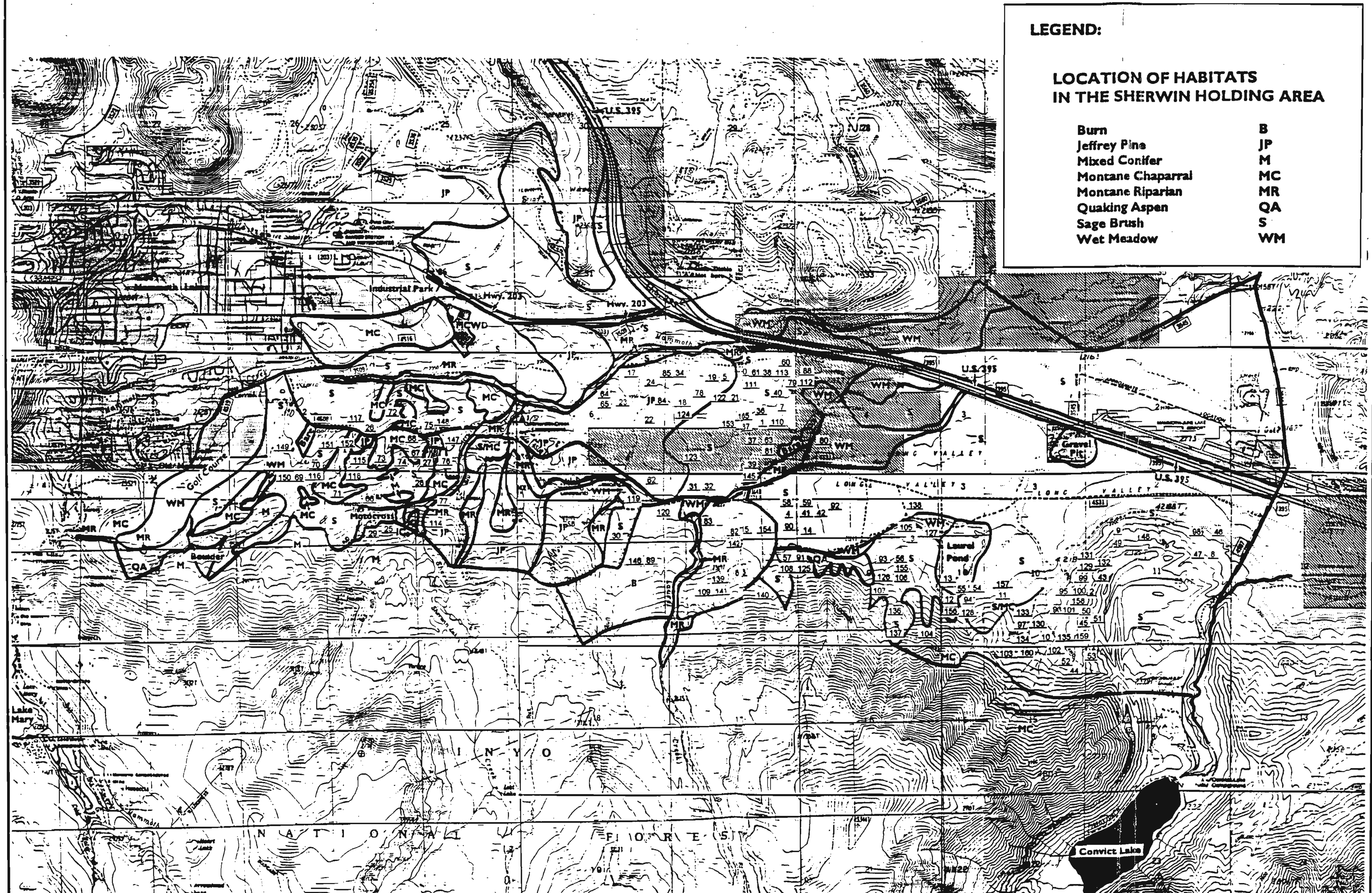
FIGURE: 2-8

LOCATIONS OF DEER GROUPS OBSERVED IN THE SHERWIN HOLDING AREA DURING SPRING MIGRATION 1993



SNOWCREEK SKI AREA

SNOWCREEK RESORT
at Mammoth Lakes, California



LOCATIONS OF DEER GROUPS OBSERVED IN THE SHERWIN HOLDING AREA DURING SPRING MIGRATION 1994

snowcreek SKI AREA
SNOWCREEK RESORT
at Mammoth Lakes, California

FIGURE: 2-9

LEGEND:

LOCATION OF HABITATS IN THE SHERWIN HOLDING AREA

Burn	B
Jeffrey Pine	JP
Mixed Conifer	M
Montane Chaparral	MC
Montane Riparian	MR
Quaking Aspen	QA
Sage Brush	S
Wet Meadow	WM

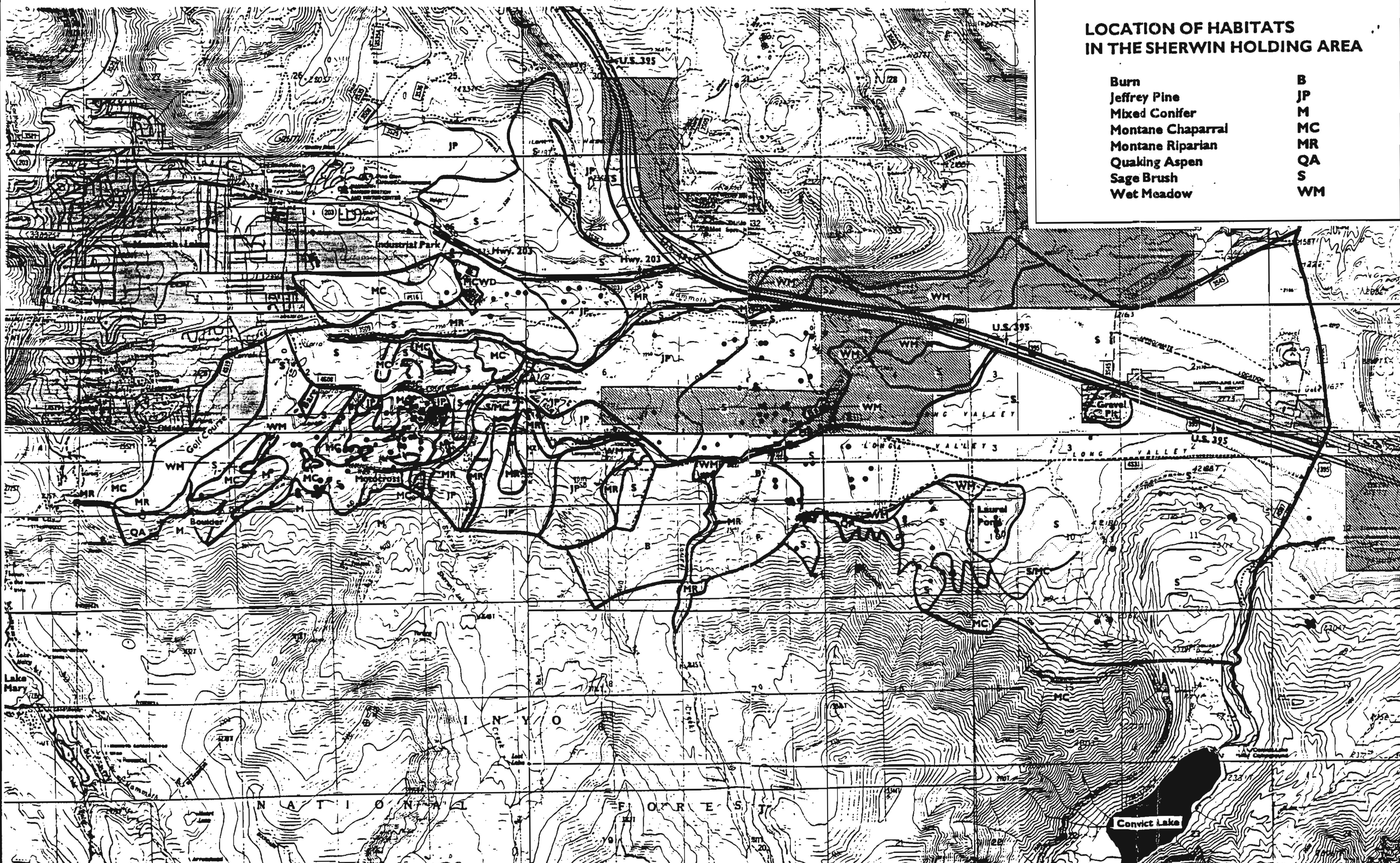


FIGURE: 2-11

LOCATIONS OF 237 OBSERVATIONS OF 27 RADIO-COLLARED DEER IN THE SHERWIN HOLDING AREA DURING THE 1994 SPRING MIGRATION

SNOWCREEK SKI AREA
SNOWCREEK RESORT
at Mammoth Lakes, California

ORGANIZATION OF THIS REPORT

This report contains the following chapters:

- Chapter 1, "Introduction and Methods"
- Chapter 2, "Spring Migration," describes the results of spring 1994 deer migration surveys.
- Chapter 3, "Fall Migration," describes the results of fall 1994 deer migration surveys.
- Chapter 4, "Conclusions and Recommendations," provides conclusions to results, identifies problems and concerns, and lists a number of recommendations necessary to improve specific tasks identified in the Deer Herd Monitoring Plan.
- Chapter 5, "Acknowledgments," identifies people who contributed to the report.
- Chapter 6. "Citations".

Chapter 2. Spring Migration

Studies to determine the temporal pattern of spring migration, patterns of deer distribution and habitat use on the Sherwin holding area and on the proposed Snowcreek Ski Area, and the locations of migration routes used by radio-collared deer were conducted between April 1 and June 30, 1994.

The temporal pattern of the 1994 spring migration consisted of three distinct stages:

1. Stage I was the northward movement of deer between the winter range in Round Valley and the SHA.

2. Stage II was the holding or delay period of spring migration. This period of migration comprised approximately 10 weeks when deer from the Round Valley herd delayed migration on the SHA.

3. Stage III was the movement of deer between the SHA and summer ranges located on the east and west slopes of the Sierra Nevada.

Stage I: Migration Between the Winter Range in Round Valley and the Sherwin Holding Area

During spring 1994, the migration routes used by 66 of 77 radio-collared deer were determined. Of these 66 deer, 63 migrated north from the Round Valley winter range, 2 migrated south, and 1 remained in Round Valley (CDFD, Unpubl. data). The migrations routes used by the remaining 11 deer were undetermined.

Locations of Deer Movements

Migration from the RVWR began in early April; the first radio-collared deer was detected moving north of Round Valley on April 1. The migration route used by deer migrating north from Round Valley followed the base of the eastern escarpment of the Sierra Nevada at elevations ranging from approximately 2,300 to 2,500 m (Figure 2-1). Upon leaving the winter range, deer first passed through the vicinity of Swall Meadows, a community comprised of a number of rural subdivisions situated directly above the winter range near the base of the Sierra escarpment (Figure 2-1). Taylor (1993a) reported that the majority of deer migrated along a rather circuitous route that passed to the west of the Pinyon Ranch and the Hilltop Estates subdivisions.

After migrating past the Swall Meadows area, deer continued northwest through Whitcher Meadow and Sand Canyon, and then crossed Whiskey Canyon (Figure 2-1).

Once past Whiskey Canyon, deer continued west, crossed the mouth of Rock Creek Canyon, and then passed directly above the communities of Aspen Springs and Crowley Lake. Field reconnaissance surveys revealed the presence of numerous well-established deer trails located within approximately 200 meters (m) south of these two subdivisions (Figure 2-1).

After moving past the community of Crowley Lake, radio-collared deer delayed migration for 1-2 days on a series of lateral moraines located adjacent to Hilton and McGee Creeks (Figure 2-1). These moraines were dominated by big sagebrush scrub vegetation and provided deer with snow free southerly aspects where they had access to succulent spring forage.

The migration route used by deer north of McGee Creek contoured the base of McGee Mountain at elevations ranging from 2,200-2,400 m, and then crossed through the Tobacco Flat area. North of Tobacco Flat, deer crossed the Convict Creek drainage between Convict Lake and Highway 395, and then entered into the Convict Knolls.

Stage II: The Sherwin Holding Area

Convict Creek has traditionally been recognized as the eastern boundary of the SHA (Kucera 1985, USFS 1991, DCC 1993). However, radio-telemetry data from spring and fall 1994 determined that deer delayed migration on the lateral moraines located between Convict Creek and Tobacco Flat. Additionally, deer delayed migration north of Highway 395 in the vicinity of the Mammoth-June Lakes Airport. Based on this knowledge, deer migrating south of Highway 395 were considered to have arrived on the SHA once they crossed Tobacco Flat (Figure 2-1). Deer migrating north of Highway 395 were considered to have arrived on the holding area once they entered the vicinity of Doe Ridge and the Mammoth-June Lakes Airport.

Timing and Intensity of Deer Use on the Sherwin Holding Area

The temporal pattern of deer migration on the SHA during the 1994 spring migration was determined from ground based radio-tracking of telemetered deer and deer count surveys conducted in the SHA.

Radio-collared deer. Of the 63 radio-collared deer that migrated north from the Round Valley winter range during the 1994 spring migration, 51 delayed migration on the SHA; 3 delayed on the Casa Diablo deer herd holding area, located some 9 airline km north of the project area near the headwaters of the Owens River; 6 delayed migration in the vicinity of McGee Mountain, located approximately 3 km south of the Convict Lake Road; and 3 deer delayed migration in the vicinity of Crowley Lake.

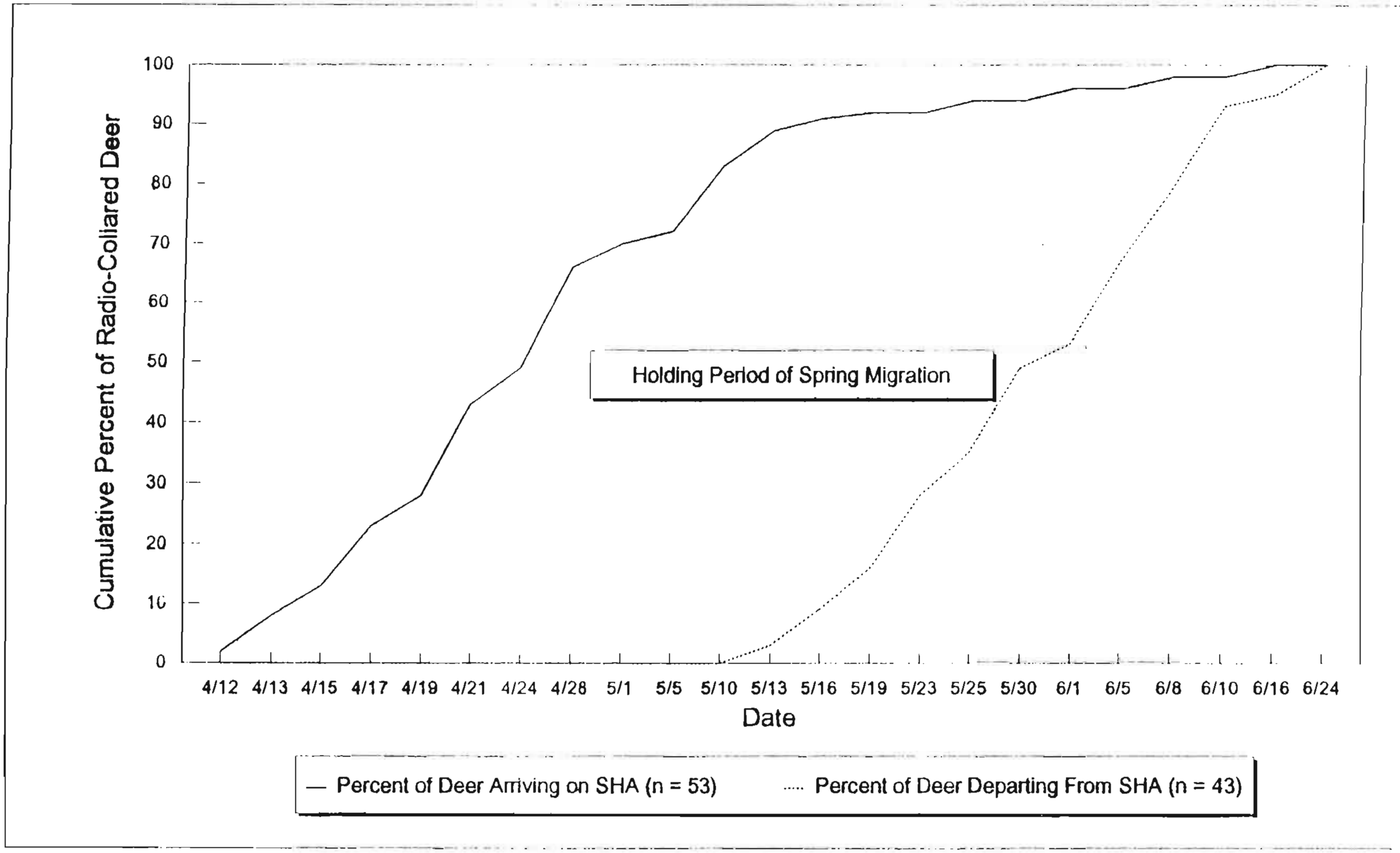


Figure 2-2. Cumulative Percent of Holdover Radio-Collared Deer Arriving on and Departing from the Sherwin Holding Area during the 1994 Spring Migration.

Deer delayed migration on the SSA for a period of approximately 10 weeks, from April 13- June 21. Of the 51 deer that delayed migration on the SSA, approximately 25% were on the holding area on April 17, and nearly 50% on April 24. By May 1, approximately 75% of deer had arrived on the SHA; the last deer arrived on June 12 (Figure 2-2).

Peak numbers of radio-collared deer were observed on the SHA during the second and third weeks of May, then decreased during late May through mid-June as deer migrated to the summer range (Figure 2-2). Approximately 25% of radio-collared deer left the SHA between May 19 and 26, 14% between May 27 and June 4, and 13% between June 5 and June 9. Deer delayed migration on the SHA for an average of 31 days (range = 3-60 days) (Figure 2-3).

Of the 51 radio-collared deer detected on the SHA during spring migration, a total of 25 (49%) are known to have delayed migration within the boundaries of the proposed SSA perimit area. Of these 25 deer, approximately 20% had arrived in the permit area by April 21 and 50% by May 5 (Figure 2-4). By May 23, approximately 85% of radioed deer had arrived in the permit area; the last deer arrived on June 12.

Peak numbers of radio-collared deer were located in the permit area during mid-May. Approximately 25% of deer departed from the SSA permit area between 12 and 24 May, 50% between 24 and 26 May. By 2 June, 75% of radioed deer had migrated from the project area; the last deer migrated on 24 June. Deer delayed migration in the SSA permit area for an average of 18 days (range 2-45 days) (Figure 2-3).

Of the 63 radio-collared deer that migrated north from the Round Valley winter range, one died on the SHA during the spring holding period, and a second died shortly after it left the SHA (CDFG, Unpubl. data). A third radio-collared deer died on the Casa Diablo deer herd holding area (CDFG, Unpubl. data). Thus, to our knowledge only 3 of 63 deer that migrated north from the Round Valley winter range died during the 1994 spring migration period.

Deer Count Surveys. Deer count surveys provided a second index of the temporal pattern of spring migration on the SHA. A total of 10 deer count surveys were conducted in the SHA between April 7 and June 9, 1994. Deer count surveys indicate that deer began arriving on the holding area during the third week of April; 37 deer were counted near the base of Laurel Mountain during a survey on April 13 (Figure 2-5). A sharp increase in deer numbers on the holding area occurred during the fourth week of April, and peak deer numbers were counted on May 12 (Figure 2-5). After May 12, deer numbers on the holding area steadily declined as animals migrated to the summer range.

The temporal pattern of deer migration from the winter range and subsequent arrival on the holding area was approximately three weeks earlier than spring 1993 (Taylor

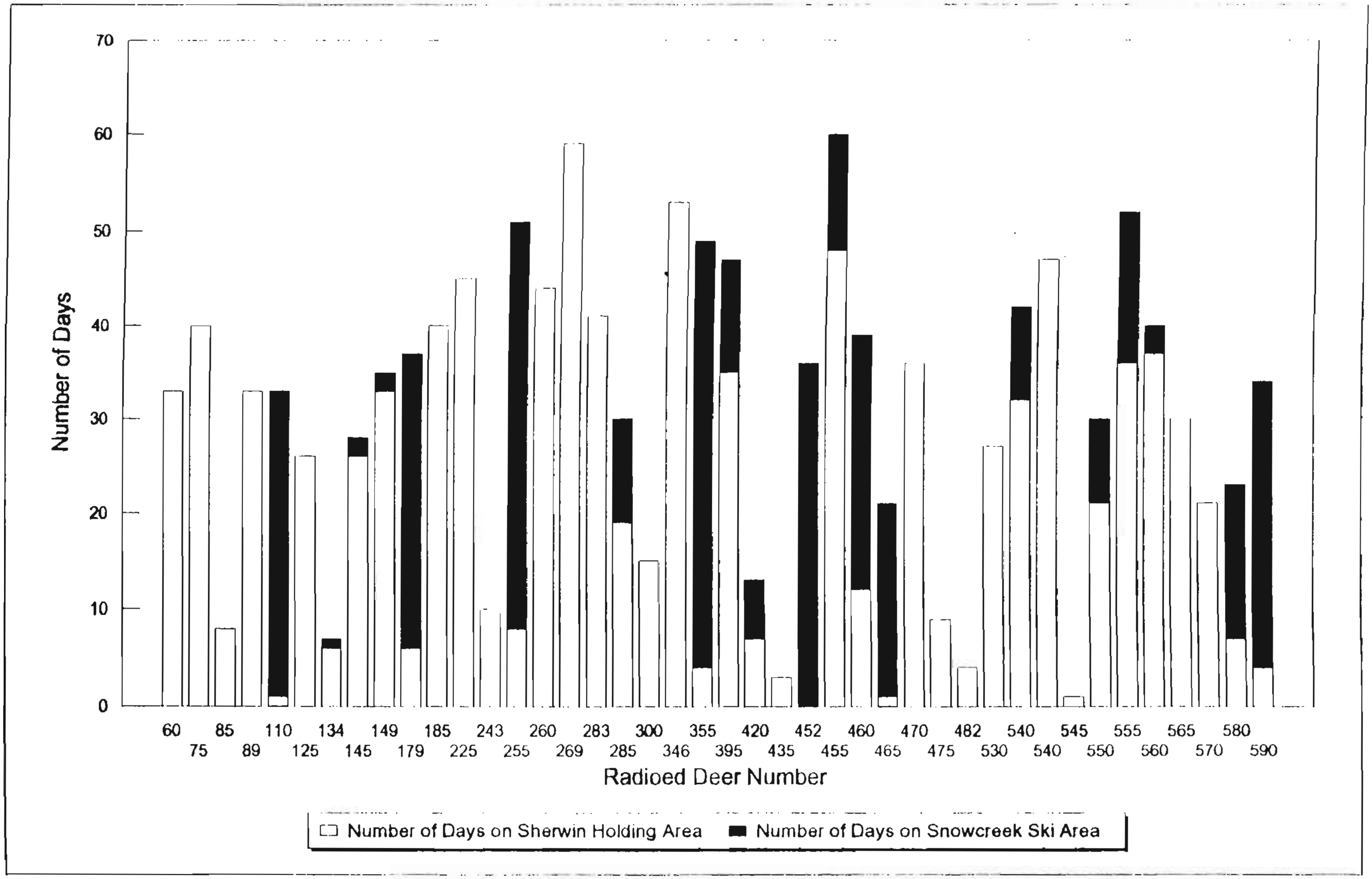


Figure 2-3. Period of Delay for Individual Radio-Collared Deer on the Sherwin Holding Area and the Snowcreek Ski Area during the 1994 Spring Migration.

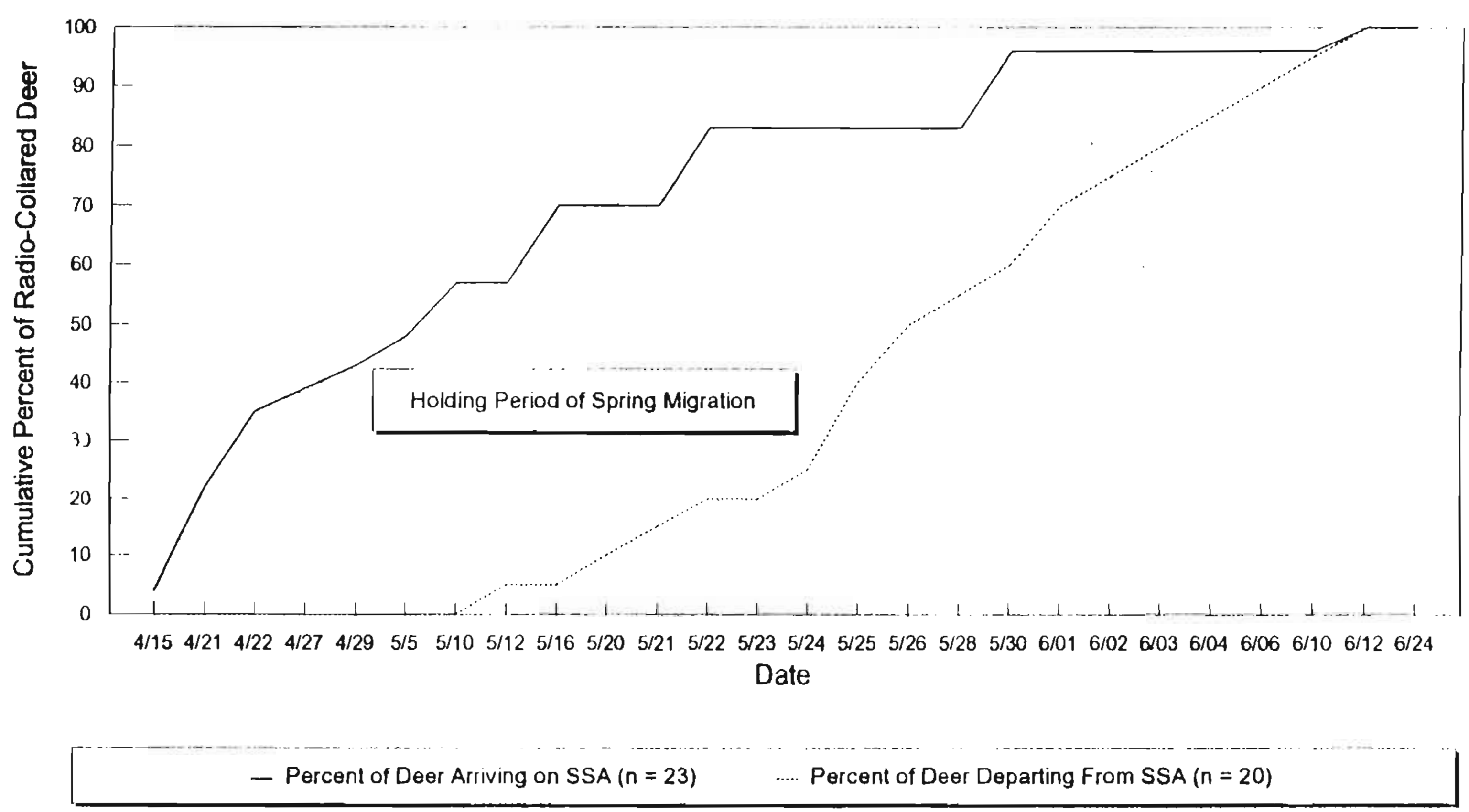


Figure 2-4. Cumulative Percent of Holdover Radio-Collared Deer Arriving on and Departing from the Snowcreek Ski Area during the 1994 Spring Migration.

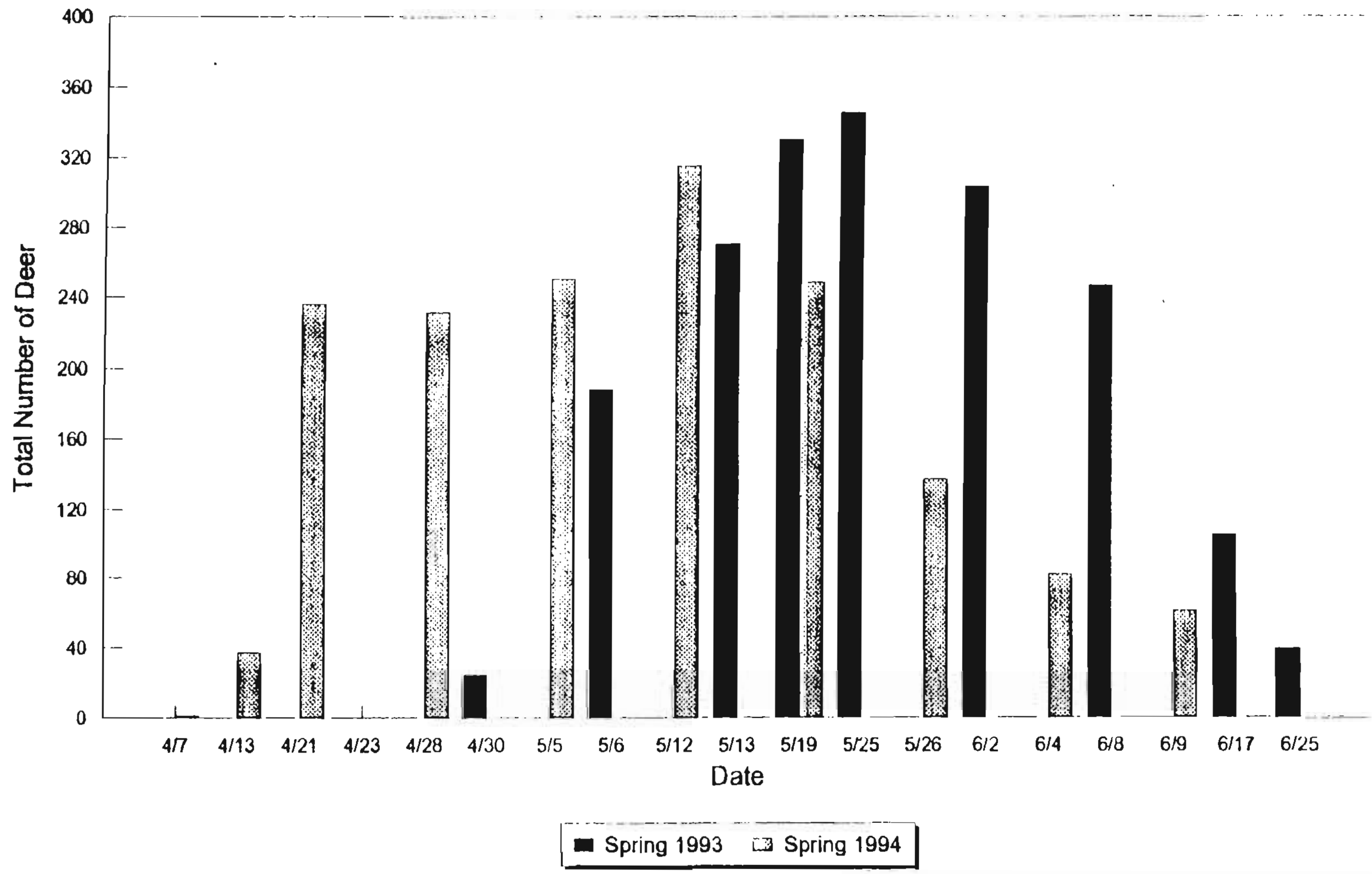


Figure 2-5. Total Number of Deer Counted per Day during Deer Count Surveys Conducted in the Sherwin Holding Area, Spring 1993 and 1994

1993) (Figure 2-5). In spring 1993, deer were first observed on the holding area on April 30 and peak numbers were counted on May 2 (Figure 2-5).

The variation between the 2 years in the temporal pattern of spring migration was related to winter severity and spring temperatures. The 1993 spring migration followed a severe winter, with total snowfall accumulations in Mammoth Lakes exceeding 120% of normal. This heavy snow pack persisted until late-April along migration routes and on the summer range because cool spring temperatures of 19° Fahrenheit (F) in March and 21° F in April prevented snow from melting rapidly. As a result, plant phenology at these higher elevations was delayed, forcing deer to remain on winter and spring ranges where herbaceous spring forage was readily available.

In comparison, the 1994 spring migration ensued an extremely mild winter, with total snowfall accumulations in the eastern Sierra averaging approximately 50% of normal. Consequently, snow melt and vegetation growth along migration routes and on the holding area occurred earlier, motivating deer to begin their migration from the winter range during the second week of April.

Several authors (Russel 1932, Leopold et al. 1951, Loft et al. 1989) have associated the timing of spring migration from the winter range with the receding snow pack and the availability of spring forage. Bertram and Remple (1977) found that deer from the North Kings herd migrated from the winter range approximately two weeks earlier following dry winters of normal to below normal precipitation. In Colorado, Garrott et al. (1987) reported that the timing of spring migration following a severe winter was approximately 1 month later than after winters that were relatively mild. These authors hypothesized that to initiate migration, which requires additional energy demands, deer must first reverse the negative energy balance experienced during the winter. Hence, after more severe winters, deer migration is delayed on lower elevation winter ranges to extend the intake of high quality forage and improve the deer's overall physiological condition. Garrott et al. (1987) also suggested that by delaying migration after a severe winter, deer can avoid the heavier snowpack at upper elevations, which would impede their movements and reduce forage availability at a time when energy demands of pregnant does are high because of the late stage of pregnancy. Energy reserves are depleted when deer are forced to traverse in snow (Wallmo and Gill 1971), and the energy output required by deer to feed in snow often exceeds that supplied by the food eaten (Kelsall 1969).

Kucera (1988) used deer count surveys in conjunction with radio-telemetry to determine the temporal pattern of deer migration from the Round Valley winter range. In this previous work, conducted from 1984-1987, deer left the winter range in early April and were present "in the hundreds" on the holding area by the time of the first deer count survey in mid-April. Maximum numbers of deer on the holding area were counted in late April and early May, with numbers declining to a minimum in mid-June, as deer migrated to the summer range. This pattern was consistent among years despite extremes in the severity of winter.

Kucera (1988) hypothesized that similarities among years in the temporal pattern of migration from the winter range may have been related to nutritional factors, assuming that forage on the winter range in early-April was of poor quality, or in lesser abundance than on the holding area. Deer may have also been attempting to seek thermal relief at upper elevations because maximum daytime temperatures in Bishop averaged about 72° in April and 80° in May.

Estimates of Deer Abundance on the Sherwin Holding Area

The probability of sighting a deer, as estimated by the probability of sighting a marked deer (Bear et al. 1989), averaged 50% during the last two weeks of April, 35% during the first two weeks of May, and 20% during the last week of May and the first two weeks of June (Table 2-1). This trend indicated a pattern of increasing visibility with increasing deer density and group size, and decreasing vegetative cover. A simple linear regression yielded a significant ($P = 0.064$) and positive correlation between sighting probability and numerical group size (Figure 2-6a). Sighting probability increased as group size increased. Sightiability was highest in late April when average group size was highest. Others, Cook and Martin (1974), Samuel and Pollack (1981), and Samuel et al. (1987), have demonstrated the importance of group size as a factor affecting sightability in ungulate populations. There was also a positive relationship ($R^2 = 0.53$) between sighting probability and deer density (Figure 2-6b), which according to Samuel et al. (1987) may partially be related to the influence of group size.

Vegetation cover is believed to be an important factor influencing sightability (Samuel et al. 1987, Ackerman 1988). Although we did not estimate percent cover for the various vegetation types in the holding area, our study also suggested that vegetative cover may substantially influence deer visibility. Sightability was highest during surveys conducted from mid-April through mid-March, when 79% of deer were observed in open sagebrush habitat. However, sightability decreased in late May and early June as the proportion of deer observed in other habitat types providing greater cover, increased (Figure 2-7).

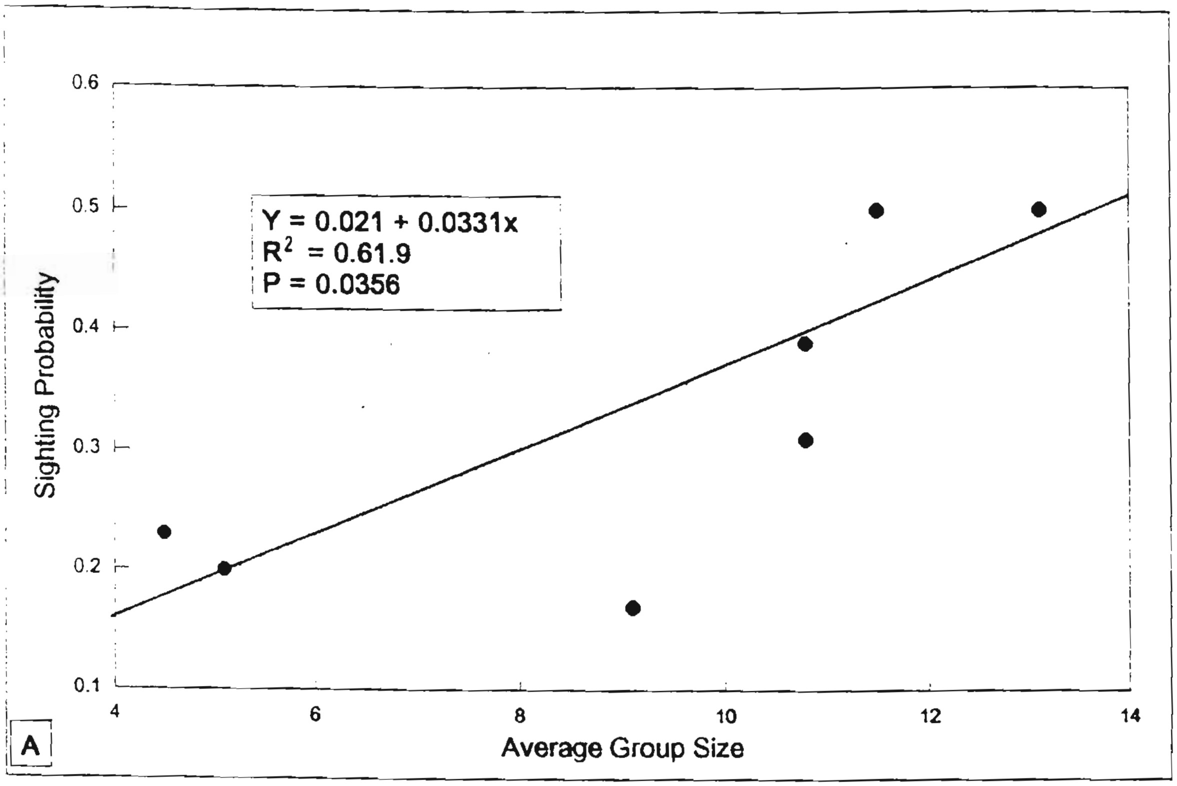
We did not attempt to fully determine the magnitude of visibility bias (Samuel et al. 1987) associated with our roadside surveys. Numerous factors including animal behavior and dispersion, topography, observer experience, weather, equipment, and methods may affect the number of animals observed (Samuel et al. 1987, Davis 1990).

Mark-resighting estimates for deer count surveys conducted on the holding area during the 1994 spring migration ranged from a low of 37 deer (95% CI = 32-42) on April 13 to a high of 809 deer (95% CI = 515-1,103) on May 12 (Table 2-1). Bleich (pers. comm.) reported a 1994 winter population estimate for the Round Valley herd of 1,127 deer (95% CI = 929-1,325), and telemetry information indicated that approximately 65% of radio-collared deer delayed migration on the SHA during the 1994 spring migration. Therefore, utilizing these two factors and assuming that deer were trapped in proportion

Table 2-1. Mean population estimates and ranges within 95% confidence limits for mule deer counted on the Sherwin holding area during 10 deer count surveys conducted from April 7-June 9, 1994.

Date of Survey	Number of Deer Observed	Number of Radioed Deer Observed	Number of Radioed Deer on the Holding Area	Estimated Number of Deer on the Holding Area	95% Confidence Intervals	Probability Sighting
April 7[a]	1	0	0			
April 13	37	1	1	37	32-42	100
April 21	236	7	14	443	247-639	50
April 28	231	12	24	445	362-524	50
May 5	248	10	32	552	410-1104	31
May 12	315	15	38	809	515-1103	39
May 19[a]	250	6	40			
May 26	137	5	30	712	272-1152	17
June 4	82	6	26	319	137-501	23
June 9	61	4	20	259	85-433	20

[a] Population estimates were not made for these surveys



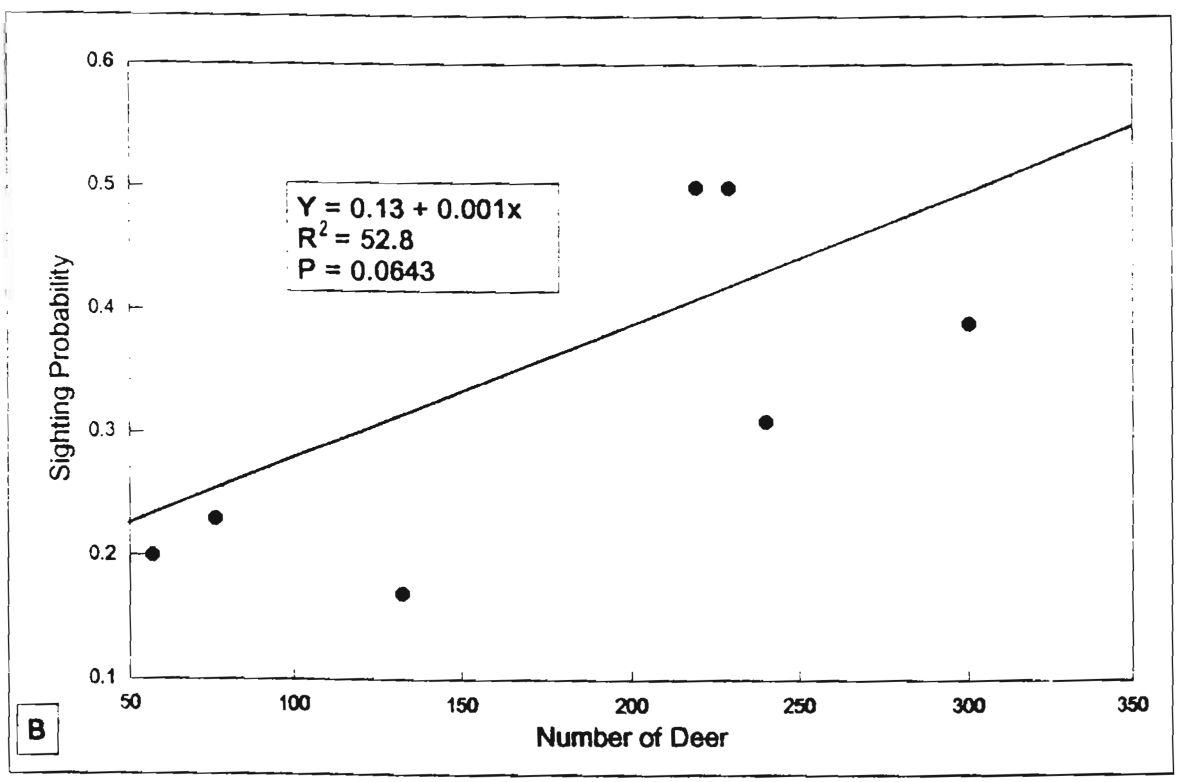


Figure 2-6. The Trend in Sighting Probability on Group Size (2-6a) and the Number of Deer Counted in the Sherwin Holding Area (2-6b) during the 1994 Spring Migration

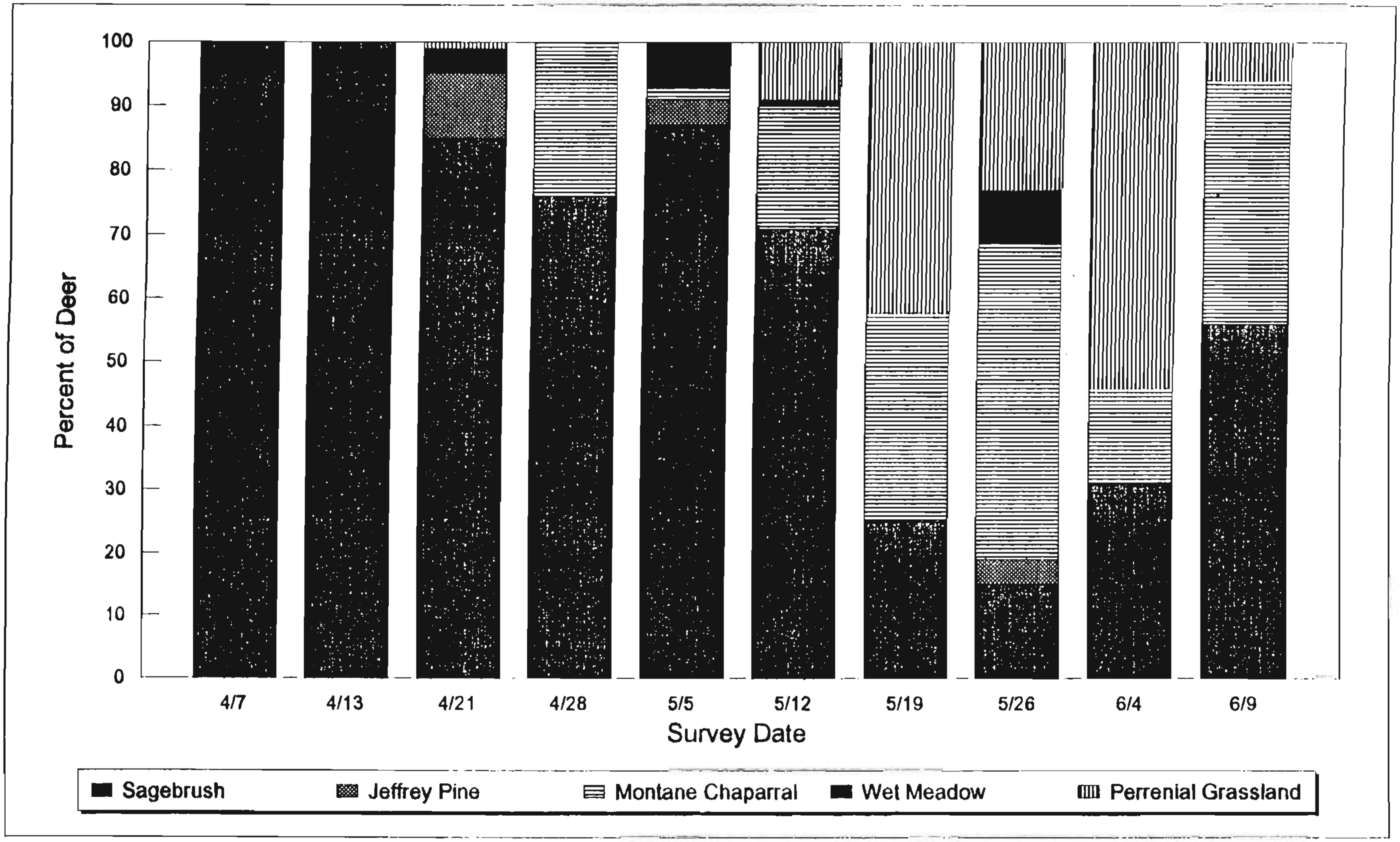


Figure 2-7. Percent of Deer Observed by Vegetation Type on the Sherwin Holding Area during the 1994 Spring Migration

to their availability, an estimated 730 deer delayed migration on the SHA. Thus, our highest population estimate of 809 deer (95% CI = 515-1,103) appears reasonable based on the most recent CDFG winter population estimate.

Patterns of Deer Habitat Use on the Sherwin Holding Area

Deer Count Surveys. A Chi-square test of independence showed no significant difference between spring 1993 and spring 1994 in the occurrence of deer groups within any habitat type ($\chi^2 = 3.84$, 4 d.f., $P > 0.05$). A total of 160 deer groups were observed on the SHA during 10 deer count surveys conducted from April 7 to June 9, 1994 (Table 2-2a, Figure 2-8). Of these 160 groups, approximately 55% and 26% were observed in sagebrush and montane chaparral habitats, respectively (Table 2-2a). Ten percent of all deer groups were observed in perennial grassland habitat on the Laurel Mountain burn, 12% in Jeffrey pine forest, and 4% in wet meadow. Chi-square Goodness-of-fit comparisons showed that the expected number of deer groups in each habitat differed significantly with the occurrence of habitat categories in the holding area ($\chi^2 = 54.76$; 4 d.f., $P < 0.05$). Montane chaparral was used and other habitats were avoided or used in proportion to availability.

In comparison, a total of 152 deer groups were observed on the SHA during 10 deer count surveys conducted between April 23 and June 25, 1993 (Table 2-2b, Figure 2-9). Of these 152 groups, approximately 53% and 26% were observed in sagebrush and montane chaparral habitats, respectively. Approximately 10% of all deer groups occurred in perennial grassland habitat on the Laurel Mountain burn and 10% were observed in Jeffrey pine forest (Table 2-2b). Only 1% of deer groups occurred in wet meadow. Chi-square Goodness-of-fit comparisons showed that the expected number of deer groups in each habitat differed significantly with the occurrence of habitat categories in the holding area ($\chi^2 = 53.3$; 4 d.f., $P < 0.05$). Deer used montane chaparral significantly more than expected, while sagebrush and wet meadow habitats were used significantly less (Table 2-2b). Perennial grassland and Jeffrey pine were used in proportion to their availability.

Habitat use differed significantly during June in 1993 ($\chi^2 = 58.48$; 4 d.f., $P < 0.05$), and May ($\chi^2 = 25.94$; 4 d.f., $P < 0.05$) and June ($\chi^2 = 93.38$ 4 d.f., $P < 0.05$) in 1994 (Figure 2-10). During May and June, montane chaparral was used and sagebrush was avoided.

Mule deer in the eastern Sierra Nevada generally forage on grasses and forbs in the spring and browse in the summer and fall (Taylor 1991, Kucera 1988). Habitat use appeared to be closely related to the temporal availability and phenological development of herbaceous spring forage. In both years, deer used montane chaparral habitat in greater proportions than expected. This habitat type is a dense, multilayered scrub comprised of a variety of plant species that provided a diverse, high quality diet for deer. A high quality diet resulting from a diversity of forage types is important to holdover deer, especially pregnant does, because it enables animals to select the most nutritious foods (Swift 1948)

Table 2-2a. Utilization-availability data for dominate habitat types in the Sherwin holding area. Mammoth Lakes. California. Utilization data is based on locations of 160 deer groups observed during 10 deer count surveys conducted during spring 1994.

Habitat Type	Total Estimated Acreage	Proportion of Total Acreage (*Pio*)	Number of Groups Observed	Expected Number of Groups Observed	Actual Proportion of Groups Observed *Pi*	Bonferroni Intervals for *Pi*
JP	800	0.121	9	19	0.056	0.047≤*Pi*≤0.189
SB	4,500	0.681	88	109	0.550	0.538≤*Pi*≤0.561[a]
MC	700	0.106	41	17	0.256	0.159≤*Pi*≤0.353[a]
WM	250	0.038	6	6	0.037	-0.005≤*Pi*≤0.079
PG	350	0.053	16	9	0.100	0.034≤*Pi*≤0.166
Total	6.600		160	160		

[a] Indicates a difference at the 0.05 level of significance

JP = Jeffrey Pine. SB = Sagebrush. MC = Montane Chaparral. WM = Wet Meadow. PG = Perennial Grassland

Table 2-2b. Utilization-availability data for dominate habitat types in the Sherwin holding area. Mammoth Lakes. California. Utilization data is based on locations of 152 deer groups observed during 10 deer count surveys conducted during spring 1993.

Habitat Type	Total Estimated Acreage	Proportion of Total Acreage (*Pio*)	Number of Groups Observed	Expected Number of Groups Observed	Actual Proportion of Groups Observed *Pi*	Bonferroni Intervals for *Pi*
JP	800	0.121	15	18	0.098	.035≤*Pi*≤0.161
SB	4,500	0.681	80	104	0.526	0.414≤*Pi*≤0.561[a]
MC	700	0.106	39	16	0.256	0.158≤*Pi*≤0.354[a]
WM	250	0.038	2	6	0.013	-.013≤*Pi*≤0.039[a]
PG	350	0.053	16	8	0.105	0.036≤*Pi*≤0.174
Total	6.600		152	152		

[a] Indicates a difference at the 0.05 level of significance

JP = Jeffrey Pine, SB = Sagebrush. MC = Montane Chaparral, WM = Wet Meadow. PG = Perennial Grassland

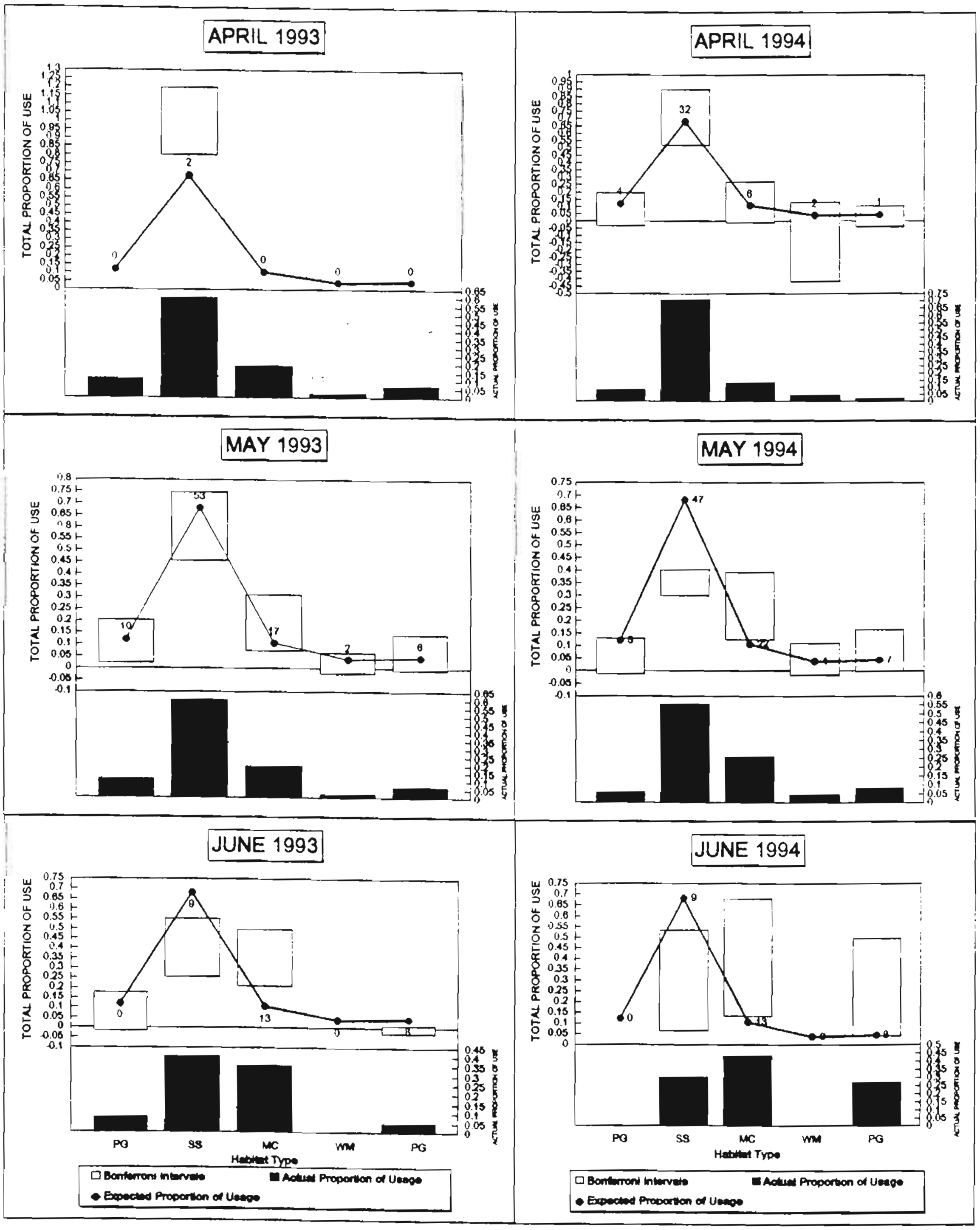


Figure 2-10. Confidence Intervals (95%) Indicating Mule Deer Use of Habitat on the Sherwin Holding Area during the 1994 Spring Migration. Black Dots Represent the Proportion of Each Habitat Available. Black Dots Below Interval Indicate Preference, Above Avoidance, and In the Interval Use in Proportion to Availability.

and quickly regain condition lost over the winter (Short 1981, Garrott et al. 1987). The dense, multilayered structure of montane chaparral vegetation also provided important thermal and hiding cover for deer.

Radio-collared Deer. Habitat use on the SHA by radio-collared deer was determined from 237 visual locations of collared animals. Triangulations were not included in the habitat analysis because many of our azimuth readings were not successfully converted into estimated X, Y coordinates. In addition, for those readings that were converted, large error polygons (> 0.25 ha) made it difficult for the observer to place the location a deer within a single habitat. In spring 1994, radio-collared deer avoided (used less than expected) perennial grassland habitat on the Laurel Mountain burn ($P < 0.05$), while other habitats were used in proportion to their availability (Table 2-3, Figure 2-11).

Table 2-3. Utilization-availability data for dominate habitat types in the Sherwin Holding Area, Mammoth Lakes, California. Utilization data is based on 237 visual locations of 27 radio-collared deer observed in the Sherwin Holding Area during the 1994 spring migration.

Habitat Type	Total Estimated Acreage	Proportion of Total Acreage (*Pio*)	Number of Deer Observed	Expected Number of Deer Observed	Actual Proportion of Deer Observed *Pi*	Bonferroni Intervals for *Pi*
JP	800	0.121	35	29	0.148	$0.085 \le Pi \le 0.213$
SB	4,500	0.681	151	161	0.637	$0.55 \le Pi \le 0.73$
MC	700	0.106	40	25	0.169	$0.101 \le Pi \le 0.238$
WM	250	0.038	7	9	0.028	$-0.017 \le Pi \le 0.058$
PG	350	0.053	4	13	0.160	$-0.006 \le Pi \le 0.038$[a]
Total	6,600		237	237		

[a] Indicates a difference at the 0.05 level of significance

JP = Jeffrey Pine, SB = Sagebrush, MC = Mixed Conifer, WM = Wet Meadow, PG = Perennial Grassland

Patterns of Deer Distribution on the Sherwin Holding Area

Observations from 27 radio-collared deer (n =237) were used to estimate a composite home range delineating the approximate size and boundaries of SHA. Minimum convex polygons, after combining all sample observations for the 27 deer, provided a total area estimate of 6,888 hectares. Outlier observations significantly effected estimates of holding area size. For example, the removal of 3 outlier observations from the data set reduced the MCP holding area size from 6,888 hectares (100% MCP) to 5,738 hectares (99% MCP). When 95% and 90% of the sample points were used, estimates of MCP declined to 3,852 and 1,761 hectares, respectively (Table 2-4, Appendix Figure 1). In comparison, calculated isopleths of the adaptive kernel (ADK) ranged from 11,260 to and 2,949 hectares for 100% and 90% of the sample points, respectively (Table 2-4, Appendix Figure 2).

Table 2-4. Calculated mule deer home range areas (hectares) for the Sherwin holding area and the Snowcreek Ski Area using the minimum convex polygon and adaptive kernel methods.

		MCP[1]				ADK[2]			
Area	Relocations (n)	100%	99%	95%	90%	100%	99%	95%	90%
Sherwin Holding Area	237	6888	5738	3852	1761	11260	9939	5720	2949

[1] Minimum Convex Polygon (Mohr 1947)
[2] Adaptive Kernel (Worton 1989)

A potential fault of MCP and ADK is that both assume that the total area within range boundaries are used by an animal. Our data appeared to fit this assumption fairly well with the 90% MCP (Appendix Figure 2). With the exception of the Jeffrey pine forest, which occupies the central portion of the holding area, we found no large unused areas within the SHA and there were few outlier locations. However, many deer moved through the Jeffrey pine forest to access migration routes located west of the holding area.

Large isopleths of the ADK (using ≥ 90% of locations) included areas that almost certainly were not used by deer, such as the TML (Appendix Figure 1), suggesting that ADK was not appropriate for estimating total range area, although the 85% ADK isopleths were useful for identifying core areas within the SHA.

The 90% MCP of 1,761 hectares was used to derive an estimate of deer density on the holding area during spring 1994. Based on deer count survey data, peak deer numbers on the SHA during spring 1994 were estimated at 809 deer (95% CI = 515-1,103). This estimate represents a density of 1 deer/0.46 hectares or 2.17 deer/hectare.

Isopleths of the ADK using 85% of locations identified two major core areas within the SHA (Appendix Figure 3). Core area A is located in the lower eastern portion of the SHA, extending from approximately Mammoth Creek south to the top of the Laurel Mountain burn (2,400 meters elevation), and from Laurel Creek east to the Cold Springs campground area (Appendix Figure 3). Core area B included the lower northern portion of the SSA, from approximately Mammoth Creek south to the Mammoth moto-cross, and from Mammoth Rock east to the Sherwin campground area.

Appendix Figure 3 may give deceptive results regarding the number of animals using each core area. Therefore, it is important to understand that core areas were delineated for the purpose of identifying high use areas within the SHA and are not a reflection of population size. The isopleth of core area A was based on approximately 109 locations of 25 radio-collared deer (x = 4.4 locations/deer), while the core area B isopleth was derived from approximately 92 locations of 15 radio-collared deer (x = 6.1 locations/deer). The fact that the isopleth of one core area includes more data points than that of the other is strictly a function of sample size.

Stage III: Deer Migration between the Sherwin Holding Area and the Summer Range

The locations of deer migration corridors and the percentage of the Round Valley winter deer population that used these corridors was determined from aerial and ground-based radio-tracking of collared deer.

Migration Routes Over the Sierra Crest

Based on the movements of radio-collared deer, Kucera (1988) delineated the migration routes over the Sierra crest used by deer from the Round Valley population. Using a sample of 27 radio-collared deer, Kucera (1988) calculated the percent of the total herd that used these migration routes (Table 2-5). In the DHMP (Raedeke Associates 1994), the deer that migrate through these different geographical areas are referred to as "herd segments". The following represents the proportion of the Round Valley population representing each herd segment (Kucera 1988):

- Thirty-four percent of deer migrated south from the Round Valley winter range and used the Bishop Pass, Lamark Pass, and Piute Pass migration routes.

- Sixty-seven percent of deer migrated north from the Round Valley winter range and used the Hopkins Pass, Solitude/Duck Pass, Mammoth Pass, and San Joaquin Ridge migration routes. The following includes a brief description of these herd segments:

    - The Hopkins pass herd segment diverts from the main migration corridor before reaching the SHA, migrates westerly up the McGee Creek drainage and crosses the Sierra crest over Hopkins Pass.

    - The Solitude/Duck pass herd segment delays spring migration on the SHA, and then migrates south to the summer range over two passes: Solitude Pass, located in the permit area atop the Sherwin Range, and Duck Pass, located some 5 km farther south on the Sierra Crest.

    - The Mammoth Pass herd segment delays spring migration primarily in the western portion of the SHA, which includes the permit area. The route used by this herd segment heads westerly through the permit area below Mammoth Rock, passes through the Mammoth Lakes Basin, and then crosses over Mammoth Pass into the Middle Fork of the San Joaquin River drainage.

    - The San Joaquin herd segment migrates northwesterly from the SHA and crosses the Sierra crest over San Joaquin Ridge, between Minaret Summit and Deadman Pass.

Table 2-5. Percent of radio-collared deer that used different migration routes over the Sierra crest, based on radio telemetry data from Kucera (1988) and spring 1994.

	Percent of Radioed Sample			
	Kucera 1988 (n = 27)		Spring 1994 (n = 39)	
Migration Routes	Number	Percent	Number	Percent
Southern Routes				
Bishop Pass	1	4		
Lamark Pass	1	4		
Piute Pass	7	26	1	3
	9	34	1	3
Northern Routes				
Hopkins Pass	4	15	3	8
Solitude/Duck Pass	7	26	15	38
Mammoth Rock	2	7	13	33
San Joaquin Ridge	5	19	7	18
	27	67	39	97

Migration Routes Over the Sierra Crest - Spring 1994

Of the 66 deer for which migration routes were determined during the 1994 spring migration, a total of 39 crossed over the Sierra crest to west side summer ranges. Of these 39 deer, 28 migrated through the SSA permit area; 7 crossed over San Joaquin Ridge; 3 migrated over Hopkins Pass; and one crossed over Piute Pass (Table 2-5).

Migration through the SSA Permit Area. Twenty-eight of the 39 deer that migrated over the Sierra crest moved through the SSA permit area. Of these 28 deer, 13 used the Mammoth Rock migration route to access summer range located in the Mammoth Lakes Basin and the Middle Fork of the San Joaquin River drainage. All 13 of these deer delayed migration for 1 or more days in the SSA permit area (Figure 2-3). Fifteen of the 28 deer that migrated through the SSA permit area moved through Solitude Canyon, and then over Solitude Pass and Duck Pass, to summer range located in the South Fork of the San Joaquin River, Fish Creek, and Mono Creek drainage's. Of these 15 deer, 6 delayed migration for 1 or more days in the SSA permit area (Figure 2-3).

Migration Over San Joaquin Ridge, Hopkins Pass and Piute Pass. A total of 7 deer migrated over San Joaquin ridge to summer range located in the upper Middle Fork of the San Joaquin River drainage (Table 2-5). Of these 7 deer, 2 delayed migration for 1 or more days in the SSA permit area. Three deer crossed over Hopkins Pass to their west side summer ranges located in the Mono Creek drainage, and 1 deer crossed over Piute Pass (Table 2-5).

Summary of Deer Migration Over the Sierra Crest. During spring 1994, a total of 77 radio-collared deer were alive at the beginning of spring migration. Of these 77 deer, 3 died during the spring migration period. Of the remaining 74 deer, 28

(38%) migrated through the SSA permit area, 7 (9%) crossed over San Joaquin Ridge; 3 (4%) migrated over Hopkins Pass; and one (1%) crossed over Piute Pass (Table 2-5). Of the 28 deer that migrated through the SSA permit area, 13 deer (18% of the Round Valley population) used the Mammoth Rock migration route and 15 deer (20% of the Round Valley population) used the Solitude/Duck pass migration route. Using the CDFG 1994 winter range population estimate of 1,127 deer (CDFG, Unpubl.), the proportion of the deer herd that migrated through the SSA permit area numbered about 430 deer or about 38% of the Round Valley population. This was approximately half the number of deer estimated to have delayed migration on the Sherwin Holding Area during the 1994 spring migration.

Based on the percentages of the different deer herd segments that migrate over the Sierra crest (Kucera 1988), Raedeke Associates (1994) estimated that some 440 deer (33%) from the Round Valley population migrated through the SSA permit area in spring 1993. During spring 1994, the proportions of deer using Solitude and Mammoth passes was approximately 14% and 26% greater, respectively, than reported by Kucera (1988) (Table 2-5). Conversely, the proportions of deer using the San Joaquin Ridge and Hopkins Pass migration routes were approximately 1% and 8% less, respectively, than reported by Kucera (1988).

It is important to note that many of the lifts and ski trails formerly proposed in the vicinity of the Motocross and lower Solitude Canyon have been eliminated. Additionally, many of the facilities serving Solitude Canyon and the Pyramid Peak areas have been reduced or relocated (SSA-MDP, pages 3-3 to 3-4). These changes were incorporated in the Mountain Master Plan to substantially reduce encroachment into areas which are currently identified as deer sensitive.

As stated earlier, if a deer's migration route over the Sierra crest could not be determined directly, the route was reconstructed using information from other aspects of the deer's life history, such as where it delayed migration and where it summered on the west slope of the Sierra. However, this approach is problematic from the standpoint that some deer could have potentially accessed their summer ranges using one of several different passes. For this reason, the proportions of deer representing each herd segment are meant only as approximations.

Timing and Intensity of Migration through the Snowcreek Ski Area

Remote Deer Counters. The Trailmaster units at Solitude Pass recorded 344 events that could be used to determine the timing and intensity of deer movements through the permit area. Deer began moving through Solitude Canyon and over Solitude Pass on May 22, and these movements continued until June 29 (Figure 2-12). Peak migration through the SSA permitt area occurred between June 2 and 15, when approximately 62% of all events were recorded. Approximately 18% of events were recorded between May 22 and June 8, and 19% of events between June 16 and 29.

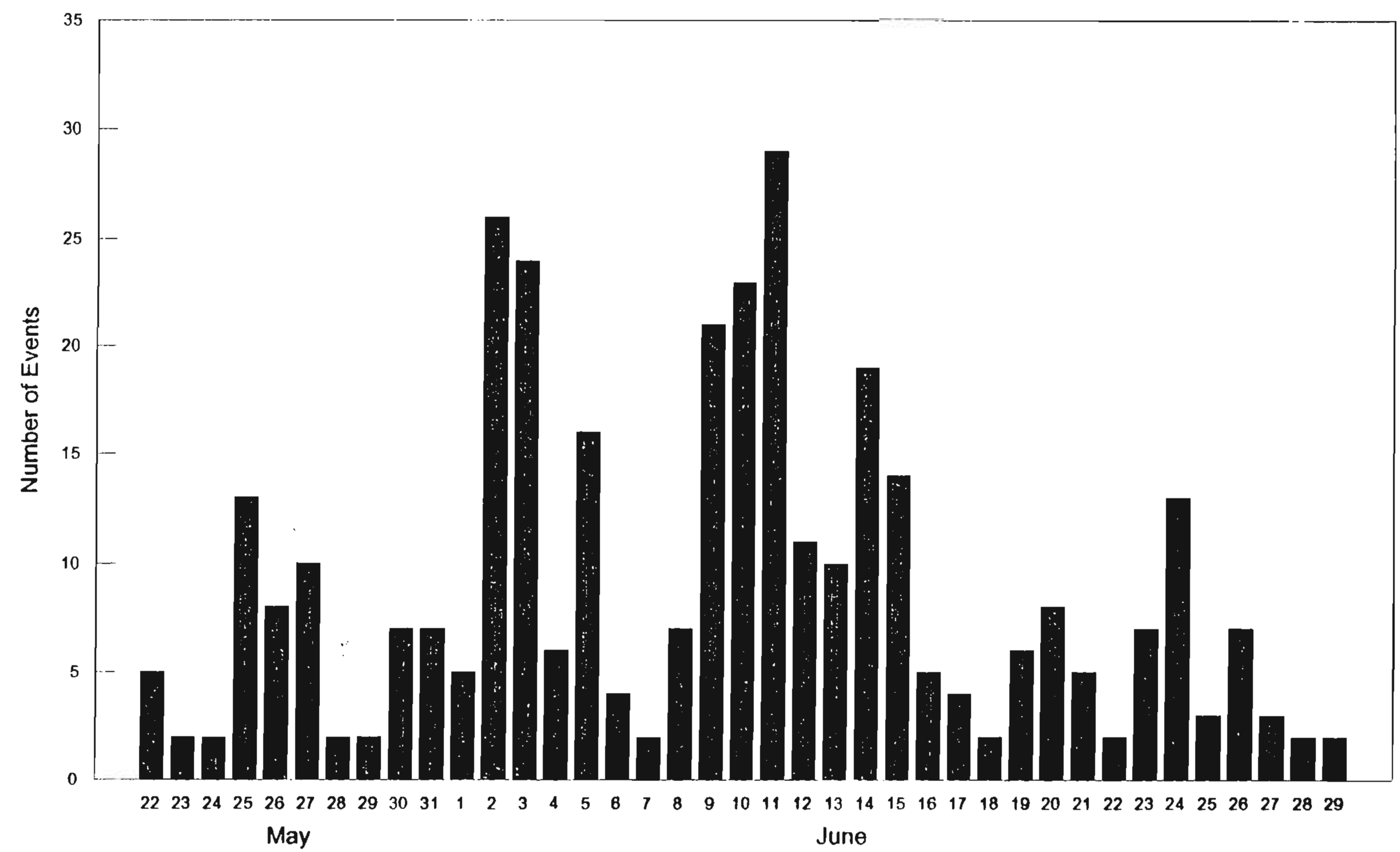


Figure 2-12. Number of Events Counted per Day by the Trailmaster Units at Solitude Pass, Spring Migration 1994

The 1994 spring migration followed an extremely mild winter, with total snowfall accumulation in the Mammoth Lakes area averaging approximately 50% of normal. Taylor (1989) reported that deer movements through Solitude Canyon lasted from approximately May 14 to June 24 following winters of below average snowfall (Table 2-6). In comparison, during the spring migration of 1993, when snowfall accumulations in the Mammoth Lakes area exceeded 120% of normal, deer movements through Solitude Canyon were delayed until May 30.

Verification of Deer Counting Accuracy. During the 1994 spring migration the accuracy of the Trailmaster units at Solitude Pass was determined from direct observations of deer crossing through the infrared beam, from a 35 mm camera used in conjunction with the Trailmaster unit at station 6, and by comparison of the Trailmaster data with radio-telemetry data.

Direct observations of deer crossing over Solitude Pass and through the counting stations were made on May 30. During this day of observation, a total of 4 deer were observed crossing over the pass. At 10:34 a.m., 3 deer (1 adult female and 2 yearling females) attempted to move through station 6, which was located on the main migration trail crossing over the pass. Station 6 was the only station with a 35 mm camera; the camera was later stolen in early June. As the first deer passed through the infrared beam, the flash from the camera startled the animals, causing the adult doe and one of the yearlings to flee back to the north the way they had come; 1 event was recorded. At 10:35 a.m. the doe and yearling again tried to move through station 6, however the flash from the camera again startled the animals, causing them to retreat to the north; 1 event was recorded. At 10:36 a.m., both deer successfully crossed through station 9 located at the upper, east end of the pass; 2 events were recorded. The fourth deer observed, an adult doe, passed, without hesitation, through station 5 at 12:20 p.m. Thus, the 4 deer that crossed over the pass on May 30 resulted in 5 event recordings, 2 each at stations 6 and 9, and 1 at station 5.

Table 2-6. Approximate timing of deer movements through Solitude Canyon and over Solitude Pass during the spring migrations of 1985-1989 and 1993-1994 (Kucera 1985, Taylor 1988, Taylor 1994).

Year	Total Annual Snowfall (in.)	Start of Spring Migration	End of Spring Migration
1984-85	264	16 May	24 June
1985-86	294	25 May	24 June
1986-87	101	14 May	24 June
1987-88	143	16 May	24 June
1988-89	186	14 May	29 June
1992-93	376	30 May	3 July
1993-94	159	22 May	29 June

Because the 35 mm camera used at station 6 was stolen in early June, before peak migration, very few photographs of deer were taken. As a result, this method provided little information regarding the accuracy of the Trailmaster as a deer counting device.

According to radio-telemetry information, of the 74 radio-collared deer on the Round Valley winter range that were alive at the end of the spring holding period, 15 (20%) crossed over Solitude Pass (Table 2-5). Using the CDFG 1994 winter range population estimate of 1,127 deer, the proportion of the deer herd that migrated through Solitude Canyon numbered about 225 animals. Thus, based on telemetry data it appears that the Trailmaster units at Solitude Pass may have overestimated the number of deer by as much as 35%. Taylor (1994) identified several inherent problems associated with use of the Trailmaster as a deer counting device. Among these were the effects of severe weather, such as high winds and heavy snowfall, that could negatively bias results. Heavy snowfall can cause the Trailmaster to record phantom events, resulting in counts that are too high. Conversely, high winds or drifted snow can force the units out of alignment, resulting in counts that are too low. However, these two factors are in opposite directions and would tend to balance each other. Thus, based on data collected from radio-collared deer and the Trailmaster units, the number of deer migrating through Solitude Canyon and over Solitude Pass was probably somewhere between 225 and 350 animals.

Daily Timing of Deer Movements. Trailmaster event data recorded at Solitude Pass was used to determine the daily timing of deer movements through the project area (Figure 2-13). Approximately 70% of events occurred during daylight hours (6 a.m.-8 p.m.); similarly, 80% of events recorded in 1993 occurred between these hours (Taylor 1993). Approximately 55% of the daytime events occurred between 6 a.m. and 11 a.m., while 39% occurred between 11 a.m. and 5 p.m. Forty percent of the nighttime events were recorded between 1 a.m. and 4 a.m., and 25% between 10 p.m. and 12 a.m.

The propensity of deer moving through the permit area between the hours of 6 a.m. and 11. a.m. may be related to the physical characteristics of the snowpack at upper elevations of the project area. The surface hardness and density of the snow at these higher elevations was greater in the early morning hours following nights when temperatures were below freezing. This hardened crust provided deer increased mobility as they moved across the snowpack. Verme (1968) observed that hard crusts allowed deer to roam freely over the snowpack, while weak crusts broke repeatedly, causing injury and excessive tiring.

Summer Ranges of Radio-Collared Deer

Of the 66 radio-collared deer for which migration routes were determined, a total of 31 (47%) summered east of the Sierra crest, from Lake Sabrina north to the Mammoth Lakes. This included 7 deer that used the Mammoth Rock and Solitude Pass migration routes and summered in the Mammoth Lakes Basin, which is east of the Sierra crest, but west of the project area. A total of 32 deer (48%) actually crossed the Sierra crest to

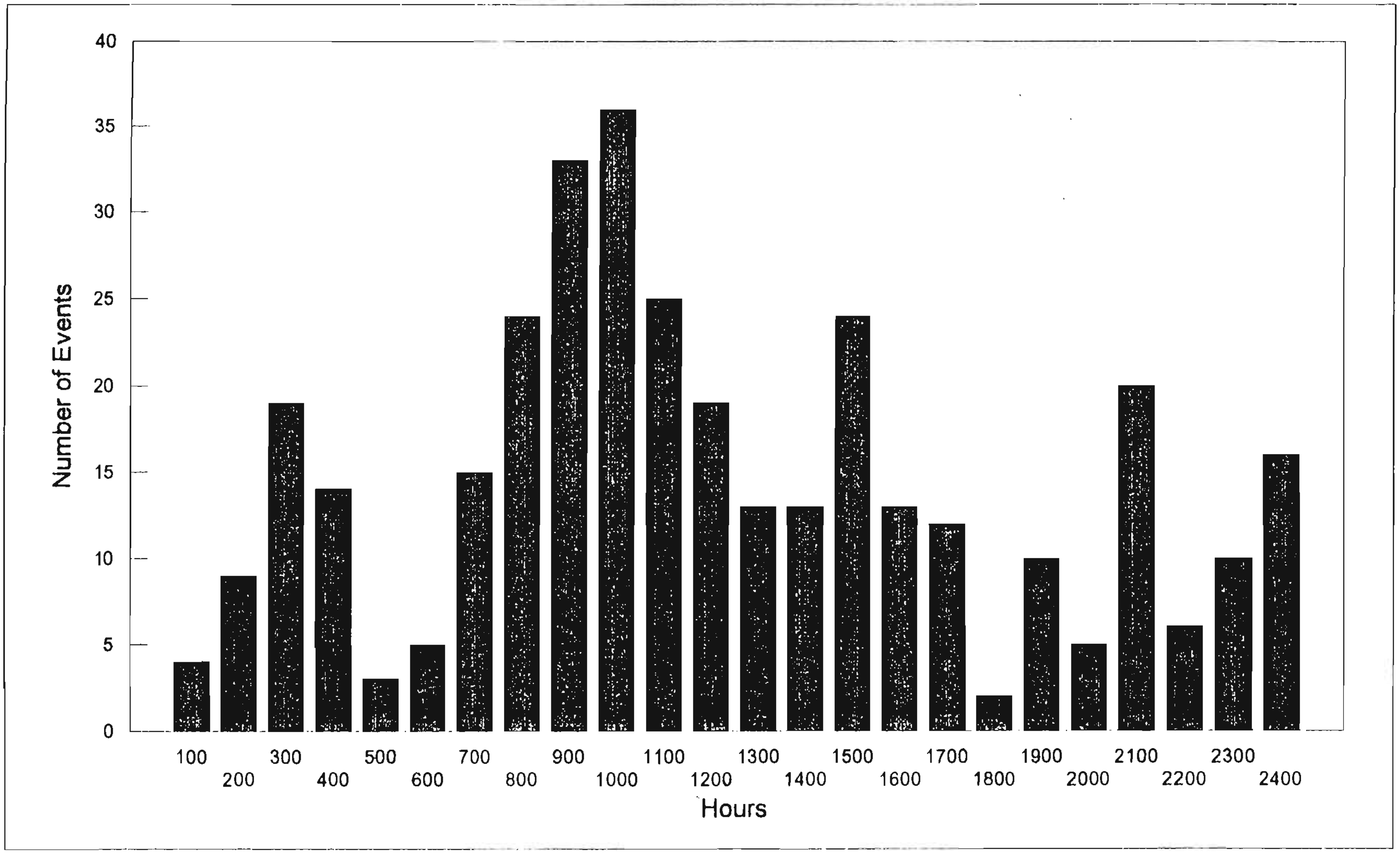


Figure 2-13. Timing of Deer Movements through the Project Area during Spring Migration 1994

west side summer ranges. Of these 32 deer, 29 were found by CDFG on their summer ranges. A total of 3 deer (5%) died before reaching the summer range.

Five of the east side residents summered in the permit area and vicinity. In addition, a total of 4 unmarked deer, all adult females, were observed in the permit area during field work conducted from June 15-30. Three of these deer were observed in montane chaparral habitat located adjacent to the Mammoth Rock Trail (Table 2-7). A fourth deer was observed in montane chaparral habitat located west of Mammoth Rock. The structural profile of montane chaparral vegetation provides suitable fawn rearing habitat for does. In addition, a number of the plant species associated with the montane chaparral community [e.g., bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpos vaccinoides*), and tobacco brush (*Ceanothus velutinus*)] are recognized as important mule deer forages because they are highly digestible and contain high levels of crude protein (Neal 1988, Risser and Fry 1988). Summer resident deer use of the SSA permit area is dependent upon sources of permanent, free water located at Hidden Pond, Mammoth Creek, and Sherwin Creek.

Table 2-7. Locations and habitats of 4 adult female mule deer observed in the Sherwin Ski Area between June 15 and June 30 1994.

Observation Number	Date Observed	X Coordinate	Y Coordinate	Distance From Water (km)	Habitat Type
1	6-16-94	326100	4165500	1.2	MC
2	6-18-94	324200	4164800	0.5	MC
3	6-22-94	326900	4165600	0.7	MC
4	6-26-94	325100	4164800	0.2	MC

MC = Montane Chaparral

Road-Kill Data

A total of 9 road-killed deer from the Round Valley herd were recorded by Caltrans crews on highways 203 and 395 during the 1994 spring migration (Table 2-8) (Caltrans Unpubl. data). In addition, a total 6 deer were killed on these highways during July-September. Six of the fatalities occurred on Highway 203, between post miles 6.0 and 8.0, and 9 fatalities occurred on Highway 395 between post miles 8.5 and 25.5.

Table 2-8. Highway fatalities recorded by Caltrans during spring and summer 1994.

Deer No.	Highway	Post Mile	Date	Sex	Age
1	395	9.3	3/14/94	UID	Fawn
2	395	19.0	5/03/94	Female	Adult
3	395	24.5	5/23/94	UID	Fawn
4	395	25.5	5/29/94	Female	Adult
5	395	24.7	6/17/94	Female	Adult
6	395	9.4	6/17/94	Female	Adult
7	395	13.5	7/08/94	Male	Adult
8	395	8.5	8/19/94	Female	Adult
9	395	11.2	9/20/94	Female	Adult
10	203	8.0	5/02/94	Female	Adult
11	203	7.5	5/23/94	Male	Adult
12	203	6.9	5/23/94	Female	Adult
13	203	6.0	6/06/94	Male	Adult
14	203	7.8	8/15/94	Male	Adult
15	203	6.8	8/30/94	Female	Adult

Chapter 3. Fall Migration

This chapter describes the results of the fall 1994 studies.

MIGRATION STUDIES

Timing and Intensity of Migration through the Snowcreek Ski Area

Radio-collared Deer. Telemetry information indicated that fall migration over the Sierra crest and through the permit area lasted from approximately October 1 to October 16 (Figure 3-1). Peak migration occurred from October 5-8, when 23 of 28 (82%) radio-collared deer crossed the Sierra crest. These deer migrated in response to a snow storm on October 5, when approximately 14 centimeters (6 inches) of snow was recorded at the Mammoth Ranger Station and over a foot of snow fell at the highest elevations of the permit area.

The timing of migration through the permit area during fall 1994 was similar to other migrations that occurred in response to fall snowstorms. In 1984 and 1985, deer migrated to the winter range in October in response to major fall snowstorms (Kucera 1992). Because of the severity of these storms, deer hastily vacated the summer range and migrated en masse through the project area. In both years, migration to the winter range was completed by early November. Others (Leopold et al. 1951, Bertram and Remple 1977, Loft et al. 1989), have also associated the timing of fall migration with snowfall.

In comparison, 1986-1988 and 1993 were drought years and fall snowstorms did not occur before migration. As a result, deer migrations occurred gradually, lacked any episodes of mass movement, and were extended into mid-November (Taylor 1989, Taylor 1993b). Garrott et al. (1987) postulated that departure from summer ranges in northwest Colorado was not induced by snow, but instead by differences in forage quality between summer and winter ranges. Kucera (1992) suggested that adult females may be constrained in their timing of fall migrations because of smaller body size, the inability of fawns to negotiate deep snow, and the energetic demands of lactation.

Remote Deer Counters. The Trailmaster units at Solitude Pass recorded 75 events that could be used to determine the timing and intensity of fall deer migration through the permit area (Figure 3-2). Deer migration through the permit area lasted for approximately 2 weeks, from October 1-13. Peak migration occurred on October 6-7, when 49% of all events were recorded.

Verification of Deer Counting Accuracy. During the 1994 fall migration, the Trailmasters at Solitude Pass were continually disabled because of high winds and blowing

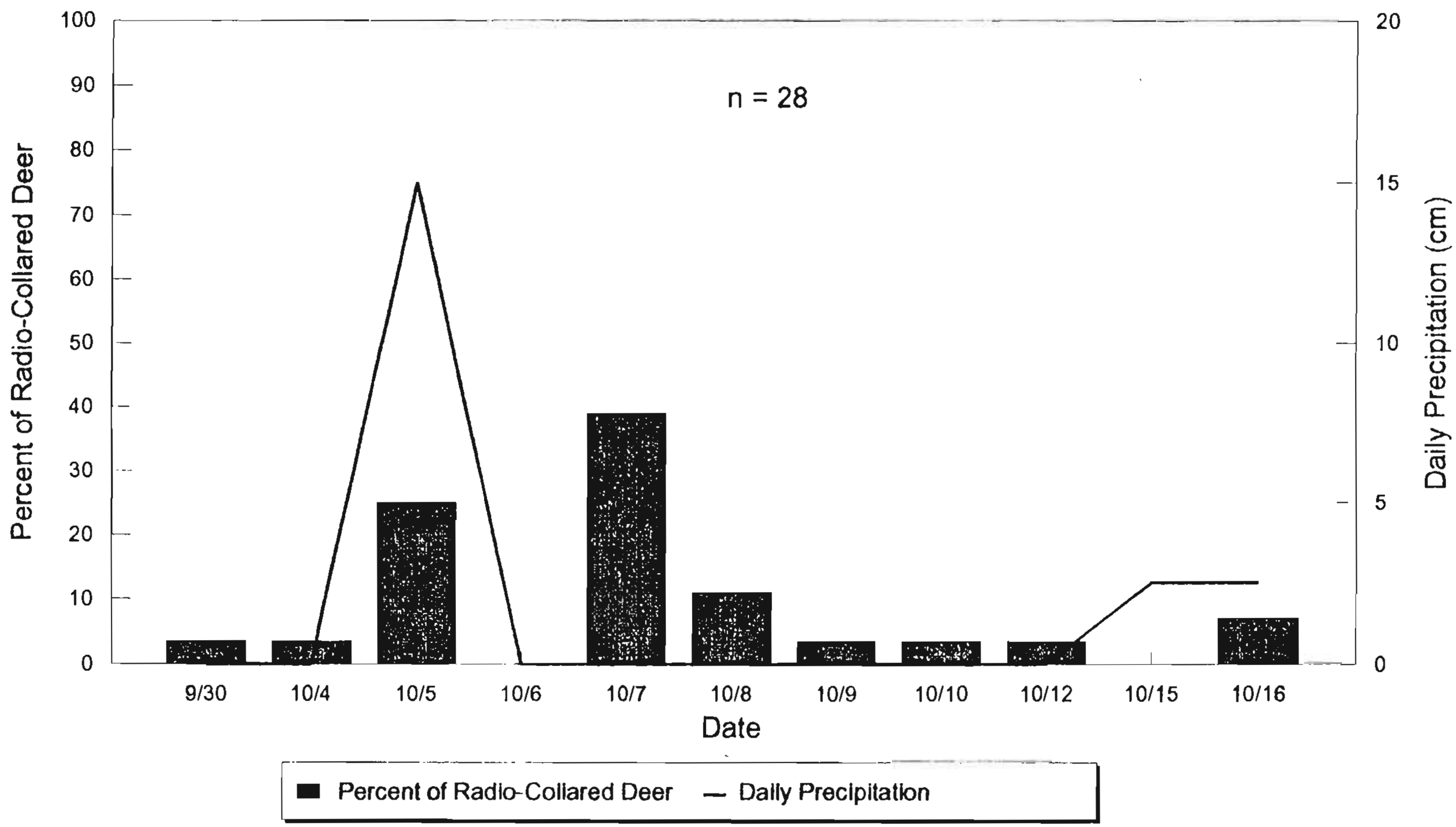


Figure 3-1. Percent of Radio-Collared Deer Crossing the Sierra Crest in

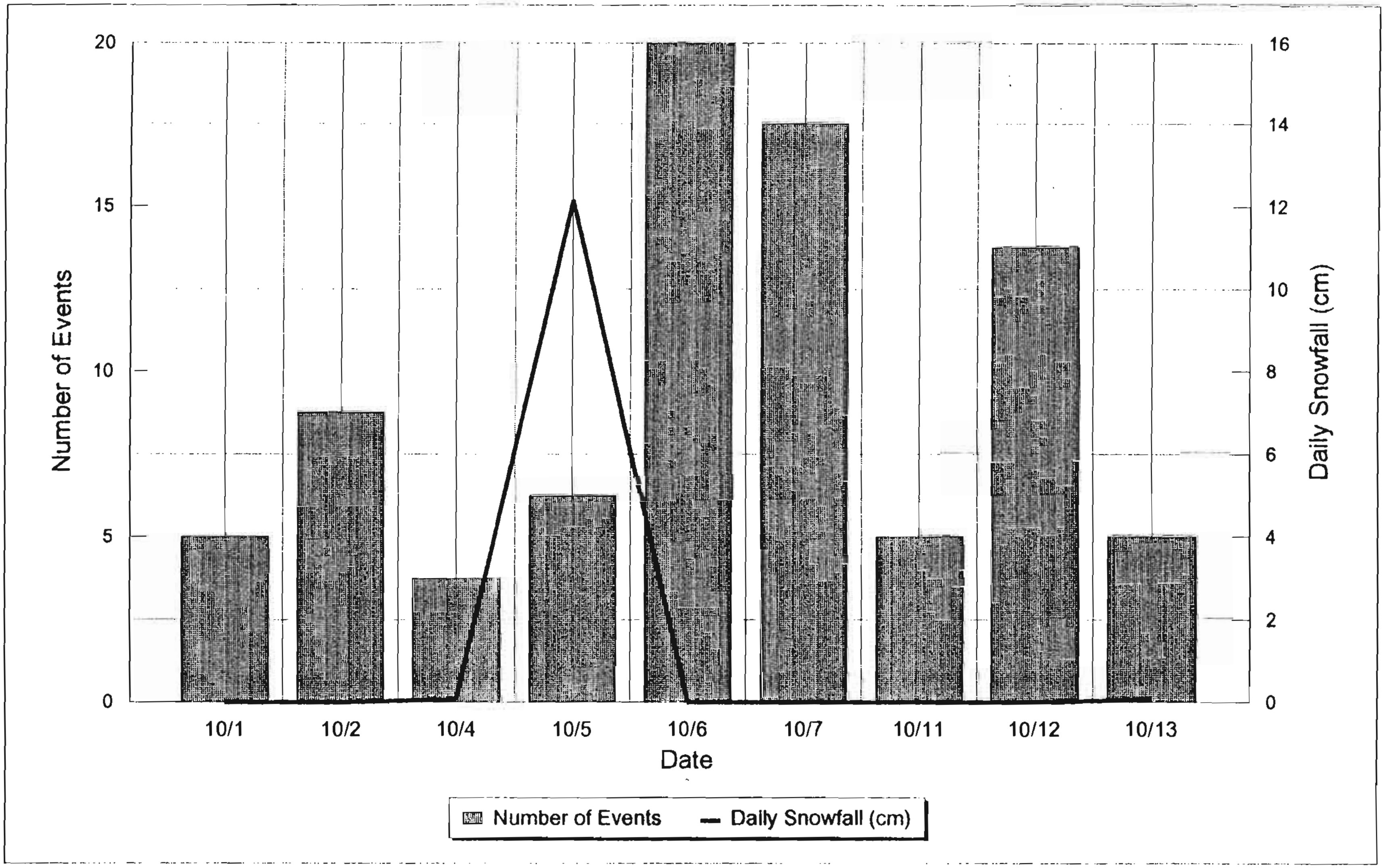


Figure 3-2. Number of Events Counted per Day by the Trailmaster Units at Solitude Pass, Fall Migration 1994

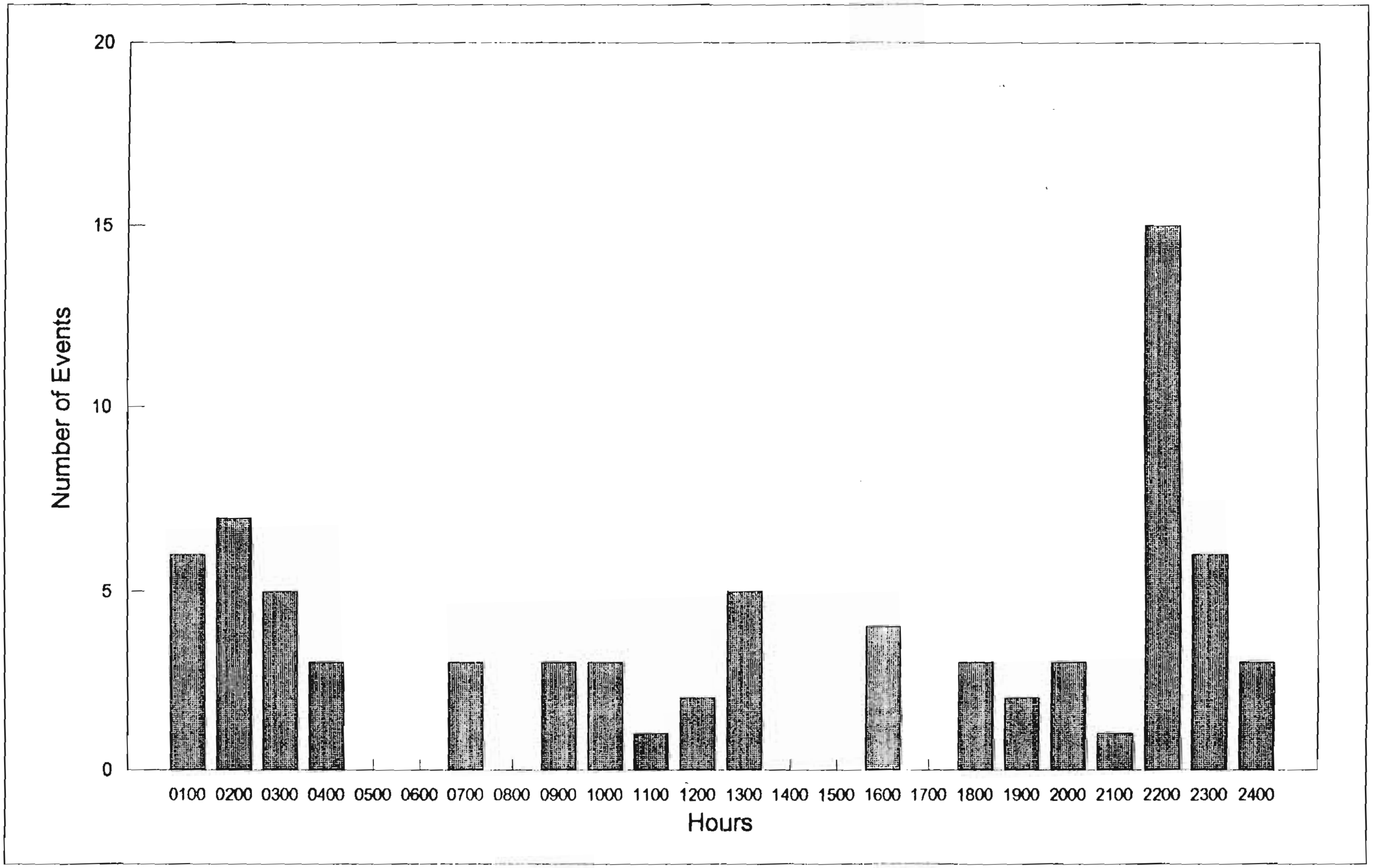


Figure 3-3. Timing of Deer Movements through the

snow. As a result, most deer were not counted when they crossed over Solitude Pass. Additionally, many radio-collared deer migrated at night and were not detected until after they arrived on the holding area or the winter range. Consequently, estimates of the number of deer crossing over the Solitude Pass from comparisons between Trailmaster data and radio-telemetry data were not possible.

Daily Timing of Deer Movements Event data recorded by the Trailmaster units at Solitude Pass was used to determine the daily timing of deer movements through the permit area. Approximately 65% of all events were recorded during the nighttime hours, from 6 p.m. to 7 a.m. (Figure 3-3). In comparison, during fall 1993, approximately 58% of the events recorded at Solitude Pass occurred during the daytime between 7 a.m. and 6 p.m. The difference between the two years in the daily timing of deer movements may be related to presence or absence of fall snowstorms.

Deer Composition Counts

During approximately 100 man-hours field work, a total of 113 deer (69 females, 11 bucks, and 33 fawns) were classified, yielding a buck/doe/fawn ratio of 16/100/48 (Table 3-1). On October 30, 45 deer (25 females, 6 males, and 14 fawns) were observed on the lava flats just north of the Mammoth-June Lakes Airport. Post-season (Janaury) composition counts conducted on the Round Valley winter range by CDFG yielded a buck/doe/fawn ratio of 24/100/34 (Vern Bleich, pers. comm.).

Table 3-1. Sex and age of deer classified in the Snowcreek Ski Area and Sherwin Holding Area during the 1994 fall migration.

Date	Males	Females	Fawns	B/D/F
10/05/94	0	1	2	0:100:200
10/08/94	3	15	3	20:100:20
10/10/94	1	5	3	20:100:60
10/12/94	1	8	2	12.5:100:25
10/13/94	0	15	9	0:100:60
10/30/94	6	25	14	24:100:56
	11	69	33	16:100:48

Road-Kill Data

There were no road-killed deer from the Round Valley herd recorded by DCC or Caltrans during the 1994 fall migration.

Chapter 4. Conclusions and Recommendations

Radio-Telemetry Studies

During January 1994, CDFG captured and marked an additional 50 deer, raising the total number of collared deer to approximately 120 (Vern Bleich, CDFG, pers. comm.). These deer will be used to determine the locations of migration routes and deer home ranges, and to provide information on spatial relationships, behavior, and energetics. A greater level of effort will be required in upcoming years to monitor this large number of radio-collared deer and successfully complete the goals of the DHMP. Therefore, the hiring of at least one part-time and two full-time biologists is recommended for the upcoming 1995 spring migration.

Because deer occupy the SHA for a short period of time (≤10 weeks) during the spring migration, a number of years will be required to obtain statistically valid samples for estimating home range size of many individuals. Swihart and Slade (1985) reported that observations using a short sampling period were autocorrelated and resulted in an underestimation of home range size. These authors suggested that when time and/or manpower are limited, as they were in this study, 1 or 2 relocations/animal/24 hours will result in statistically valid samples for estimating home range size of many individuals.

During the 1995 spring migration, attempts will be made to determine the level of visibility bias (Samuel et al. 1987) associated with our weekly roadside surveys. Numerous variables including animal behavior and dispersion, topography, observer experience, group size, habitat cover types, and weather may affect the number of animals observed (Samuel et al. 1987, Davis 1990). Samuel et al. (1992) suggested that maintaining standardized procedures with constant bias will provide relative information on long-term population trends. Therefore, future studies will focus on standardizing those factors that can be controlled by observers and measuring the effect of any uncontrolled biases on our population size estimates. During Stage I and II of the DHMP, radio-collared deer observed during our weekly deer counts will be used to develop a "sightability index". The "sightability index" will be used in Stage III of the DHMP to estimate the number of deer actually on the holding area based on the number of deer observed during a given census (Raedeke Associates 1994).

Habitat Use and Selection Patterns

In spring 1994, we used telemetry data from 27 radio-collared deer to estimate a composite home range that delineated the boundaries of the SHA. The expected use of habitat within the SHA was the proportional distribution of habitat types within the composite home range, while the observed use was based on the distribution of the telemetry locations. This approach was useful for determining habitat preference within the SHA, however levels of habitat selection (Johnson 1980) were not determined because we did not have the time or manpower to randomly sample plant communities within the holding area boundaries. Thus, a priority of spring 1995 work will be to measure random plots located within the composite home range to determine habitat characteristics (e.g., elevation, slope, aspect, distance to water and roads, etc.). This will enable the analysis of second order (selection of home range within the SHA) and third order (selection of habitats within the home range) habitat selection as described in Raedeke Associates (1994).

Trailmasters

The use of Trailmasters to count deer crossing over Solitide Pass has worked with mixed success. Taylor (1993) discussed problems inherent in this technique that could result in large errors, including the effects of severe weather (e.g., high winds and drifting snow). Use of a 35 mm camera in conjunction with each Trailmaster unit is the only way to accurately verify event data (Steve Holl, Jones & Stokes Assoc. pers. comm.). However, the theft of our only camera from Solitude Pass makes this solution impracticable. Because conditions for good results are extremely rigorous, it is recommended that the counting stations at Solitude Pass be checked every other day during peak migration periods so that adjustments and modifications can be made in accordance with changing environmental conditions, e.g., fluctuating snow levels. This level of effort would require one part-time employee whose sole job would be to maintain the Trailmasters in operating condition.

Chapter 5. Acknowledgements

This study was conducted under contract with Dempsey Construction Corporation, Mammoth Lakes, California, with cooperation of a Special Use Permit from the U.S. Forest Service, Mammoth Ranger District, Inyo National Forest. Tim Taylor was the project manager responsible for the study and preparation of the report. Karl Chang collected and compiled field data and helped with the graphics. Dr. Ken Raedeke provided useful comments on the manuscript.

Chapter 6. Citations

Ackerman, B. B. 1988. Visibility bias of mule deer aerial census procedures in southeast Idaho. Ph.D. Thesis, Univ. Idaho, Moscow. 106 pp.

Andelt, W. F., and S. H. Andelt. 1981. Habitat use by coyotes in southeastern Nebraska. J. Wildl. Manage. 45:1001-1005.

Bear, G. D., G. C. White, L. H. Carpenter, R. B. Gill, and D. J. Essex. 1989. Evaluation of aerial mark-resighting estimates of elk populations. J. Wildl. Manage. 53(4):908-915.

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

Byers, C. R., R. K. Stienhorst, and P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48:1050-1053.

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with application to zoological sample censuses. Univ. Calif. Publ. Stat. 1:131-160.

Cook, R. D., and J. O. Jacobson. 1979. A design for estimating visibility bias in aerial surveys. Biometrics 35:735-742.

Davis, D. E., and R. L. Winstead. 1980. Estimating the numbers of wildlife populations. Pages 221-246 In S. D. Schemnitz ed., Wildlife management techniques manual. Third ed. The Wildlife Society, Washington, D.C. 686 pp.

_____. 1990. Calculations used in census methods. Pages 344-369 In D. E. Davis ed., Handbook of census methods for terrestrial vertebrates. CRC Press, Inc., Boca Raton, FL. 397 pp.

Dempsey Construction Corporation. 1993. Snowcreek Ski Area Master Development Plan.

Garrott, R. A., C. 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.

Jenkins, K. J., and E. E. Starkey. 1984. Habitat use by Roosevelt elk in unmanaged forests of the Hoh Valley, Washington. J. Wildl. Manage. 48:642-646.

Johnson. D. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61(1):65-71.

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

Kie, J. G., J. A. Baldwin, and C. J. Evans. 1994. CALHOME home range analysis program electronic users manual. U.S. Forest Service Pacific Southwest Research Station, Fresno, CA.

Kucera, T. E. 1992. Influence of sex and weather on migration of mule deer in California. Great Basin Naturalist 52(2). pp. 122-130.

_____. 1988. Ecology and population dynamics of mule deer in the Eastern Sierra Nevada, California. Ph.D. Thesis, Univ. of California Berkeley. 205 pp.

Leopold, A. S., T. Riney, R. McCain, and L. Tevis, Jr. 1951. The Jawbone deer herd. California Department of Fish and Game, Bulletin No. 4. 139 pp.

Loft, E. R., 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.

Marcum , C. L., and D. O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. J. Wildl. Manage. 44:963-968.

Mayer, K. E., and W. F. Laudenslayer Jr. 1988. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA.

Mohr C. O. 1947. Table of equivalent populations of North American mammals. Amer. Midland Nat. 37:223-249.

Neal, D. L., 1988. Bitterbrush. Pages 98-99 in K. E. Mayer and W. Laudenslayer (eds.), A guide to wildlife habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Raedeke Associates, Inc. 1994. Deer herd monitoring plan for the Snowcreek Ski Area-Final Review Draft, Inyo National Forest Bishop, California. 32 pp.

Risser, R. J., and M. E. Fry. 1988. Montane chaparral. Pages 102-103 99 in K. E. Mayer and W. Laudenslayer (eds.), A guide to wildlife habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA.

Russel, C. P. 1932. Seasonal migration of mule deer. Ecological monograph. 2:1-46.

Samuel, M. D., and R. E. Green. 1988. A revised test procedure for identifying core areas within the home range. J. Wildl. Ecol. 57:1067-1068.

_____, D. J. Pierce, and E. O. Garton. 1985. Identifying core areas of concentrated use within the home range. J. Animal. Ecol. 57:1067-1068.

_____, E. O. Garton, M. W. Schlegel, and R. G. Carson. 1987. Visibility bias during aerial surveys of elk on northcentral Idaho. J. Wildl. Manage. 51(3):622-630

_____, and K. H. Pollock. 1981. Correction of visibility bias in aerial surveys where animals occur in groups. J. Wildl. Manage. 45:993-997.

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

Swihart, R. K., and N. A. Slade. 1985. Influence of sampling interval on estimates of home range size. J. Wildl. Manage. 49:1019-1025.

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

Taylor, T. 1994. Snowcreek Ski Area deer migration study - 1993 fall migration report. Final report to Dempsey Construction Corporation, Mammoth Lakes, CA.

_____. 1993a. Rimrock Ranch Specific Plan deer study. Mono County Planning Dept. 59 pp.

_____. 1993b. Snowcreek Ski Area deer migration study - 1993 spring migration report. Final report to Dempsey Construction Corporation, Mammoth Lakes, CA.

_____. 1991. Ecology and productivity of two eastern Sierra deer herds. California Dept. of Fish and Game. 155 pp.

_____. 1989. Sherwin Ski Area deer study spring migration report. 9 pp.

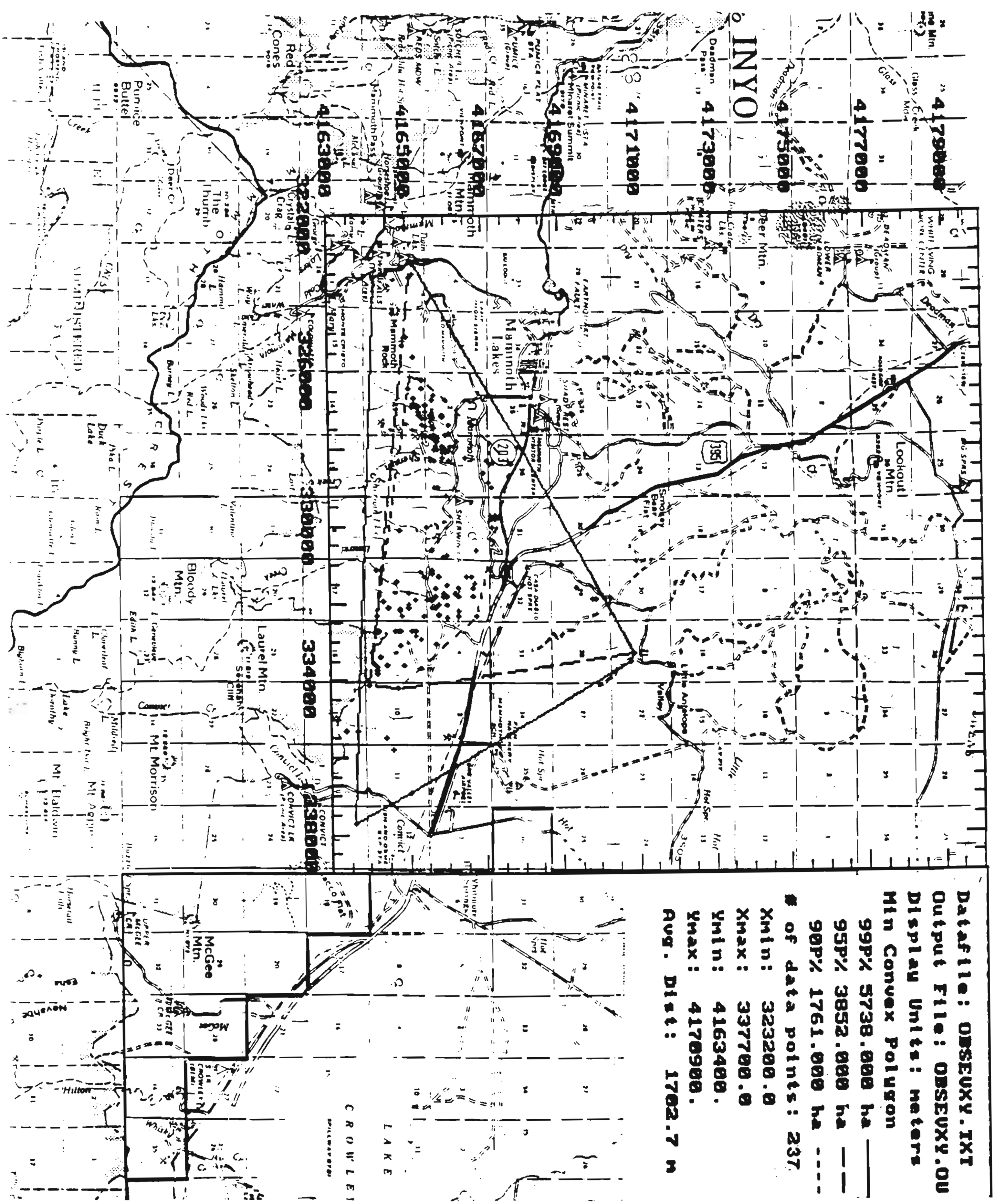
U.S. Forest Service. 1991. Sherwin Ski Area Final Environmental Impact Statement. USDA Forest Service, Bishop, CA.

Verme, L. J. 1968. An index to winter severity for northern deer. J. Wildl. Manage. 32 (3):556-574.

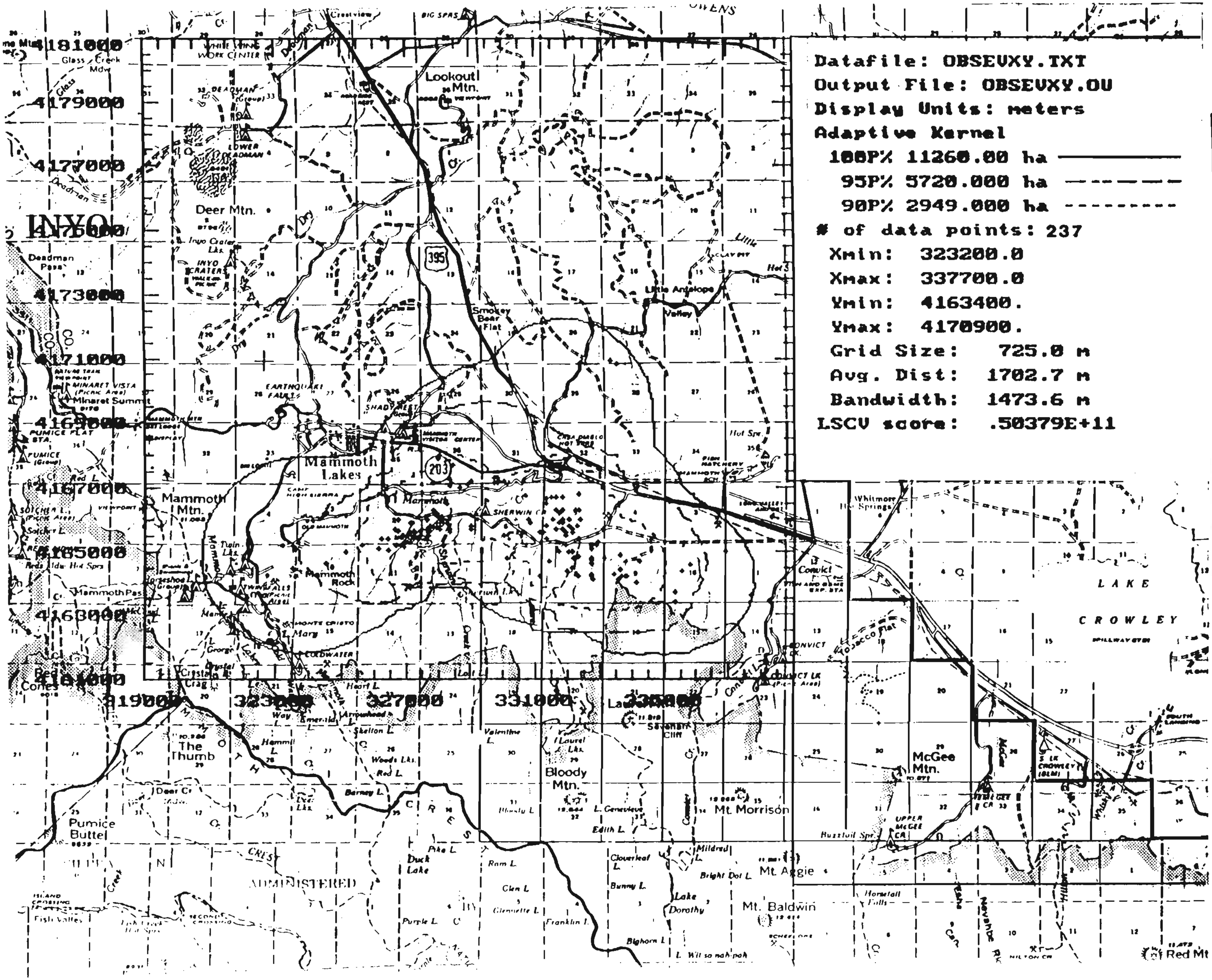
Wallmo, O. C., and R. B. Gill. 1971. Snow, winter distribution and population dynamics of mule deer in the central Rocky Mountains. In Proc. snow and ice in relation to wildlife and recreation symp., ed. A. O. Haugen, pp. 1-15. Ames. Cooperative Wildlife Research Unit. Iowa State University, 280 pp.

Worton B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168.

APPENDIX



Appendix Figure 1. Minimum convex polygon composite home range areas (ha) in the Sherwin Holding Area using 99%, 95%, and 90% of sample observations.



Appendix Figure 2. Adaptive kernel isopleths for composite home range areas (ha) in the Sherwin Holding Area using 99%, 95%, and 90% of sample observations.