SNOWCREEK SKI AREA DEER STUDY
1995 SPRING AND FALL MIGRATION STUDY

DRAFT REPORT

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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.

Over 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 1995 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 permit area and surrounding vicinity; 2) estimate deer population size on the Sherwin Holding Area (SHA) from mark-recapture techniques; 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; 4) determine patterns of diurnal habitat use by radio-collared deer on the SHA, SSA permit area, and surrounding lands; and 5) delineate specific migratory routes over the Sierra Crest used by individual radio-collared deer. Objectives of the fall work were to determine the timing and intensity of fall migration through the SSA permit area and the specific locations of deer migration routes.

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 (1,226 hectares) of steep, generally north-facing, mountainous terrain at elevations ranging from 2,490 to 3,663 meters (m). 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

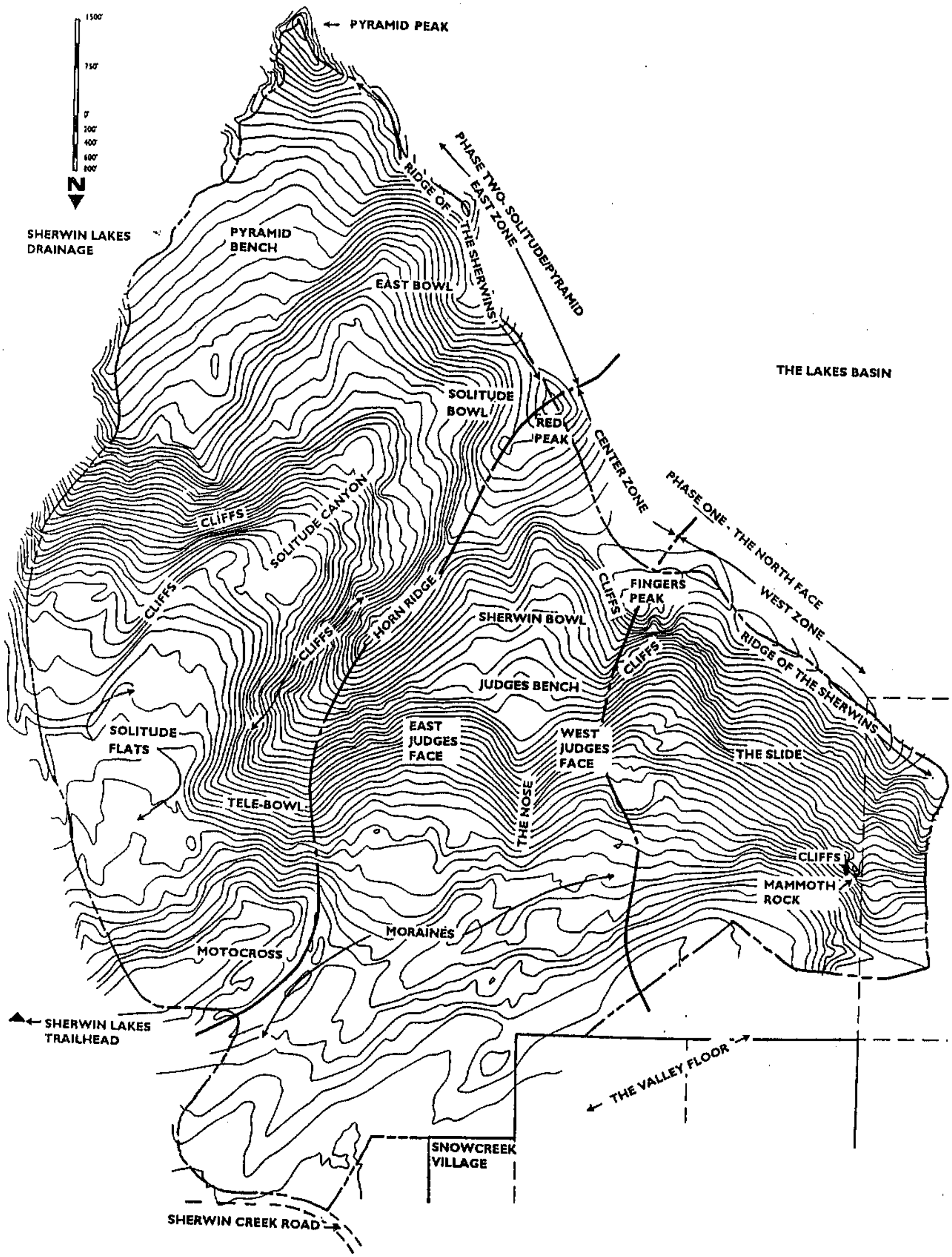
Section 2.0 of the Draft Deer Herd Monitoring Plan (Raedeke Associates 1994) described specific tasks that would be used to achieve the objectives outlined above. These tasks are to be conducted in different stages, related to development of the SSA. The following sections describe the methodologies used to complete specific tasks performed during 1995 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.

Individual deer were relocated an average of 3 times/week (range 1-5 times/week) during daylight hours. To maintain independence between successive relocations, an individual deer was never located more than once per day (Dunn and Gipson 1977). 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



SNOWCREEK SKI AREA
SNOWCREEK RESORT
at Mammoth Lakes, California

MASTER DEVELOPMENT PLAN

PERMIT BOUNDARY AND TOPOGRAPHY

Land Plan Services

FIGURE:

Survey 7.5 minute topographic maps and the Universal Transverse Mecator (UTM) coordinates for the positions were recorded to the nearest 50 meters.

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 CALHOME is limited to 500 data points, we pooled data for all individuals to estimate monthly composite home-ranges on the SHA (Andelt and Andelt 1981, Jenkins and Starkey 1984). Areas of concentrated deer use within monthly 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).

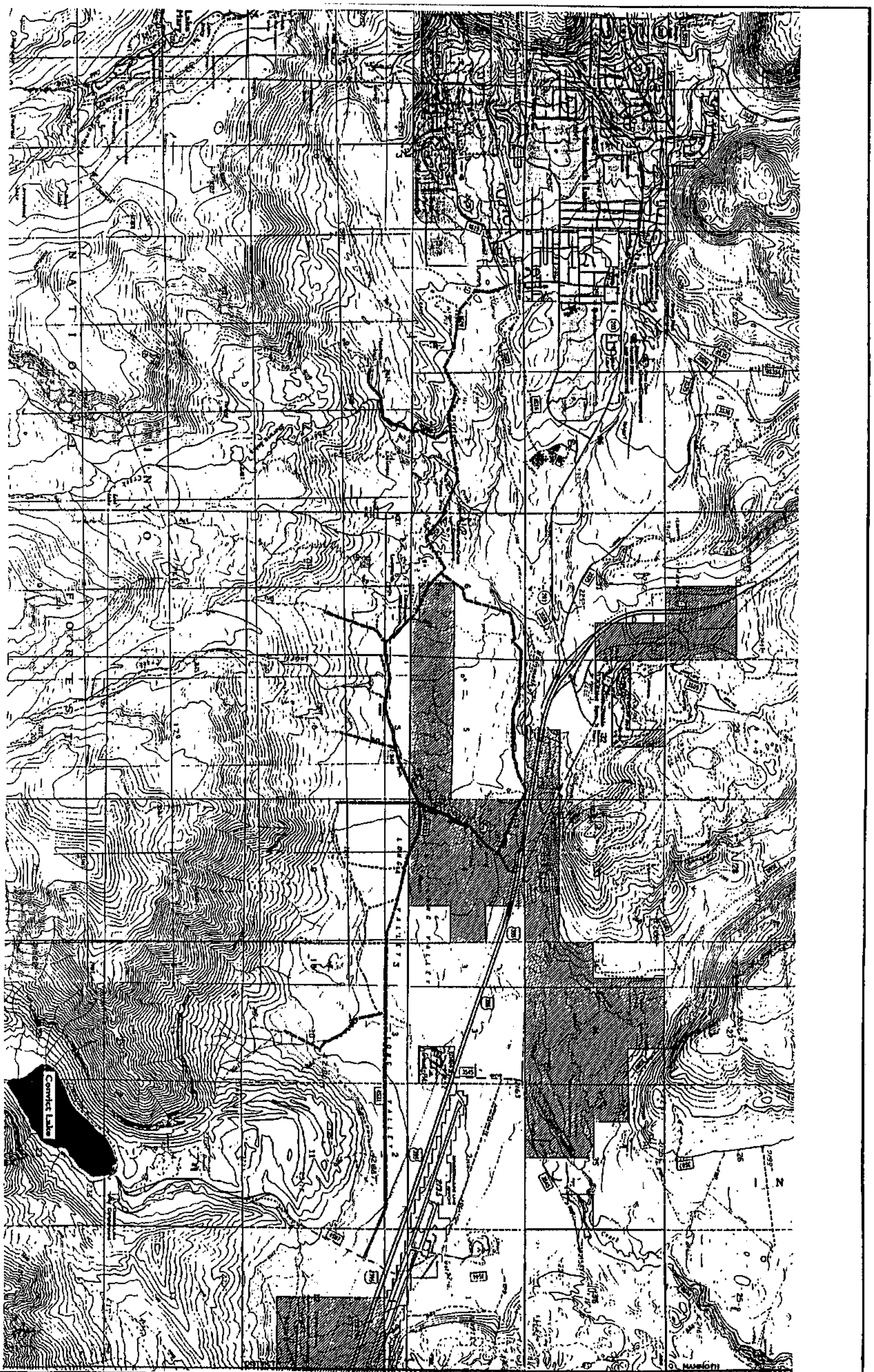
Major migration routes between winter and summer ranges were ascertained by tracking radioed deer closely once they departed the winter range. The locations of these routes were mapped on U.S. Geological Survey 7.5 minute maps and the proportions of radio-collared deer using each route was recorded. If a deer's migration route 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. The summer range locations of radio-collared deer were determined by CDFG from a fixed-wing aircraft during September 1995.

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, 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 UTM X and Y coordinates were recorded for the location of each group. 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 determining deer locations.

We estimated population size (N) for each deer count survey using Chapman's (1951) modification of the Petersen-Lincoln estimator: $N_i = (n_1 + 1)(n_i +1)/m_i +1) - 1$, and



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DEER COUNT SURVEY ROUTE

FIGURE: 1-2

variance (var) of $N_i = (n_1 + 1)(n_i + 1)(n_1 - m_i)(n_i - m_i)/(m_i + 1)^2(m_i + 2)$, where n_1 is the total number of radio-collared deer available on the SHA, n_i is total number of animals observed, and m_i is total number of radio-collared deer observed on survey i. 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). Accuracy was evaluated by comparing our Petersen-Lincoln estimates (N) with CDFG winter population estimates.

We first estimated population size (N) for each survey based on the total number radio-collared deer available (n_1) on the SHA and the total number of marked animals observed (m_i). To determine if collar color affected observability, we then calculated population estimates for each survey using only adult females marked with yellow, yellow-green, and white radio-collars. Raedeke Associates (1994) suggested that mark-resighting could be a reliable method of estimating deer population size on the SHA. Therefore, we used radio-collared deer to determine the sightability of deer during our weekly surveys. This information will be used to develop an index to predict deer sightability on the SHA during Phase III of the DHMP.

Habitat Use Studies

Proportional use of habitat parameters on the SHA was determined from deer clusters observed during weekly deer count surveys and from pooled relocation data obtained for all radio-collared animals during the 1995 spring migration. Chi-square Goodness-of-fit tests were used to determine whether deer use on the SHA was similar to expected use. Boniferroni confidence intervals (Neu et al. 1974, Marcum and Loftsgaarden 1980, Byers et al. 1984) were used to determine which habitats in the SHA deviated from expected use. We set the level of statistical significance at an alpha level = 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 (10,300 meters elevation) during spring 1995 surveys. Each station consisted of two units, a transmitter and a receiver, both of which were fastened to 5 x 6.5 centimeter (cm) posts. The units were spaced approximately 19 m apart, with the infrared beam aligned at 60 cm above ground. The 10 stations were oriented back-to-back in a continuous straight line that spanned the entire width of Solitude Pass.

Severe weather conditions (e.g., high winds and drifting snow) at Solitude Pass during spring 1995 made it difficult to maintain the Trailmaster units in continuous working condition. Therefore, prior to 1995 fall migration, we moved Trailmaster units from Solitude Pass to a more protected, lower elevation area of Solitude Canyon (8,900 m elevation). A total of 8 Trailmaster counting stations were established along heavily used deer trails in the canyon. Trailmaster units were fastened to wooden posts and the infrared beam aligned to cross the deer trail at 60 cm above ground.

We used Trailmaster event data to determine the timing and intensity of seasonal migrations through the SSA permit area. Julian date was used to determine the mean date of deer crossing over Solitude Pass during the spring and fall migrations. Analysis of variance (ANOVA) was used to test for differences among years in mean crossing dates of deer over Solitude Pass. Differences were considered significant at an alpha level of ≤ 0.05.

Deer Fatalities

All deer fatalities encountered by DCC field personnel during the course of deer herd monitoring studies were recorded and analyzed. Protocol and field forms for necropsy and data collection procedures were developed by CDFG. The following information was recorded for each deer fatality: sex, age, identification number, cause of death, and UTM location. In addition, the following carcass measurements were recorded: estimated weight, neck girth, chest girth, hindfoot length, and animal condition. Following these measurements, the kidneys, reproductive tracts, two first incisors, and femurs were collected for transfer to CDFG personnel.

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.

ORGANIZATION OF THIS REPORT

This report contains the following chapters:

- Chapter 1, "Introduction and Methods"
- Chapter 2, "Spring Migration," describes the results of spring 1995 deer migration surveys and compares these results to data collected by DCC during spring 1993 and 1994.
- Chapter 3. "Summer Range", describes the results of deer fawning surveys conducted in the SSA permit area during August 1995.
- Chapter 4, "Fall Migration", describes the results of fall 1995 deer migration surveys and compares these results to data collected by DCC during fall 1993 and 1994.
- 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 25 and July 7, 1995.

The temporal pattern of the 1995 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 9 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

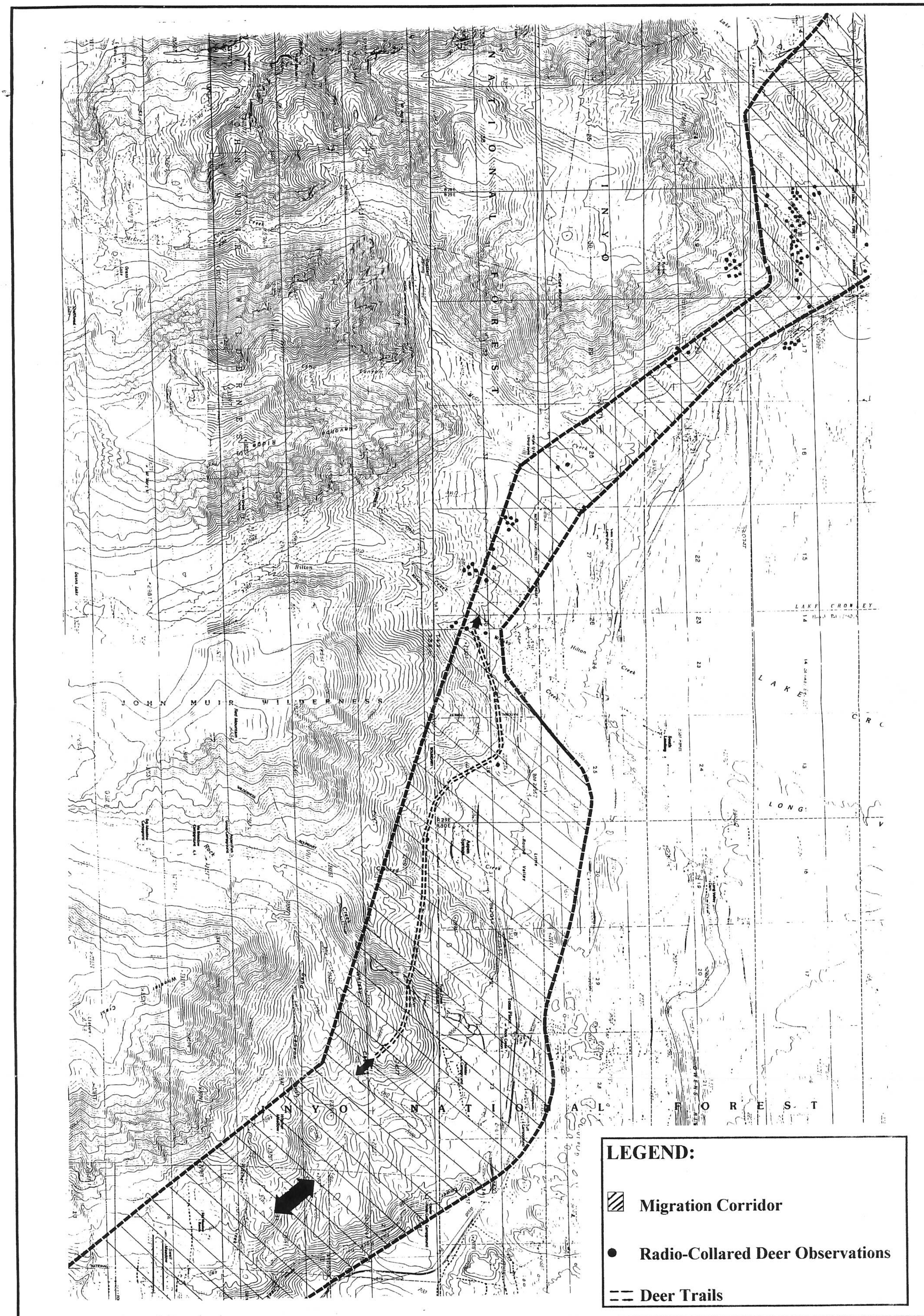
During spring 1995, migration patterns were determined for 106 radio-collared deer from the RVWR. Of these 106 deer, 98 migrated north from the RVWR, 7 migrated south, and 1 remained on RVWR during the summer.

Locations of Deer Movements

During spring 1995, deer migration from the RVWR occurred gradually between late April and early June; the first radio-collared deer was detected moving north of the Round Valley winter range on April 28. The migration corridor used by deer migrating north from Round Valley to the SHA followed the base of the eastern slope of the Sierra Nevada (Figure 2-1). A description of topography, vegetation, and deer use patterns within this corridor was provided by Taylor (1995).

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 1994 and 1995 indicated that deer delayed migration on the lateral moraines located



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LOCATION OF THE ROUND VALLEY DEER HERD MIGRATION CORRIDOR, SPRING 1995

FIGURE: 2-1

between Convict Creek and Tobacco Flat (Figure 2-1). 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 entered on the SHA once they arrived on 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 1995 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 98 radio-collared deer that migrated north from the Round Valley winter range during spring 1995, 93 delayed migration on the SHA, from Tobacco Flat west to the TML. The remaining 5 deer delayed at various points along the migration corridor between Hilton Creek and Tobacco Flat (Figure 2-1). Deer delayed migration on the SHA for a period of approximately 9 weeks, from April 29-June 30. Of the 93 deer that delayed migration on the SHA, approximately 25% were on the holding area by May 5 and nearly 50% by May 10. By May 19, approximately 75% of deer had arrived on the SHA; the last deer arrived on June 10 (Figure 2-2).

Peak numbers of radio-collared deer occurred on the SHA during the last week of May and the first two weeks of June (Figure 2-3). After mid-June, the number of radio-collared deer on the SHA gradually decreased as deer migrated to the summer range. Of the 93 deer that delayed on the SHA during spring migration, 58 migrated from the SHA after the holding period, 29 remained on the SHA for the summer, and 6 died. Of the 58 deer that migrated from the SHA, approximately 25% left between May 13 and June 9; 50% between June 9 and 16; 75% between June 16 and 21; and the remainder between June 20 and 30 (Figure 2-2). Deer delayed migration on the SHA for an average of 32 days (range = 2-62 days, SE = 1.67) (Figure 2-4).

Of the 93 radio-collared deer that delayed migration on the SHA during spring migration, 16 (17%) were detected within the boundaries of the SSA permit area. Of these 16 deer, approximately 30% had arrived in the permit area by May 24 and 60% by June 2 (Figure 2-5). By June 5, approximately 94% of radioed deer had arrived in the permit area; the last deer arrived on June 6.

Peak numbers of radio-collared deer were detected in the SSA permit area during late May. Approximately 30% of deer migrated from the permit area between June 3 and June 5, 60% between June 5 and June 8 (Figure 2-5). By June 14, nearly 90% of radioed deer had migrated from the permit area; the last deer migrated on 24 June. Deer delayed migration in the permit area for an average of 21 days (range 1-43 days) (Figure 2-4).

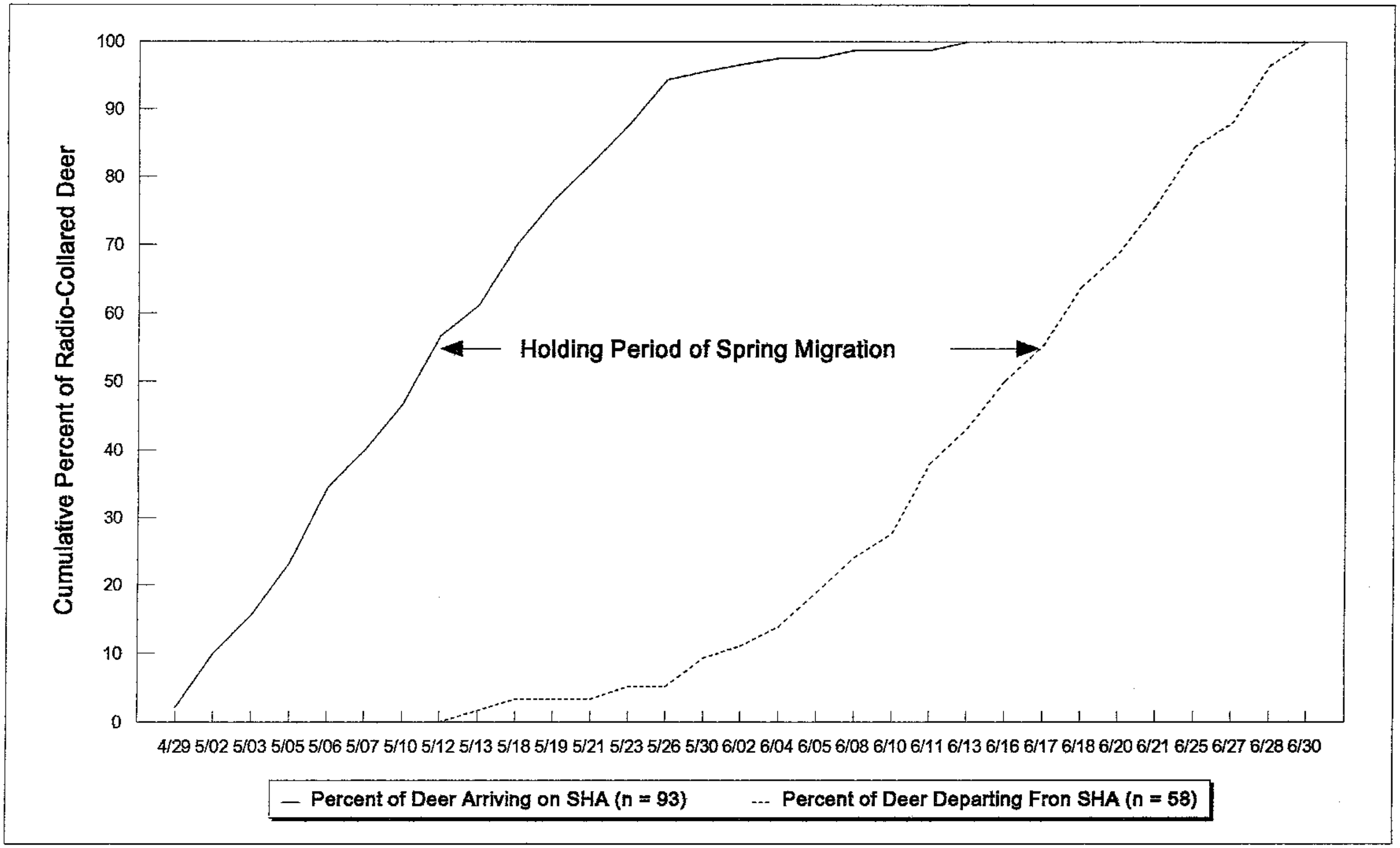

Figure 2-2. Cumulative Percent of Holdover Radio-Collared Deer Arriving on and Departing from the Sherwin Holding Area during the 1995 Spring Migration.

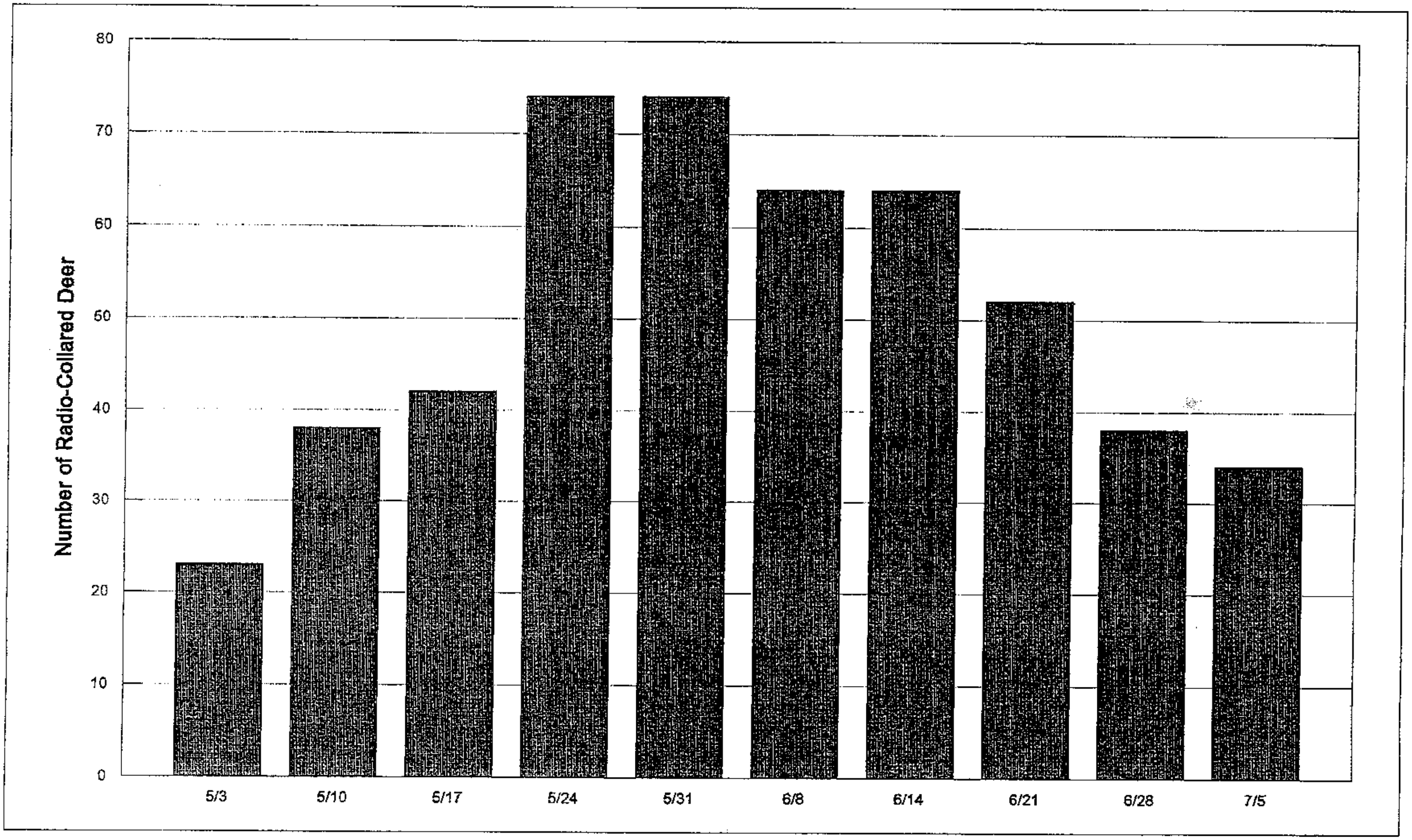

Figure 2-3. Weekly Number of Radioed-Collared Deer Detected on the Sherwin Holding Area during the 1995 Spring Migration.

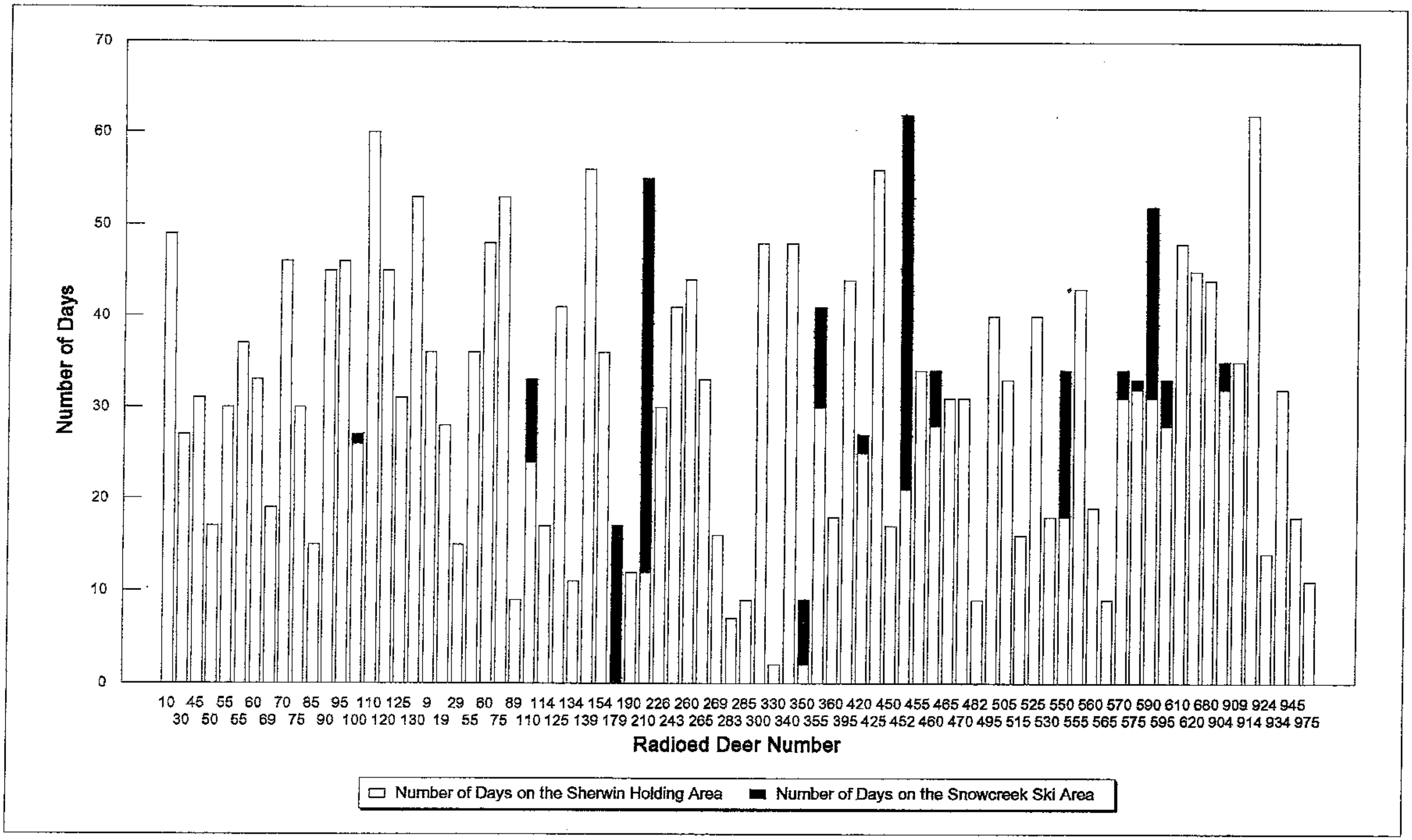

Figure 2-4. Period of Delay for Individual Radio-Collared Deer on the Sherwin Holding Area and the Snowcreek Ski Area during the 1995 Spring Migration.

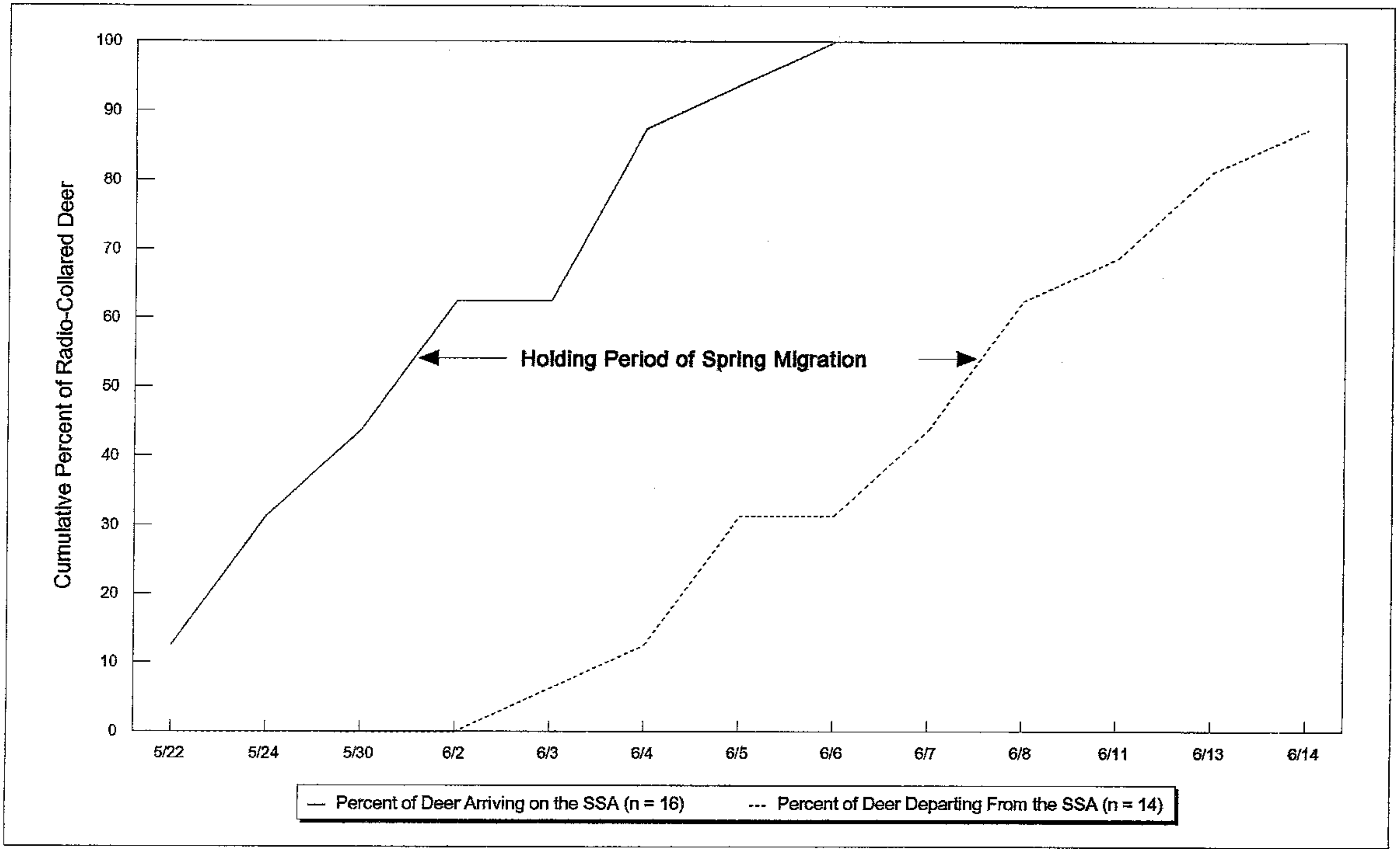

Figure 2-5. Cumulative Percent of Holdover Radio-Collared Deer Arriving on and Departing from the Snowcreek Ski Area during the 1995 Spring Migration.

In comparison, during spring 1994, which followed an unusually mild winter, radio-collared deer delayed spring migration on the SHA for a period of approximately 10 weeks, from April 13-June 21 (Taylor 1995). Radio-collared deer occurred in peak numbers on the SHA during the second and third weeks of May, then decreased from late May through mid-June as deer migrated to the summer range. Deer delayed spring migration on the SHA for an average of 31 days (range 3-60 days).

During the 1994 spring migration, 49% of radio-collared deer that used the SHA, also delayed migration within the boundaries of the SSA permit area (Taylor 1995). Deer delayed migration within the SSA permit area for a period of approximately 9 weeks, from April 21 and June 24. Peak numbers of deer were located in the SSA permit area during mid-May, then decreased through mid-June as deer migrated to the summer range. Deer delayed spring migration in the SSA permit area for an average of 18 days (range = 2-45 days).

Deer Count Surveys. Deer count surveys provided a second index of the temporal pattern of spring migration on the SHA. Ten deer count surveys were conducted in the SHA between May 3 and July 5. These surveys indicated that deer began arriving on the holding area during the last week of April and the first week of May (Figure 2-6). Peak numbers of deer were counted on the SHA during late May and early June; a total of 337 and 251 deer were counted during surveys conducted on May 24 and June 8, respectively. After June 8, the number of deer counted during weekly surveys 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 comparable to spring 1993 and approximately 1 month later than spring 1994 (Figure 2-6). During spring 1993, deer were first observed on the holding area on April 30 and peak numbers were counted on May 25 (Taylor 1993). In comparison, during spring 1994, deer were first observed on the holding area on April 7 and peak numbers were counted on May 12 (Taylor 1995).

The variation between years in the temporal pattern of spring migration was related to winter severity and spring temperatures. The 1993 and 1995 spring migrations followed severe winters, with total snowfall accumulations in Mammoth Lakes exceeding 120% of normal. During both years, a heavy snow pack persisted until early May along migration routes and on the summer range because cool spring temperatures prevented snow from melting rapidly. Average minimum temperatures of 19° Fahrenheit (F) (-7° C) March and 21° F (-6° C) in April delayed plant phenology at higher elevations, forcing deer to remain on winter and spring ranges where herbaceous spring forage was readily available.

Conversely, 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

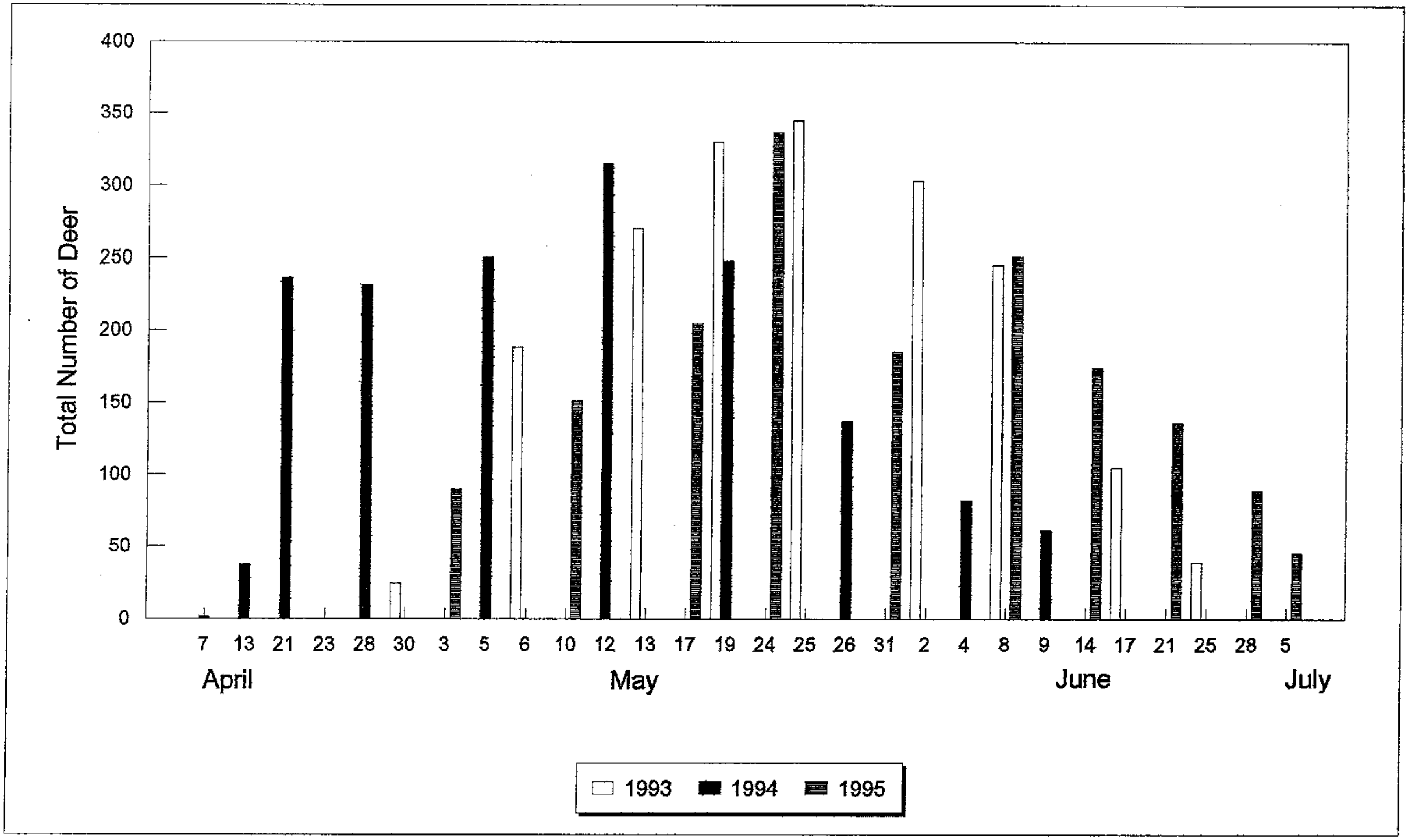

Figure 2-6. Number of Deer Counted per Day during Deer Count Surveys Conducted on the Sherwin Holding Area, Spring 1993-1995

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° F (22° C) in April and 80° F (27° C) in May.

Estimates of Deer Abundance on the Sherwin Holding Area

Petersen-Lincoln Estimates. During spring 1995, mark-resighting estimates (N) based on the total number radio-collared deer available (n_1) on the SHA and the total number of marked animals observed (m_i), ranged from a low of 363 deer (95% CI = 267-449) on May 3 to a high of 1,101 deer (95% CI = 972-1,230) on May 24 (Table 2-1). CDFG (CDFG, unpubl. data) reported a 1995 spring population estimate for the Round Valley herd of 1,147 deer (95% CI = 881-1,373) and radio-telemetry data indicated that approximately 63% of these animals, or some 730 deer, were on the holding area during the May 3 survey. Therefore, our highest population estimate of 1,101 deer did not seem reasonable because it indicated that approximately 96% of the Round Valley population was on the holding area during the May 3 survey.

To determine if collar color affected observability, we performed population estimates using only adult females marked with yellow, yellow-green, and white radio-collars. Yellow, yellow-green, and white collars worn by adult does would enhance deer identification because they are more visible to observers. In contrast, orange and brown collars worn by fawns and bucks are less visible and would have a higher probability of being missed. Based on 45 yellow, yellow-green, and white collared animals known to be on the SHA during the May 3 survey, and the observation of 14 of those collars during the survey, we derived a maximum population estimate of 968 deer (95% CI = 634-1,302) (Table 2-1). This estimate was 84% of the CDFG population estimate, but the CI exceeded the CDFG estimate by 12%. Assuming that approximately 70% of the radio-collared deer with yellow, yellow-green, and white collars were on the SHA during the May 3 survey, we derived a population estimate of 809 animals using radio-telemetry data. Thus, it appears that errors in the Petersen-Lincoln estimates based on females only were approximately 13% less than for all deer (Table 2-1), but still substantial for most surveys.

During spring 1994, mark-resighting estimates based on the total number radio-collared deer available (n_1) on the SHA and the total number of marked animals observed (m_i), 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 (Taylor 1995). CDFG (CDFG, unpubl. data) reported a 1993-94 winter population estimate of 1,127 deer (95% CI = 929-1,325) and telemetry data indicated that approximately 52% of radio-collared deer were on the SHA during the May 12 survey. Therefore, assuming that deer were trapped in proportion to their availability, we derived population estimate of 597 deer using radio-telemetry.

Sighting Probability. Our data implies that estimates of population size based on females with yellow, yellow-green, and white collars were better than those for all deer because of smaller biases in observability (Table 2-1). When all radio-collars were included, the probability of sighting a deer, as estimated by the probability of sighting a marked deer (Bear et al. 1989), averaged 0.23 (range = 0.13-0.34, SD = 7.4) for the 9 deer count surveys (Table 2-1). In comparison, sighting probability based on yellow, yellow-green, and white collars averaged 0.30 (range = 0.13-0.44, SD = 9.6). Thus, we

Table 2-1. Mean population estimates and ranges within 95% confidence limits for mule deer counted on the Sherwin holding area during deer count surveys conducted from May 3-July 7, 1995.

Date of Survey	Number of Deer Observed (n_i)	Number of Radioed Deer Observed (m_i)	Number of Radioed Deer on the Holding Area (n_1)	Estimated Number of Deer on the Holding Area (N)	95% Confidence Intervals	Probability Sighting (%)
Yellow, green-yellow, and white radio-collars used as marked animals						
May 3	90	4	15	290	32-548	27
May 10	151	10	29	424	234-594	34
May 17	205	12	27	443	286-600	44
May 24	337	14	45	968	634-1,302	31
May 31	185	9	46	873	441-1,325	20
June 8	251	15	40	645	413-887	38
June 14	174	13	35	449	277-621	37
June 21	136	7	31	437	230-644	26
June 28	89	3	23	359	245-437	13
All radio-collars used as marked animals						
May 3	90	5	23	363	269-459	22
May 10	151	13	38	422	304-540	34
May 17	205	13	42	632	549-715	31
May 24	337	22	74	1,101	972-1,230	30
May 31	185	13	74	995	791-1,199	18
June 8	251	18	64	861	656-1,040	29
June 14	174	16	64	338	522-814	29
June 21	136	11	52	605	523-813	17
June 28	89	5	38	584	490-678	13

can conclude that yellow, yellow-green, and white collars were less likely to be missed than brown and orange collars.

Group size is generally believed to be an important factor affecting sightability in ungulate populations (Cook and Martin 1974, Cook and Jacobson 1979, Samuel and Pollock 1981). For example, Samuel et al. (1987) reported that average sightability of elk (*Cervus elaphaus*) increased from 0.22 for a single animal to 1.0 for groups >15. To examine the influence of numerical group size on sightability, we pooled deer count survey data collected during 1994 and 1995. A simple linear regression yielded a significant ($P = 0.064$) and positive ($R^2 = 0.60$) correlation between sighting probability and group size (Figure 2-7a). There was also a weak positive relationship ($R^2 = 0.18$) between sighting probability and deer density (Figure 2-7b), which according to Samuel et al. (1987) may partially be related to the influence of group size. In both 1993 and 1994, the trend in sighting probability followed a pattern of increasing visibility with increasing deer density and group size.

We did not attempt to fully determine the magnitude of visibility bias associated with our roadside surveys. Numerous factors including animal behavior and dispersion,

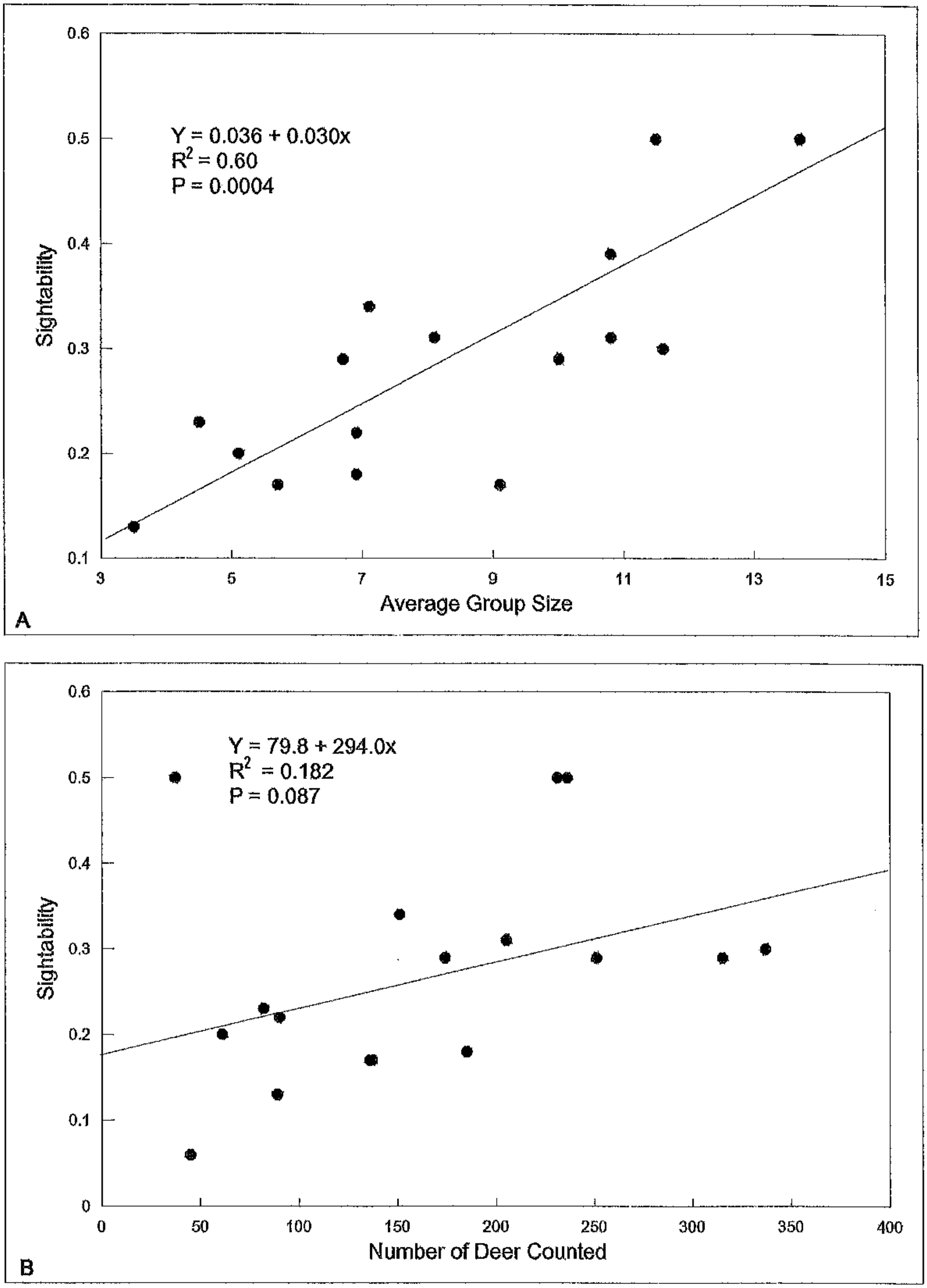

Figure 2-7. The Trend in Sighting Probability on Group Size (2-7a) and the Number of Deer Counted in the Sherwin Holding Area (2-7b) during the 1995 Spring Migration

vegetation, topography, observer experience, weather, equipment, and methods may affect the number of animals observed (Samuel et al. 1987, Ackerman 1988, Davis 1990). Moreover, bias may result in part from violation of the assumption of equal observability among animals (Bartmann et al. 1986, McCullough and Hirth 1988) and between sex-age classes (Downing et al. 1977, McCullough et al. 1994). Because our objective is to monitor long-term trends in deer abundance on the holding area, we stabilized visibility biases by standardizing our weekly surveys to route, time of day, weather, observers, and habitat conditions (McCullough et al. 1994).

Patterns of Deer Habitat Use on the Sherwin Holding Area

Habitat use on the SHA during spring migration was determined from deer count surveys and from observations of radio-collared deer. Data from deer count survey included observations of deer made during weekly dawn surveys on approximately 6,600 acres of the SHA lying adjacent to the deer count survey route (Figure 1-2). Observations of radio-collared deer were made daily throughout the spring holding period on approximately 9,440 acres of the SHA located between Tobacco Flat and the TML.

Deer Count Surveys. A Chi-square test of independence showed that habitat use differed significantly among years (Chi-square, $\chi^2 = 54.9$; 8 df; $P < 0.05$) (Table 2-2); therefore these data were analyzed separately. Sagebrush habitat was used less than expected in 1993 ($\chi^2 = 54.8$; 4 df; $P < 0.05$) and 1994 ($\chi^2 = 53.3$; 4 df; $P < 0.05$) and more than expected in 1995 ($\chi^2 = 11.9$; 4 df; $P < 0.05$). Conversely, montane chaparral habitat was preferred in 1993 and 1994 and avoided in 1995. Wet meadow and Jeffrey pine were avoided in 1993 and 1995, respectively. Perennial grassland was used in proportion to its availability during all years.

Habitat use differed significantly during May in 1994 ($\chi^2 = 25.9$; 4 df; $P < 0.05$) and 1995 ($\chi^2 = 23.3$, 4 df, $P < 0.05$) and June in 1993 ($\chi^2 = 58.5$; 4 df; $P < 0.05$) and 1994 ($\chi^2 = 93.4$; 4 df; $P < 0.05$) (Table 2-3). During May 1994, montane chaparral was used and sagebrush was avoided, while in May 1995, sagebrush was used and other habitats were avoided or used in proportion to their availability. During June 1993, deer preferred montane chaparral and perennial grassland and avoided sagebrush. In both years, use of habitat during April was not significantly different from availability.

In 1993 and 1994, deer preferred montane chaparral and avoided sagebrush; while in 1995, sagebrush was preferred and montane chaparral was avoided. The 1995 spring migration followed an extremely wet winter, with snowfall accumulations in the Mammoth Lakes area exceeding 150 percent of normal. This heavy snowpack lasted until late June and delayed plant phenology on upper elevation, north aspect slopes that supported large, dense stands of montane chaparral. As a result, deer used lower elevation, snow-free sagebrush habitat that provided an abundance of succulent herbaceous forage and new growth of browse, primarily antelope bitterbrush and snowberry. During spring 1994, use of montane chaparral may have been accentuated by drought conditions that would have

Table 2-2. Percent mule deer use (considered by groups) of available habitats on the Sherwin holding area during spring migration, 1993-1995.

Habitat type	Availability (%)	Use (%) 1993 (152)[a]	1994 (160)	1995 (219)	
Sagebrush	68	53-	55-	76+	71
Jeffrey Pine	12	10	6	6-	8 -
Montane Chaparral	11	25+	25+	11	14
Perennial Grassland	5	11	10	5	10
Wet Meadow	4	1-	4	2	5

[a] No. of observations shown in parentheses.
+ Indicates use > availability and - indicates use < availability ($P < 0.05$).

Table 2-3. Percent mule deer use (considered by groups) of available habitats on the Sherwin holding area by month during spring migration, 1993-1995.

Habitat Type	Availability (%)	Use (%) 1993 A (2)[a]	1993 M (88)	1993 J (62)	1994 A (45)	1994 M (85)	1994 J (30)	1995 M (115)	1995 J (100)	1995 J (4)
SB	68	100+	11	40-	71	55-	30-	90+	62	50-
JP	12	0-	60	8	9-	6	0	5-	7	0-
MC	11	0-	20	36+	14	26+	43+	3-	20	50+
PG	5	0-	2	0-	4	8	27+	1	5	0-
WM	4	0-	7	16	2	5	0	1-	4	0-

[a] No. of observations shown in parentheses.
+ Indicates use > availability and - indicates use < availability ($P < 0.05$).
JP = Jeffrey pine, SB = Sagebrush, MC = Montane Chaparral, WM = Wet Meadow, PG = Perennial Grassland.

reduced herbaceous forage production in other habitats on the SHA. Montane chaparral 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) and quickly regain condition lost over the winter (Short 1981, Garrott et al. 1987). Moreover, the dense multilayered structure of montane-chaparral vegetation also provided important thermal and hiding cover for deer.

Radio-collared Deer. Radio-collared deer provided a second measure of habitat use on the SHA during spring migration. A Chi-square test of independence showed that habitat use differed significantly between 1994 and 1995 ($\chi^2 = 22.9$, 4 df, $P \leq 0.05$) (Table 2-4); therefore the data were analyzed separately. During 1994, radio-collared deer preferred montane chaparral and avoided sagebrush and wet meadow ($\chi^2 = 49.0$, 4 df, $P < 0.001$), while other habitats were used in proportion to their availability. In comparison, during spring 1995, deer preferred montane chaparral and avoided wet meadow and perennial grassland ($\chi^2 = 123.7$, 4 df, $P < 0.001$); sagebrush and Jeffrey pine were used in proportion to availability (Table 2-4).

A Chi-square test of independence showed that habitat use differed significantly by month in 1994 ($\chi^2 = 18.1$, 4 df, $P \leq 0.05$) and 1995 ($\chi^2 = 34.1$, 4 df, $P \leq 0.05$) (Table 2-5); the data were analyzed separately. In 1994, habitat use differed significantly during April ($\chi^2 = 4.5$, 4 df, $P < 0.001$) and May ($\chi^2 = 62.1$, 4 df, $P < 0.001$). During April, perennial grassland was avoided and other habitats were used in proportion to their availability. During May, montane chaparral was preferred and sagebrush and wet meadow were avoided.

In comparison, in 1995, habitat use differed significantly during May ($\chi^2 = 34.6$, 4 df, $P < 0.001$) and June ($\chi^2 = 21.0$, 4 df, $P = 0.0003$) (Table 2-5). During May, sagebrush was preferred and wet meadow and perennial grassland were avoided. During June, montane chaparral was preferred and other habitats were used in proportion to their availability.

Mean elevations (2,345 and 2,260 m in 1994 and 1995, respectively) occupied by radio-collared deer on the SHA differed between years (t-test, $t = 12.8$, 1,259 df, $P \leq 0.000$). During spring 1995, a heavy snowpack that persisted until late June delayed plant phenology on upper elevation, north aspect slopes of the holding area. As a result, deer occupied lower elevation, snow-free sagebrush habitat that provided an abundance of high quality forage. Elevation of deer observations varied significantly by month in 1995 (ANOVA, $F = 162.2$, 1,000 df, $P \leq 0.000$), but not in 1994 (ANOVA, $F = 2.69$, 236 df, $P = 0.069$). During 1995, mean elevation of locations increased from 2,232 m ($n = 568$, $SE = 2.53$) in May to 2,297 m ($n = 433$, $SE = 4.89$) in June. This increase was likely related to the temporal availability and phenological development of herbaceous spring forage on the SHA during spring migration.

There was no significant difference ($\chi^2 = 7.8$, 4 df, $P \geq 0.05$) between years in the proportions of northerly (NW, N, NE) and southerly (SW, S, SE) aspects occupied during spring migration. During spring 1994, 75% and 2% of deer observations occurred on northerly and southerly aspects, respectively. In comparison, during spring 1995, 77% and 4% of deer observations occurred on northerly and southerly aspects, respectively. Proportions of deer locations on northerly and southerly aspect slopes varied by month in 1994 ($\chi^2 = 15.6$, 4 df, $P \leq 0.05$) and 1995 ($\chi^2 = 204.3$, 4 df, $P \leq 0.05$). During spring 1994, proportions of monthly locations on northerly aspects decreased in May, whereas

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Table 2-4. Availability and use (%) of habitats by radio-collared deer observed on the Sherwin holding area during spring migration, 1994-1995.

Habitat type	Availability (%)	Use (%) 1994 (n = 237)	Use (%) 1995 (n = 995)
Sagebrush	74	63	71
Jeffrey Pine	9	15	8
Montane Chaparral	7	17+	15+
Perennial Grassland	6	3	1.0-
Wet Meadow	4	2-	5.0-

[a] No. of observations shown in parentheses.

+ Indicates use > availability and - indicates use < availability ($P < 0.05$).

Table 2-5. Availability and use (%) of habitats by month for radio-collared deer observed on the Sherwin holding area during spring migration, 1994-1995.

Habitat Type	Availability (%)	Use (%) 1994 A (58)	Use (%) 1994 M (175)	Use (%) 1995 M (566)	Use (%) 1995 J (422)
Sagebrush	~~68~~ 74	72	58-	84+	56
Jeffrey Pine	~~12~~ 9	7	18	7	10
Montane Chaparral	~~11~~ 7	9	20+	5	24+
Perennial Grassland	~~5~~ 6	0-	2	1-	9
Wet Meadow	4 4	12	2-	3-	1

[a] No. of observations shown in parentheses.

+ Indicates use > availability and - indicates use < availability ($P < 0.05$).

proportions on southerly and westerly aspects increased (Figure 2-8). During spring 1995, proportions of deer locations on northerly aspects increased in June, while, at the same time, proportions of locations on other aspects decreased.

Observations of radio-collared deer on the SHA indicated that during spring 1994 deer preferred montane chaparral and avoided sagebrush and wet meadow. During spring 1995, deer also preferred montane chaparral, but used wet meadow and perennial grassland in proportions less than available. Our deer count survey data demonstrated similar significant differences in habitat use during 1994, but not during 1995. Deer count survey data indicated that during 1994, deer used montane chaparral and sagebrush, while

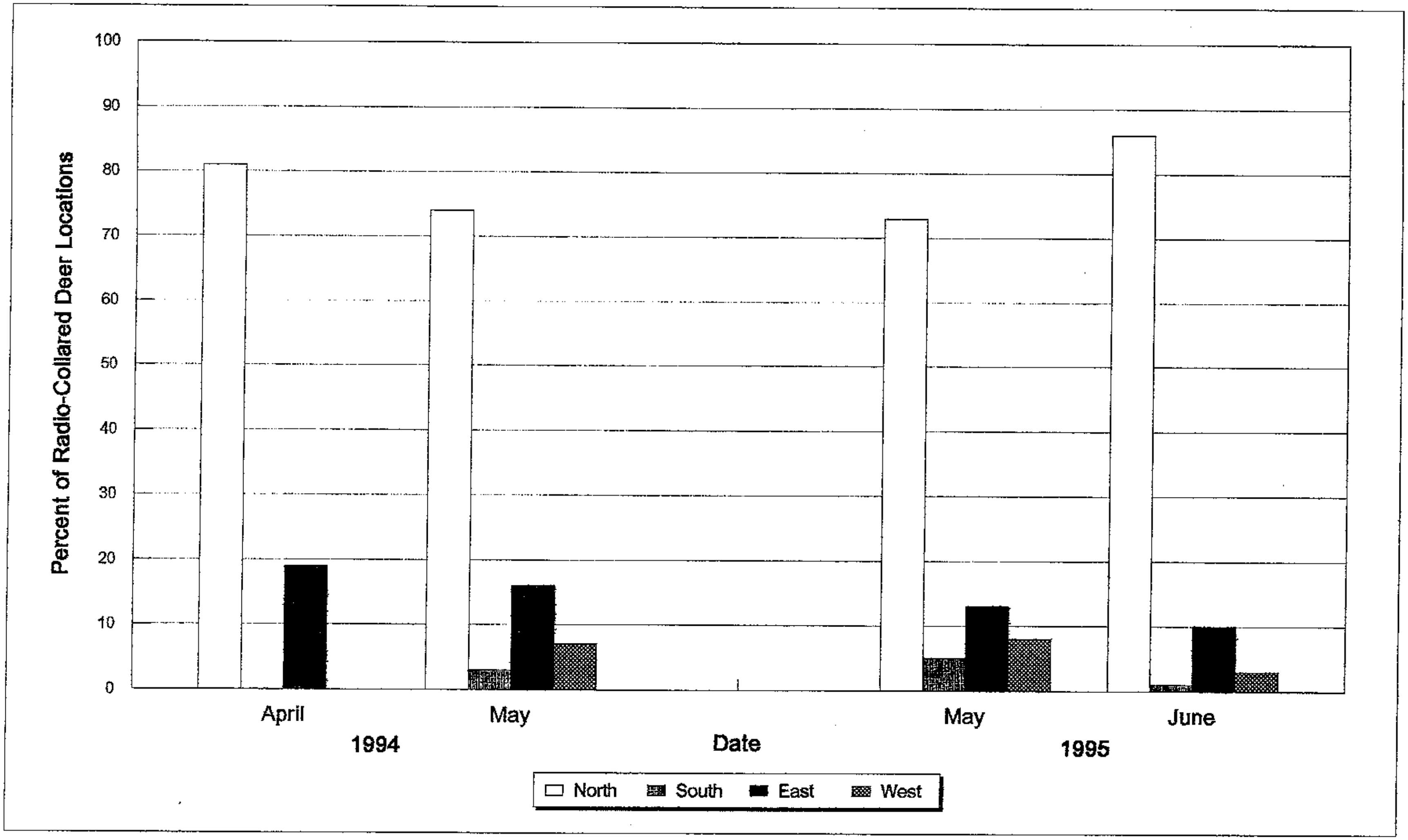

Figure 2-8. Use of Aspect (%) by Month for Radio-Collared Deer Observed on the Sherwin Holding Area during the 1994 and 1995 Spring Migrations.

other habitats were used in proportion to their availability (Table 2-2). In comparison, during 1995, deer used sagebrush in greater proportion than available; montane chaparral and Jeffrey pine were used less than available.

Observations of radio-collared deer may more accurately predict habitat use on the SHA, than observations of deer made during deer count surveys. Deer count surveys were conducted once weekly between 0530 and 1100 hours along a fixed route circulating through ≥ 5 habitats with different amounts of cover. Therefore, as indicated by our sighting probabilities, many animals were missed during deer count surveys because of differences in animal behavior, visual cover, weather, and other environmental factors. Unlike deer count surveys, observations of radio-collared deer were made daily, usually between 0600 and 1800 hours. Hence, these observations were not subjected to the same visibility bias affecting deer count surveys because a radio-collared deer had to be observed to be included in the analysis of habitat use.

Patterns of Deer Distribution on the Sherwin Holding Area

From April 29-July 7, 1995, a total of 995 observations from 92 radio-collared deer were obtained on the SHA. Because program CALHOME is limited to 500 data points, observations were pooled separately for May and June and used to estimate monthly composite home-ranges. After combining data points obtained for all individuals (n = 500) during May 1995, we estimated a composite minimum convex polygon (MCP) home-range size of 3,047 hectares (ha). Outlier observations significantly effected estimates of home-range size. For example, the removal of 25 outlier observations (95% MCP) from the data set reduced the MCP home-range size from 3,047 ha to 2,100 ha. When 90% of the sample points were used, estimates of the composite MCP home-range size declined to 1,907 ha (Table 2-6, Appendix Figure 1). In comparison, calculated isopleths of the adaptive kernel (ADK) for pooled observations obtained during May ranged from 2,148 to 6,973 ha for 100% and 90% of the sample points, respectively (Table 2-6, Appendix Figure 2).

A total of 433 observations from 90 radio-collared deer were used to estimate a composite home range for June 1995. Home-range size increased during June as the snow pack retreated and deer moved to higher elevations. When all data points were included, we estimated a composite home-range size of 5,487 hectares. Removal of outlier observations using 95% and 90% of data points reduced the MCP home-range size to 3,484 and 2,891 ha, respectively (Table 2-6, Appendix Figure 3). In comparison, estimated home-range isopleths of the ADK for pooled observations obtained during June ranged from 2,387 to 11,930 ha for 90% and 100% of the sample points, respectively (Table 2-4, Appendix Figure 4).

Table 2-6. Calculated monthly composite home ranges for mule deer on the Sherwin Holding Area using the minimum convex polygon and adaptive kernel methods, Spring 1995.

		MCP[1]			ADK[2]		
Year/ Month	Observations (n)	100%	95%	90%	100%	95%	90%
1994	237	6,888	3,852	1,761	11,260	5,720	2,949
1995							
May	500	3,047	2,100	1,907	6,973	2,780	2,184
June	433	5,487	3,485	2,891	11,930	3,617	2,387

[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 home-range boundaries are used by an animal. Our data appeared to fit this assumption fairly well for both May and June with the 95% ADK (Appendix Figures 2 and 4). Isopleths of the 95% ADK showed no large unused areas within the SHA and there were relatively few outlier locations. MCP's ≥ 90% and the 100% ADK included areas that received little holdover deer use, such as the Convict Lakes Basin, the steeper slopes of Laurel Mountain (> 2,500 m), and mixed conifer forest located on the north slope of the Sherwin range (Appendix Figures 1-4).

Isopleths of the ADK using 95% of May locations identified a single area of concentrated deer use extending from the Convict Lake Road northwest to Hwy 203, and from Hwy 395 southwest to Sherwin campground (Appendix Figure 2). In comparison, isopleths of the ADK using 95% of June locations identified 3 core areas (Appendix Figure 4). Core area A was located at the extreme eastern portion of the SHA in the vicinity of Tobacco Flat; core area B was located in the central portion of the SHA, between the west side of the Convict Knolls and Hwy 203; and, core area C was located at the extreme western end of the SHA, between the Mammoth Motocross road and the Mammoth Rock trail.

Estimates of home range size for June 1995 were similar to estimates obtained for spring 1994 (Taylor 1995) (Table 2-6). In spring 1994, we estimated MCP home-range sizes ranging from 1,761 to 6,888 ha for 90% and 100% of deer observations (n = 237), respectively. Isopleths of the ADK ranged from 2,949 to 11,260 ha for 90% and 100% of deer observations (n = 237), respectively. Isopleths of the ADK using 85% of locations identified two major core areas within the SHA during Spring 1994. Core area A extended 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. Core area B included the lower northern portion of the SSA, from approximately Mammoth Creek south to the Mammoth Motocross, and from Mammoth Rock east to the Sherwin campground area.

During spring 1995, MCP home range sizes for individual deer with ≥ 25 relocations (n = 5) averaged 549 ± 118 ha (range = 181-882 ha); ADK home-range sizes averaged 792 ± 148 ha (range = 367-1,206). Home-ranges for individual deer generally overlapped extensively. The size and shape of MCP and ADK home-ranges occupied by individual deer were large, elongated, and oriented from northwest to southeast along the base of Sierra escarpment. In addition, isopleths were generally larger in sagebrush habitat at the lower, southeast end of the home-range where deer activity was most concentrated. As the holding period progressed, however, activity centers shifted northwesterly into upper elevations of the SHA.

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

Overview. As discussed previously, during spring 1995, we determined movement patterns for 106 radio-collared deer from the RVWR. Of these 106 deer, 98 (92%) migrated north from the RVWR, 7 (7%) migrated south, and 1 (1%) remained on RVWR during the summer. Of the 98 deer that migrated north from the RVWR, 30 remained on the east slope of the Sierra during the summer, 45 migrated over the Sierra crest to west side summer ranges, and 6 died during the spring holding period; migration routes used by the remaining 17 deer were undetermined after the spring holding period. Of the 7 deer that migrated south from the RVWR, 2 summered on the east slope of the Sierra and 5 crossed the Sierra Crest to west side summer ranges. Thus, of the 106 deer for which movement patterns were determined, 50 (47%) crossed the Sierra Crest to west side summer ranges.

Deer that migrate north from the RVWR cross the Sierra Crest at 4 locations: Hopkins Pass, Solitude/Duck Pass, Mammoth Pass, and San Joaquin Ridge (Kucera 1988, Taylor 1995). Deer that migrate south from the RVWR cross the Sierra Crest at 3 locations: Piute Pass, Bishop Pass, and Lamarck Pass (Kucera 1988, Taylor 1995). The deer that used these different crossings are collectively referred to as herd segments, following Raedeke Associates (1994). The following provides a brief description of each herd segment:

- The Piute Pass, Bishop Pass, and Lamarck Pass segments represent deer that move south from the RVWR and cross the Sierra Crest at these locations.

- 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 to summer range over two passes: Solitude Pass, located in the permit area atop the Sherwin Range, and Duck Pass, located some 5 km further south on the Sierra Crest.

- The Mammoth Pass herd segment delays spring migration primarily in the western portion of the SHA, which includes the SSA 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

Of the 45 deer that migrated north and crossed the Sierra Crest, 35 moved through the SSA permit area; 6 crossed San Joaquin Ridge, and 4 used Hopkins Pass.

Migration through the SSA Permit Area. Of the 35 deer that migrated through the SSA permit area during the 1995 spring migration, 24 used the Mammoth Rock migration corridor to access summer range located in the Mammoth Lakes Basin and the Middle Fork of the San Joaquin River (Table 2-7). Thirteen of these 24 deer delayed migration for 1 or more days in the SSA permit area. Eleven of the 35 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 the Mono Creek drainage. To our knowledge, none of these 11 deer delayed migration in the SSA permit area.

Migration over Hopkins Pass and San Joaquin Ridge. Four deer migrated over Hopkins Pass to summer range located in the Mono Creek drainage (Table 2-7). All 4 of these deer delayed migration for 1 or more days in the vicinity of McGee Mountain. Six deer crossed San Joaquin Ridge to summer range located in the Upper Middle Fork of the San Joaquin River and the Rush Creek drainage.

Migration over Piute Pass, Bishop Pass, and Lamarck Pass. Of the 7 deer that migrated south from the RVWR, 5 crossed over either Piute Pass, Bishop Pass, or Lamarck Pass to west side summer ranges. Two deer remained on the east slope for the summer, one near Bishop Creek and the other on the upper Buttermilk (Table 2-7).

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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.

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- The Piute Pass, Bishop Pass, and Lamarck Pass segments represent deer that move south from the RVWR and cross the Sierra Crest at these locations.

- 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 to summer range over two passes: Solitude Pass, located in the permit area atop the Sherwin Range, and Duck Pass, located some 5 km further south on the Sierra Crest.

- The Mammoth Pass herd segment delays spring migration primarily in the western portion of the SHA, which includes the SSA 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.

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Of the 45 deer that migrated north and crossed the Sierra Crest, 35 moved through the SSA permit area; 6 crossed San Joaquin Ridge, and 4 used Hopkins Pass.

Migration through the SSA Permit Area. Of the 35 deer that migrated through the SSA permit area during the 1995 spring migration, 24 used the Mammoth Rock migration corridor to access summer range located in the Mammoth Lakes Basin and the Middle Fork of the San Joaquin River (Table 2-7). Thirteen of these 24 deer delayed migration for 1 or more days in the SSA permit area. Eleven of the 35 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 the Mono Creek drainage. To our knowledge, none of these 11 deer delayed migration in the SSA permit area.

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Table 2-7. Percent of radio-collared deer that used different migration routes over the Sierra crest during spring migration, 1994 and 1995.

	Percent of Radioed Sample			
	Spring 1994 (n = 39)		Spring 1995 (n = 50)	
Migration Routes	Number	Percent	Number	Percent
Southern Routes				
Bishop, Lamarck, and Passes	1	3	5	10
Subtotal	1	3	5	10
Northern Routes				
Hopkins Pass	3	8	4	8
Solitude/Duck Pass	15	38	11	22
Mammoth Rock	13	33	24	48
San Joaquin Ridge	7	18	6	12
Total	39	100	50	100

Summary of Deer Migration Over the Sierra Crest. Of the 106 deer for which movement patterns were determined during spring 1995, 50 (47%) crossed the Sierra Crest to west side summer ranges. Of these 50 deer, 24 (48%) used the Mammoth Rock migration corridor, 11 (22%) crossed over Solitude Pass, 6 (12%) used San Joaquin Ridge, 4 (8%) used Hopkins Pass, and 5 (10%) crossed over either Piute Pass, Bishop Pass or Lamarck Pass (Table 2-7). Using the CDFG 1995 winter range population estimate of 1,147 deer (CDFG, Unpubl.), the proportion of the deer herd that migrated through the SSA permit area numbered about 380 (35/106) or about 33% of the Round Valley population.

In comparison, during spring 1994, 39 (53%) of 74 radio-collared deer from the RVWR crossed the Sierra Crest to west side summer ranges (Table 2-7). Of these 39 deer, 13 (33%) used the Mammoth Rock migration corridor, 15 (38%) crossed over Solitude Pass, 7 (18%) crossed over San Joaquin Ridge; 3 (8%) used Hopkins Pass; and 1 (3%) crossed over Piute Pass. 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.

As mentioned previously, 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 many deer could potentially access 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.

Additionally, 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. Moreover, 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.

Timing and Intensity of Migration through the Snowcreek Ski Area

Remote Deer Counters. Trailmaster units at Solitude Pass recorded 317 events that could be used to determine the timing and intensity of deer movements through the SSA permit area. Deer began moving through Solitude Canyon and over Solitude Pass on June 22 and these movements continued until July 24 (Figure 2-9). Peak migration through the SSA permit area occurred between June 23 and June 30, when approximately 68% of all events were recorded. Approximately 17% of events were recorded between July 1 and July 6 and 15% between July 7 and July 24.

There was a significant difference (ANOVA, $F = 522.9$; 2, 825 df; $P \leq 0.000$) among years (1993-95) in the mean crossing dates of deer migrating over Solitude Pass during spring migration. Mean date of deer crossing during spring 1995 was June 29. In comparison, mean dates of deer crossing during spring 1993 and 1994 were June 9 and June 15, respectively. Differences among years in the timing of migration were probably related to winter severity and spring temperatures. The 1995 spring migration ensued an extremely wet winter, with snowfall accumulations in the Mammoth Lakes area exceeding 150% of normal. In addition, cool spring temperatures at upper elevations prevented the snowpack from melting rapidly. As a result, deer delayed migration over Solitude Pass until the third week of June. In comparison, during spring 1993, deer began moving through Solitude Canyon and over Solitude Pass on May 30 and peak migration occurred between June 14 and 15; the last deer crossed Solitude Pass on July 3 (Taylor 1993) (Figure 2-9, Table 2-8). During spring 1994, which followed an extremely mild winter, deer migration over Solitude Pass lasted from May 22 to June 30 and peak migration occurred between June 2 and June 15 (Taylor 1995).

Daily Timing of Deer Movements through the Snowcreek Ski Area

Remote Deer Counters. Trailmaster event data was used to determine the daily timing of deer movements through the SSA permit area. During spring 1995, 57% of events were recorded during daylight hours (6 a.m.-8 p.m.) (Figure 2-10). Of the daytime events, approximately 70% occurred between 10 a.m. and 5 p.m. During nighttime, 50% of events were recorded between 9 p.m and 11 p.m. and 36% between 2 a.m. and 4 a.m.

In comparison, during spring 1993 and 1994, 79% and 71% of events, respectively, were recorded during the daytime. In both years, approximately 50% of events occurred between 1 a.m.-9 a.m. The higher proportion of deer moving through the

Table 2-8. Approximate timing of deer movements through Solitude Canyon and over Solitude Pass during the spring migration, 1985-1989 and 1993-1995 (Kucera 1985, Taylor 1988, Taylor 1994).

Year	Total Annual Snowfall (in.)[1]	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
1994-95	393	22 June	24 July

[1] U.S. Forest Service, Mammoth Lakes, California.

permit area during these hours 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.

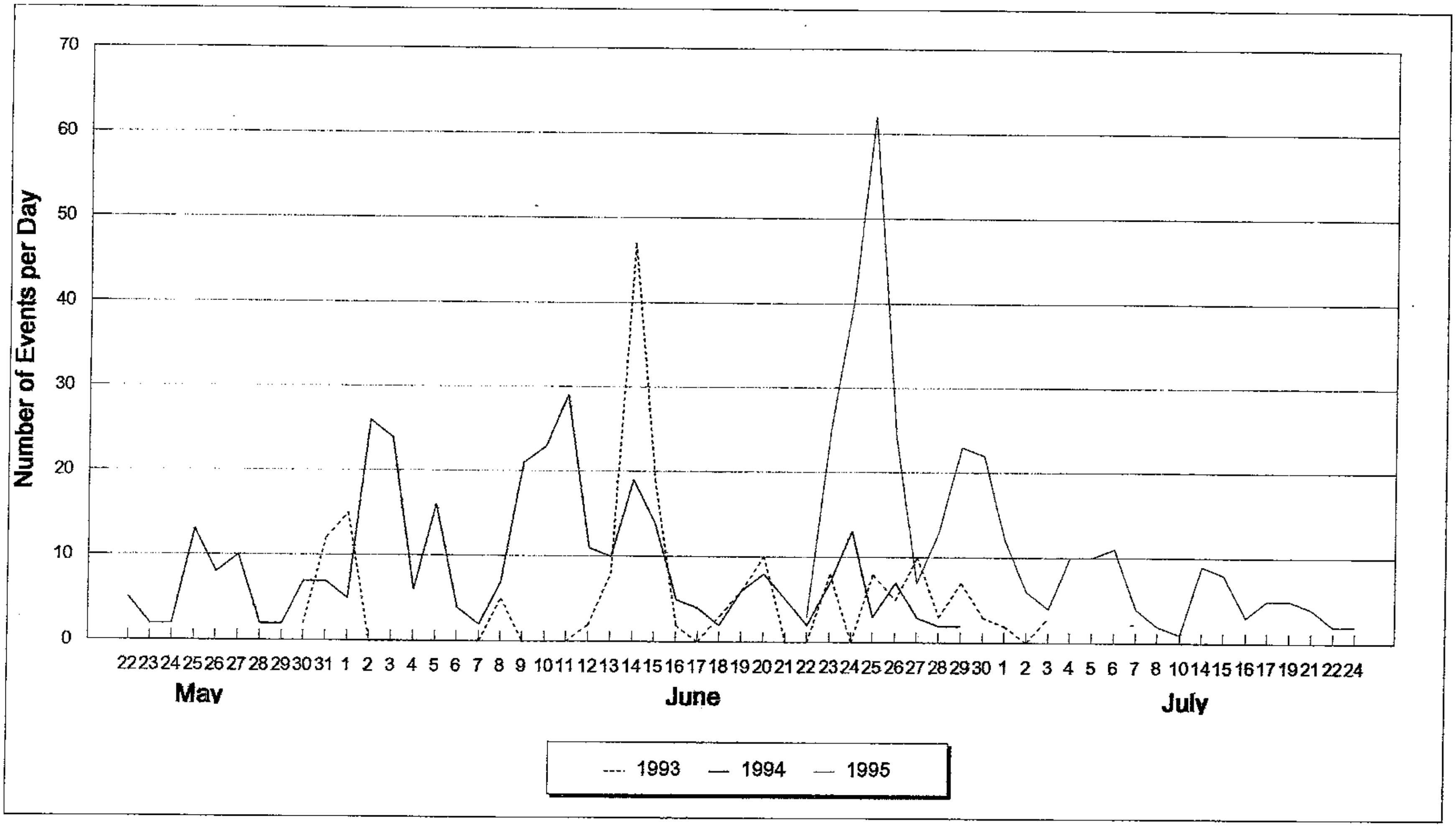


Figure 2-9. Number of Events Counted per Day by the Trailmaster Units at Solitude Pass, Spring 1993-1995.

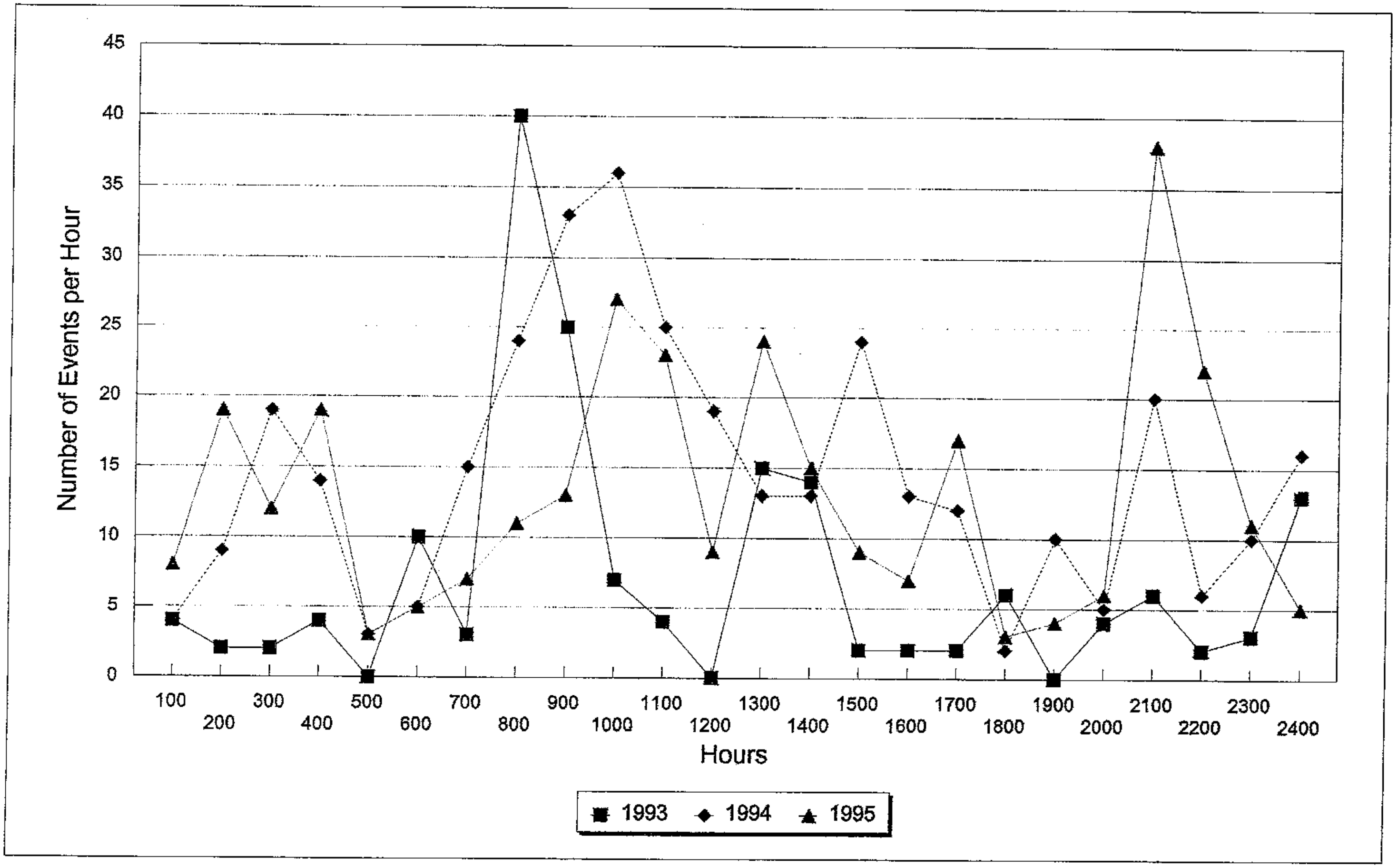


Figure 2-10. Timing of Daily Deer Movements through the Snowcreek Ski Area, Spring 1993-1995

Deer Fatalities

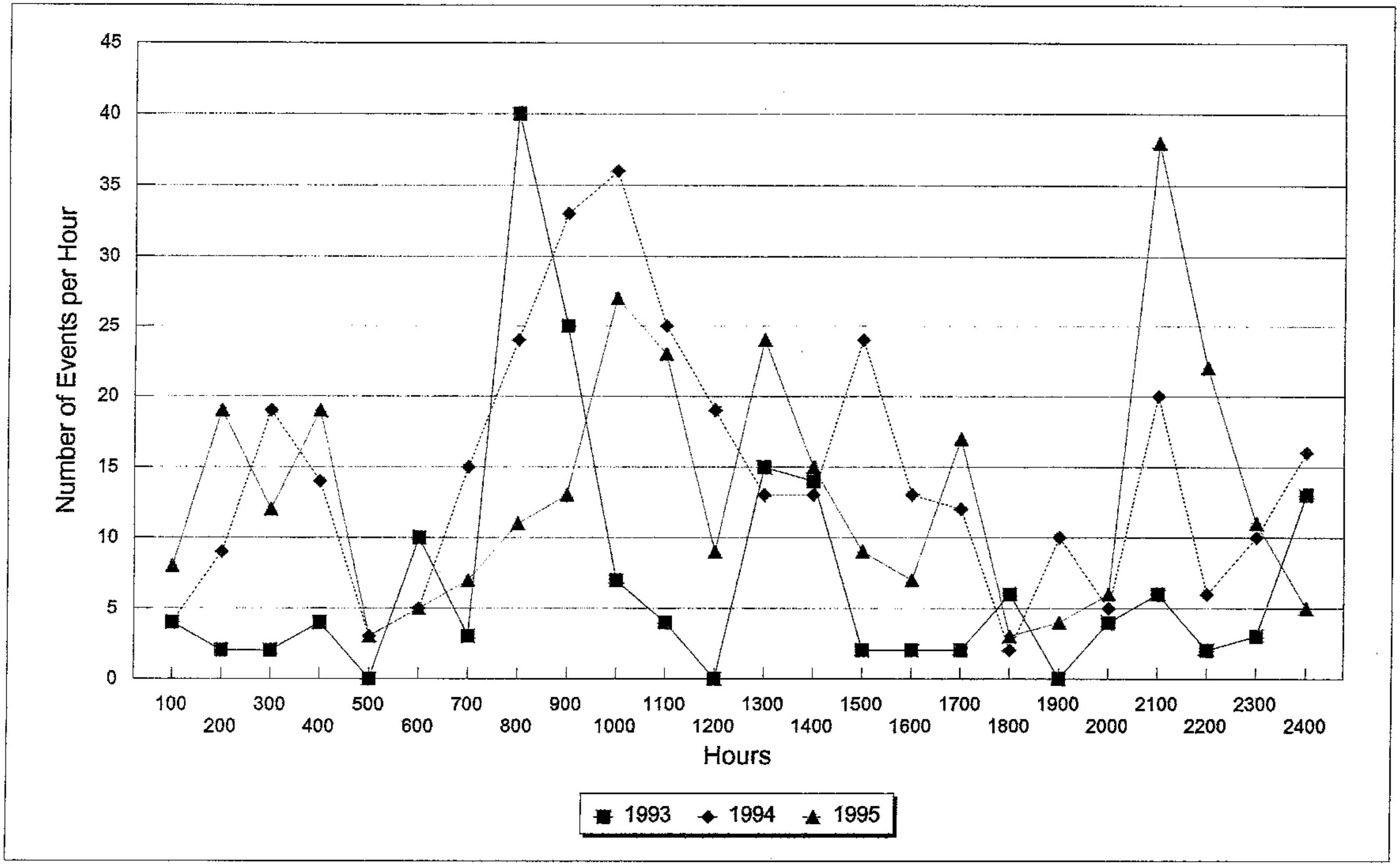
Dempsey Construction Company located 23 deer carcasses, including 4 radio-collared deer, during the 1995 spring migration (Table 2-9). Seventeen deer were killed by automobiles, 5 by coyotes (*Canis latrans*), and 1 by a mountain lion (*Felis concolor*). Of the 17 deer killed by automobiles, 15 were hit on Hwy 395, 1 on Hwy 203, and 1 on Hwy 168. Necropsy data and tissue samples from each fatality were provided to CDFG.

Table 2-9. Deer fatalities located by Dempsey Construction Company during the 1995 spring migration.

Fatality Number	Date	Radioed Deer No.	Sex	Age	Cause of Death	Location
1	4/14/95		Male	Fawn	Auto	Hwy 395
2	4/21/95		Male	Adult	Auto	Hwy 395
3	4/26/95		Female	Adult	Auto	Hwy 395
4	5/11/95		Female	Adult	Coyote	SHA
5	5/17/95	9.313	Female	Adult	Coyote	SHA
6	5/17/95		Female	Adult	Auto	Hwy 203
7	5/19/25		Female	Adult	Auto	Hwy 395
8	5/20.95		Female	Adult	Auto	Hwy 203
9	5/22/95		Male	Adult	Auto	Hwy 395
10	5/22/95		Female	Adult	Auto	Hwy 395
11	5/23/95		Female	Adult	Auto	Hwy 168
12	6/01/95	9.565	Female	Adult	Lion	SHA
13	6/02/95		Female	Adult	Auto	Hwy 395
14	6/04/95		Female	Adult	Auto	Hwy 395
15	6/05/95	0.030	Male	Adult	Auto	Hwy 395
16	6/08/95	9.482	Female	Adult	Coyote	SHA
17	6/09/95		Female	Adult	Auto	Hwy 395
18	6/10/95		Female	Adult	Coyote	SHA
19	6/16/95		Female	Adult	Coyote	SHA
20	6/17/95		Female	Adult	Auto	Hwy 395
21	6/29/95		Male	Yearling	Auto	Hwy 395
22	6/29/95		Male	Adult	Auto	Hwy 395
23	7/01/95		Female	Yearling	Auto	Hwy 395

Deer Fecal Pellet Collections

During spring 1995, DCC field personnel collected deer fecal pellet-groups from the SHA and surrounding vicinity. A total of 20 fresh pellet-groups were collected monthly from May-July and stored in individual paper bags. All samples were provided to CDFG for evaluation of diet composition and quality.



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19	6/16/95		Female	Adult	Coyote	SHA
20	6/17/95		Female	Adult	Auto	Hwy 395
21	6/29/95		Male	Yearling	Auto	Hwy 395
22	6/29/95		Male	Adult	Auto	Hwy 395
23	7/01/95		Female	Yearling	Auto	Hwy 395

Deer Fecal Pellet Collections

During spring 1995, DCC field personnel collected deer fecal pellet-groups from the SHA and surrounding vicinity. A total of 20 fresh pellet-groups were collected monthly from May-July and stored in individual paper bags. All samples were provided to CDFG for evaluation of diet composition and quality.

Chapter 3. Summer Range

This chapter describes the results of deer fawning surveys conducted during late August within and immediately adjacent to the SSA permit area.

Fawning Areas in the SSA Permit Area

From August 30-31, DCC personnel surveyed on foot areas of potential deer fawning habitat located within the SSA permit area and immediately surrounding vicinity. During the surveys, 2 radio-collared females (9.210 and 9.350) were located east of the permit area, in vicinity of the Mammoth Motocross (Figure 3-1). Both deer were observed in dense montane-chaparral habitat within 100 m of Sherwin Creek. In addition, several sets of fawn tracks were observed in the Motocross and the road leading to the Motocross, between the Sherwin Lakes trailhead and the Motocross entrance.

Within the permit area, fawn tracks were observed in sagebrush habitat between the Motocross and the Mammoth Rock Trail and in mixed conifer forest below Mammoth Rock (Figure 3-1). Fawns tracks were also observed along the northwest perimeter of the permit area, where aspen (*Populus tremuloides*) riparian and mixed conifer habitats interface with areas of wet meadow.

The structural profile of montane chaparral and aspen-riparian 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 and surrounding vicinity is dependent upon sources of permanent water located at Hidden Pond and Sherwin Creek.

Chapter 4. Fall Migration

This chapter describes the results of the fall 1995 migration studies.

MIGRATION STUDIES

Timing and Intensity of Migration through the Snowcreek Ski Area

Radio-collared Deer. Telemetry information indicated that fall migration from the summer range during 1995 lasted from October 13 to December 5 (Figure 4-1). There were no major fall storms during 1995. Consequently, migration was gradual and lacked any episodes of mass movement. In comparison, the 1994 fall migration lasted from October 1 to October 16, with peak migration occurring from October 5 and October 8 (Figure 4-2) (Taylor 1995).

The difference between the two years in the timing of migration was probably related to snowfall. In 1994, fall migration began in late September and early October when a series of fall storms deposited heavy snow over the highest elevations of the summer range. Because of the severity of these storms, deer hastily vacated the summer range and migrated en masse to the winter range. Others (Russell 1932, Dixon 1934, Leopold et al. 1951, Bertram and Remple 1977, Kucera 1992) have also associated the timing of fall migration with snowfall.

Migration in 1995 could not have been initiated by weather because no measurable precipitation occurred during October and November (Figure 4-1). Instead, deer may have migrated in response to below freezing temperatures that desiccated forage on the summer range, forcing deer to migrate to lower elevations. 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.

Remote Deer Counters. Trailmaster units in Solitude Canyon recorded 189 events that could be used to determine the timing and intensity of fall migration through the SSA permit area. Deer began crossing over Solitude Pass and through Solitude Canyon on approximately October 9 and these movements continued until December 7 (Figure 4-3). There was a significant difference (ANOVA, $F = 215.3$; 2, 431 df; $P \leq 0.000$) among years (1993-95) in the mean dates of deer crossing over Solitude Pass. Mean date of deer crossing during fall 1995 was November 11. In comparison, mean dates of deer crossing during fall 1993 and 1994 were October 26 and October 7, respectively (Taylor, 1993, Taylor 1995). As discussed previously, differences in the timing of migration between 1995 and the previous years was related to snowfall.

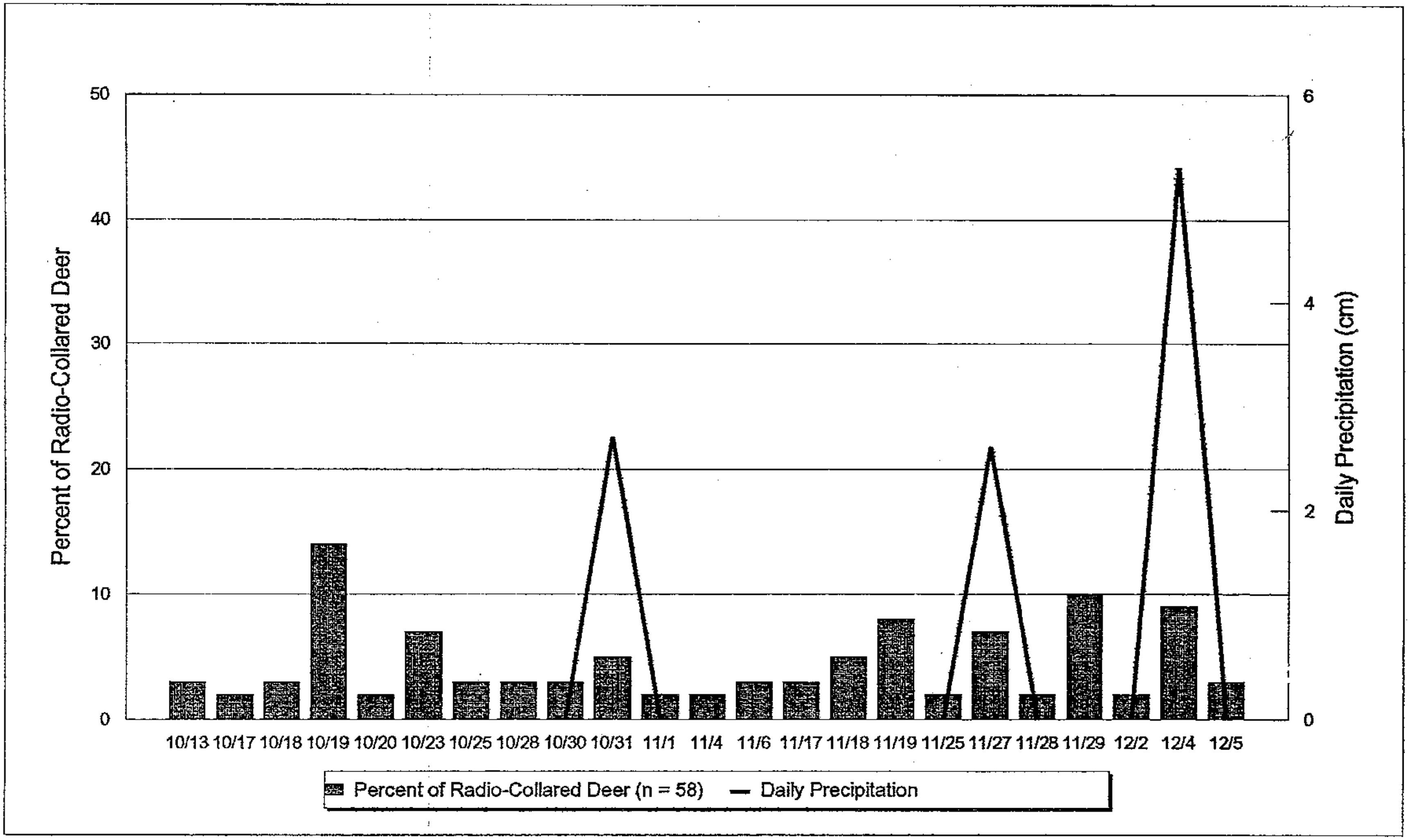

Figure 4-1. Percent of Radio-Collared Deer Migrating from the Summer Range in Relation to Daily Precipitation, Fall Migration 1995

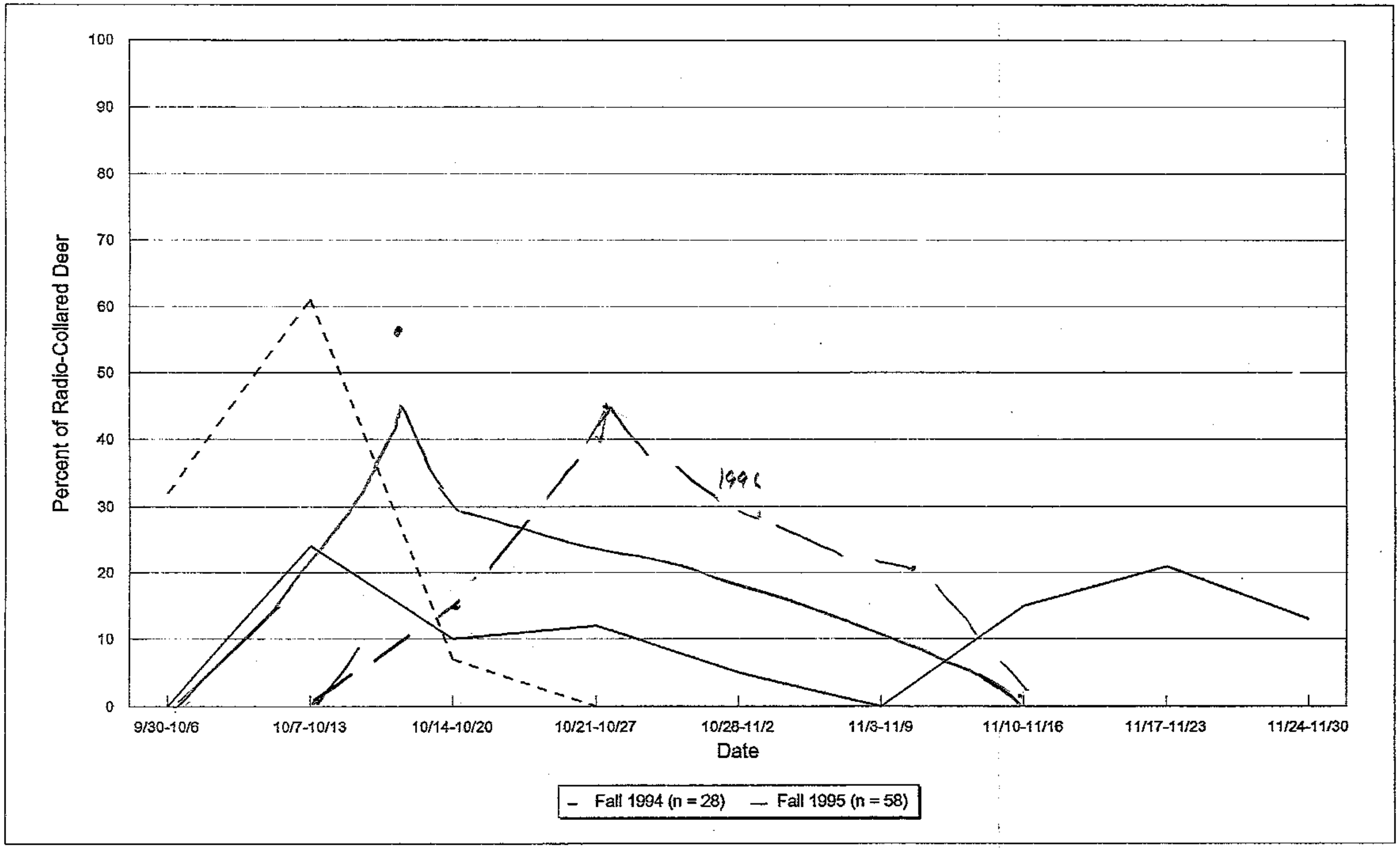

Figure 4-2. Percent of Radio-Collared Deer Migrating from the Summer Range by Date, Fall 1994 and 1995.

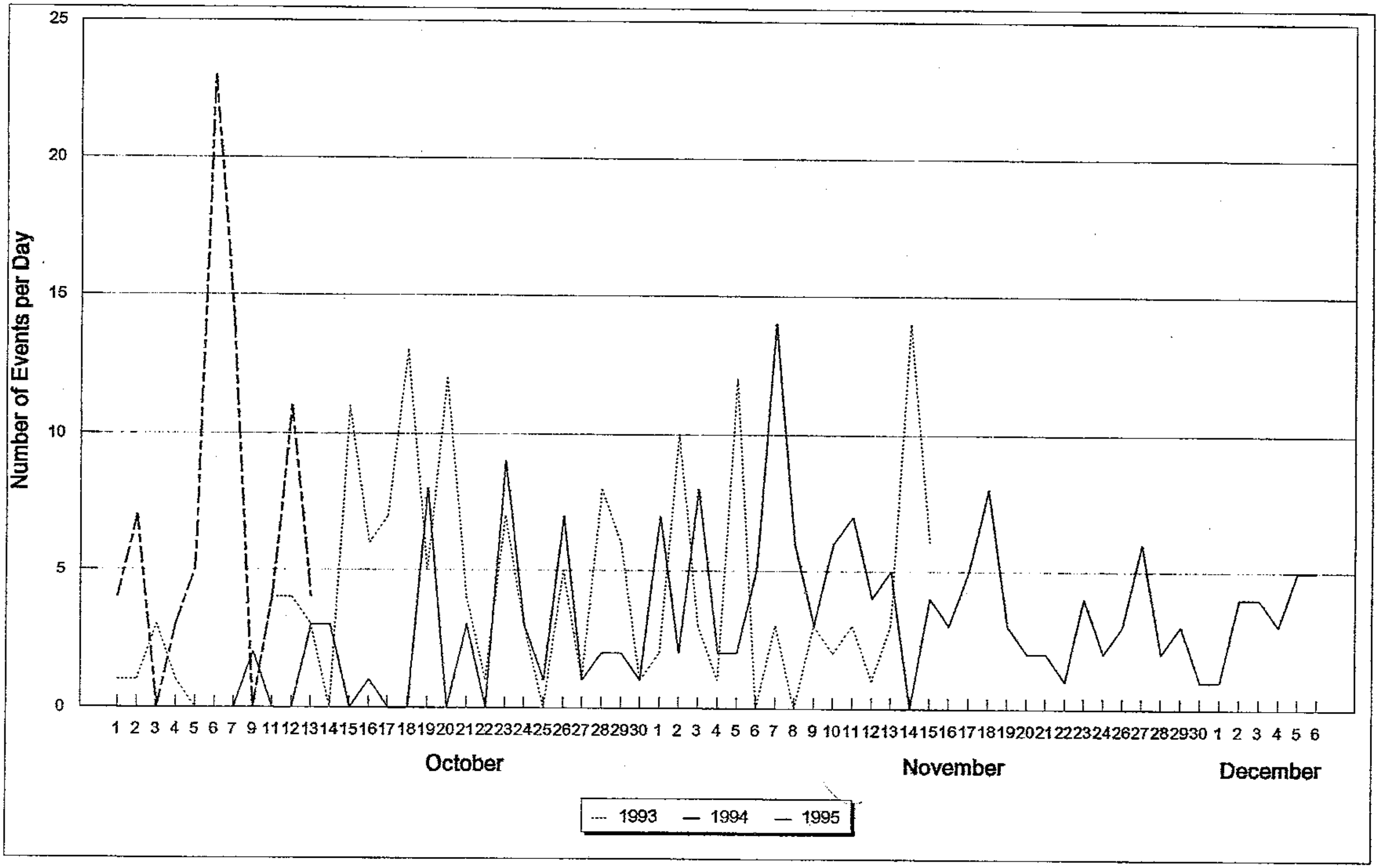

Figure 4-3. Number of Events Counted per Day by the Trailmaster Units at Solitude Canyon, Fall 1993-1995.

Daily Timing of Deer Movements

Remote Deer Counters. Event data recorded by the Trailmaster units at Solitude Pass was used to determine the daily timing of deer movements through the SSA permit area. During fall 1995, approximately 63% of all events were recorded during daylight hours, between 7 a.m. and 6 p.m. (Figure 4-4). In comparison, during fall 1993 and 1994, approximately 39% and 48% of events, respectively, occurred during the daytime. The difference between years in the daily timing of deer movements may be related to presence or absence of fall snowstorms.

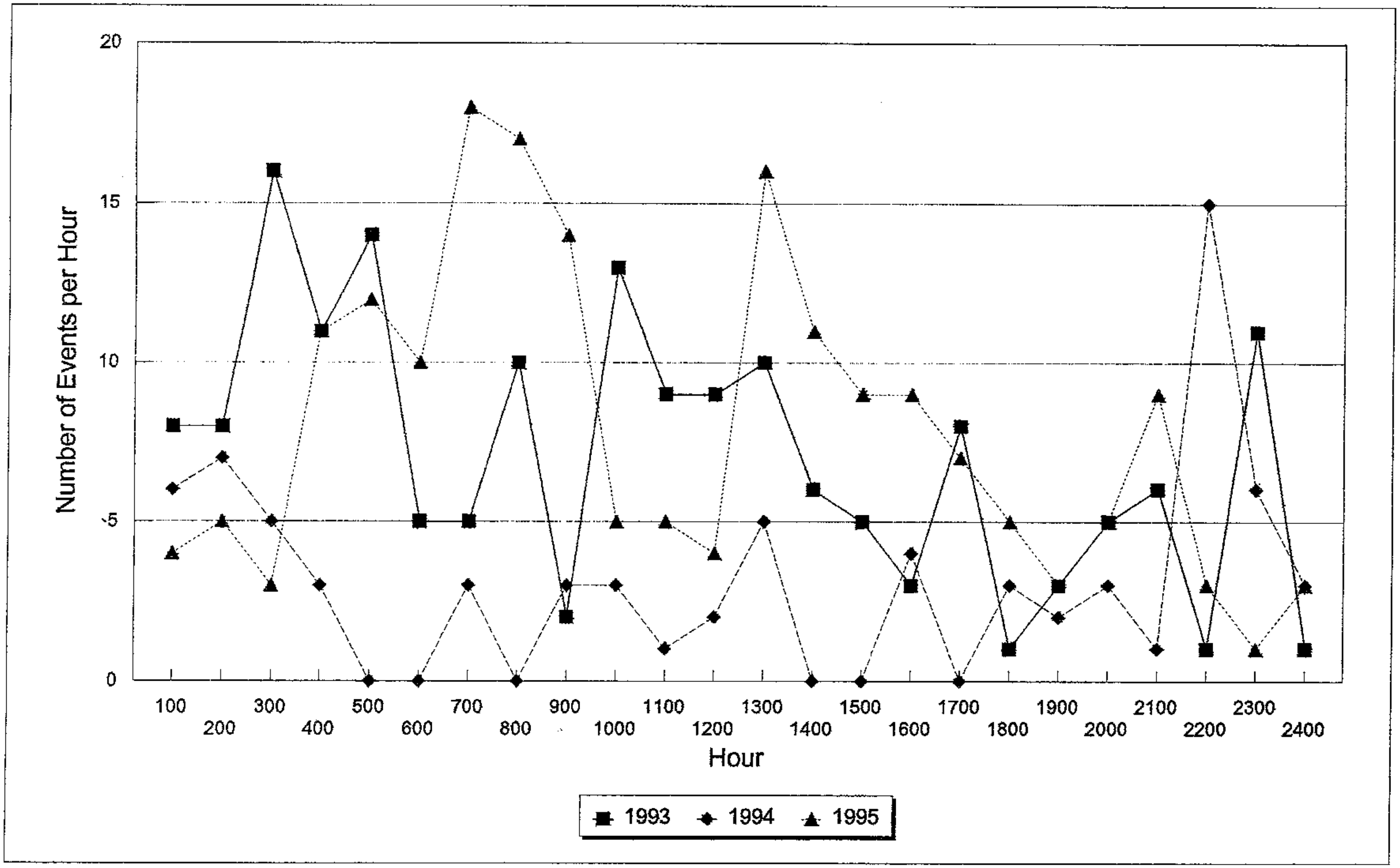

Figure 4-4. Timing of Daily Deer Movements through the Snowcreek Ski Area, Fall 1993-1995

Chapter 5. Acknowledgments

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. Jeff Davis, Vicki Davis and Warren Allsep assisted in data collection. Dr. Ken Raedeke provided useful comments on the manuscript.

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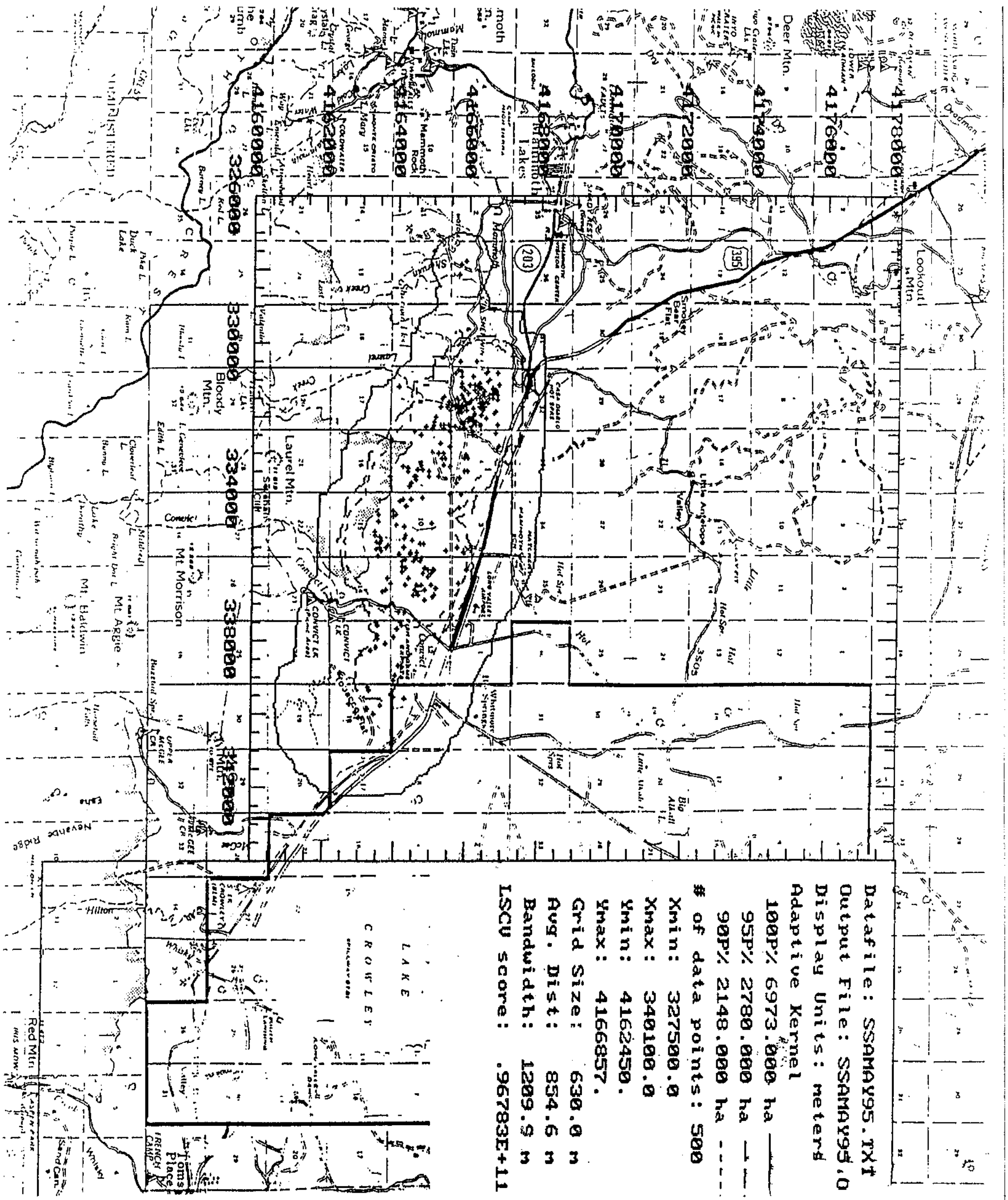
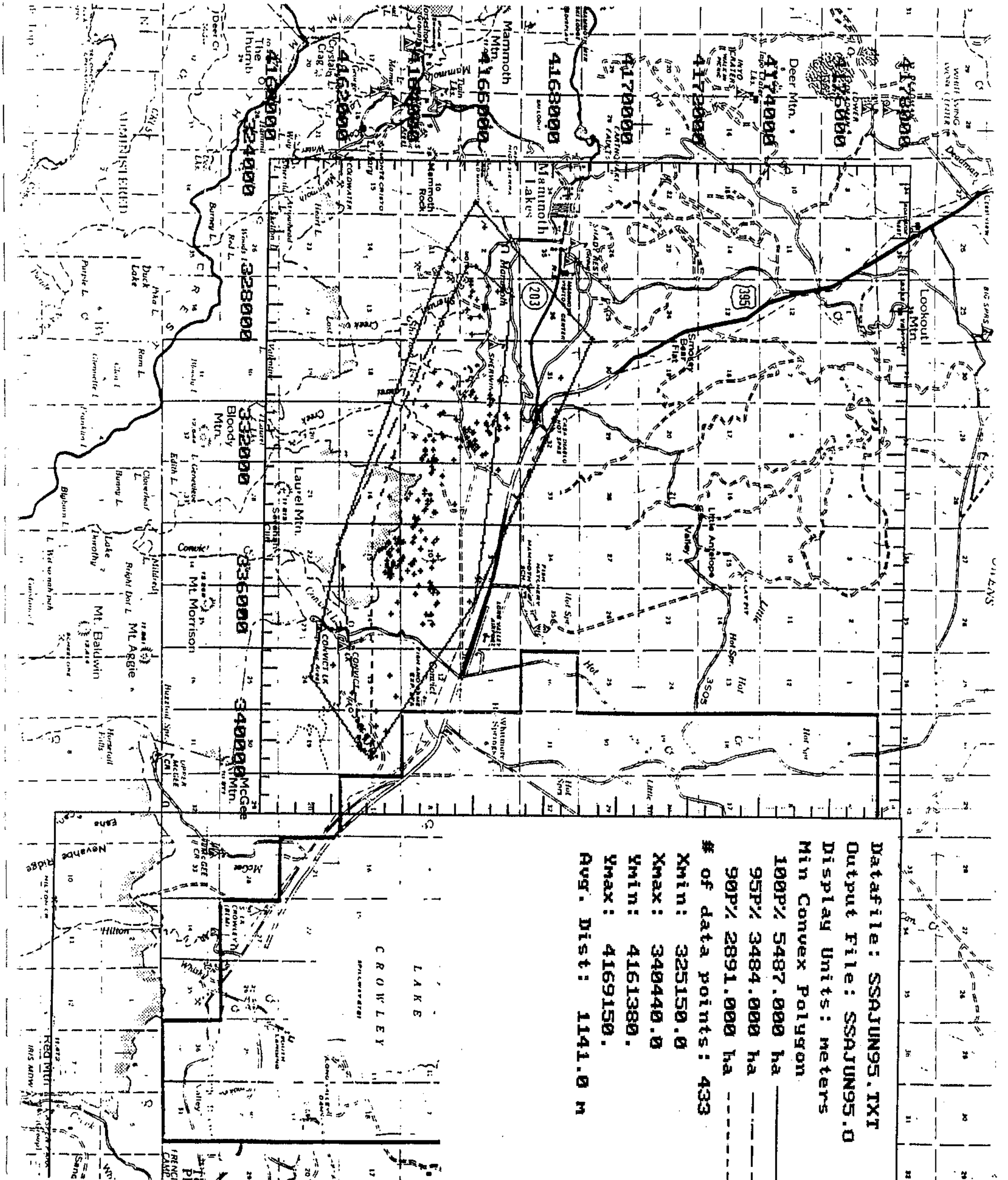
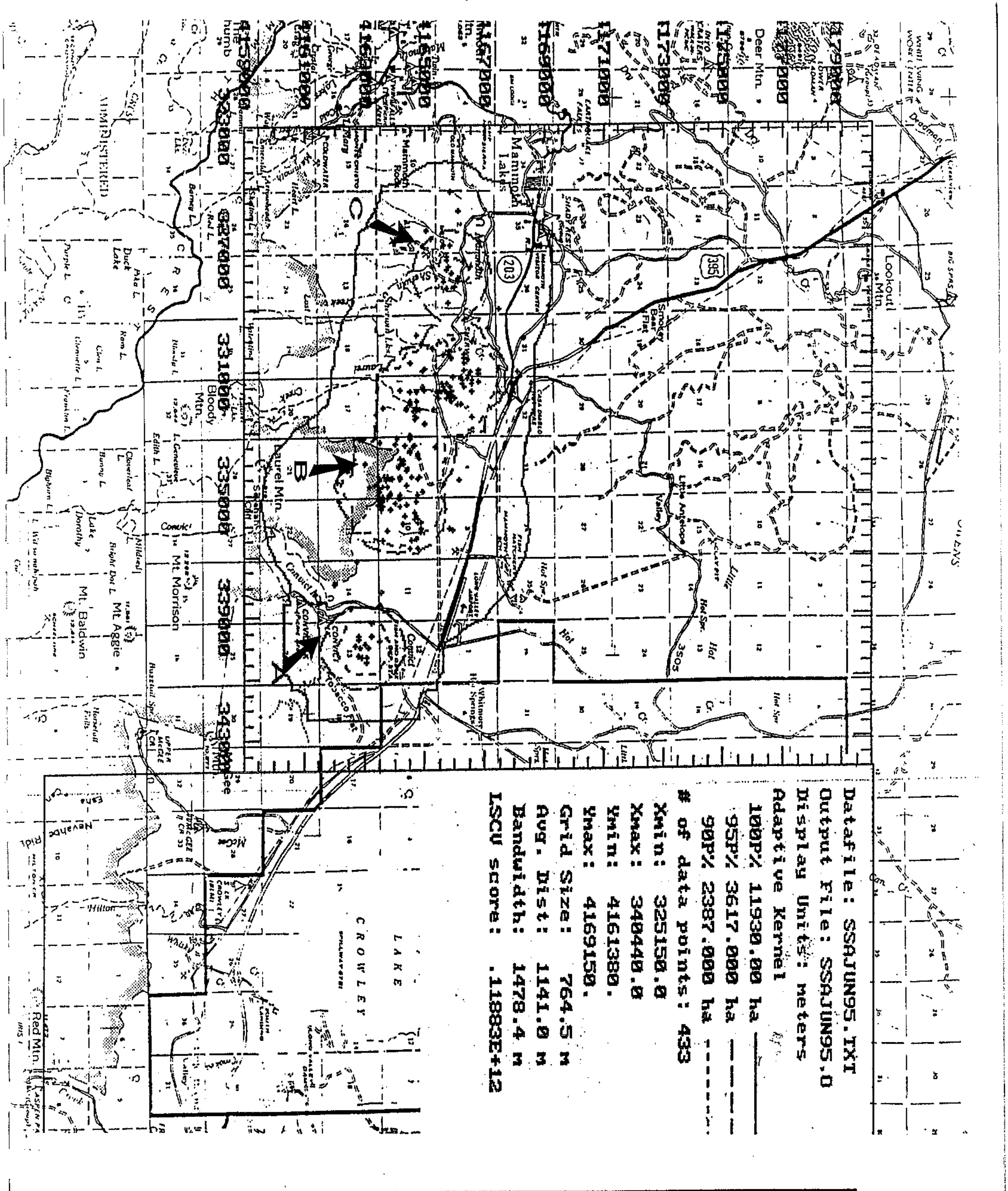


Appendix Figure 2. Adapative kernel isopleths for composite home ranges (ha) in the Sherwin Holding Area using 100%, 95%, and 90% of sample observations for May 1995.



Appendix Figure 3. Minimum convex polygons for composite home ranges (ha) in the Sherwin Holding Area using 100%, 95%, and 90% of sample observations for June 1995.



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