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ELK SEASONAL RANGES
AND MIGRATIONS
IN ARIZONA
A Final Report

RICHARD L. BROWN
August 1994

FEDERAL AID IN WILDLIFE
RESTORATION PROJECT

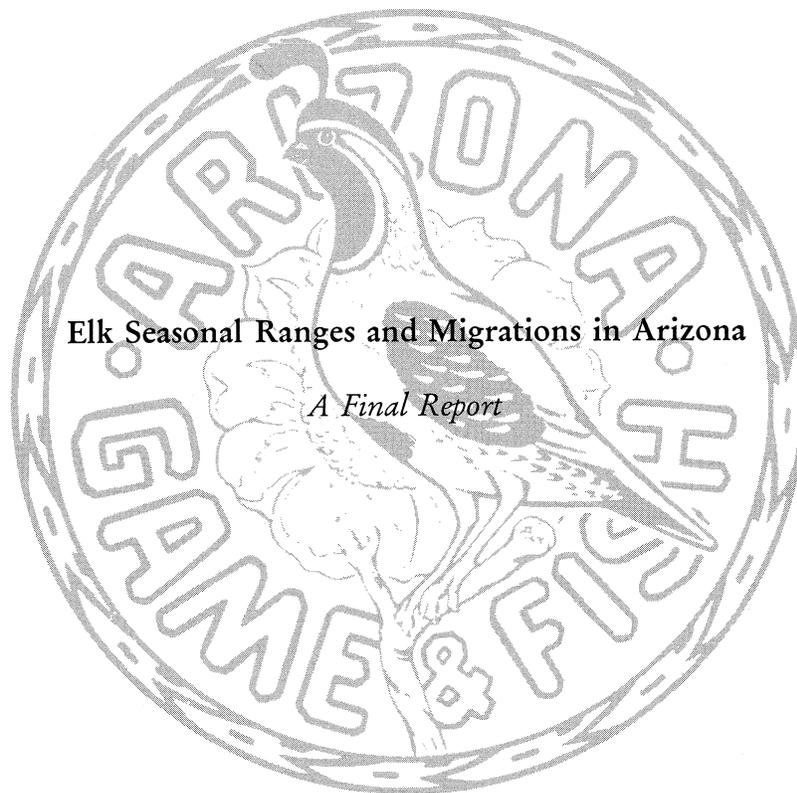


Arizona Game and Fish Department Mission

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations.

Arizona Game and Fish Department
Research Branch

Technical Report Number 15



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Federal Aid in Wildlife Restoration
Project W-78-R

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Elk Seasonal Ranges and Migrations in Arizona

Richard L. Brown

Abstract From 1985 to 1994, 360 (357 female, 3 male) elk (*Cervus elaphus nelsoni*) were radio-tracked from aircraft in Arizona at approximately 30-day intervals. Additionally, the White Mountain Apache Tribe provided us with data from 27 telemetered elk captured on their Reservation. Combined, the data from those elk provided home range and migration information on most elk herds within Arizona. Exceptions were populations occupying other Indian Reservations, and small herds at the western and southern periphery of the state's elk range. Mapped locations of radio-marked elk usually formed discrete clusters, the boundaries of which defined seasonal use areas; telemetered elk showed a high degree of fidelity to those areas. Subsequently, we defined individual elk populations that occupied each use area and determined the level of exchange with other areas. The levels of exchange were expressed as percentages. In this manner, migration patterns between use areas were determined and quantified. Elk movement across Game Management Unit boundaries was common. Exchange of individuals between Arizona Game and Fish Department Regions 1 and 2 appeared to be unimportant. However, exchanges between Region 6 and Region 1 and 2 occurred, and have management implications. Time and duration of migration were also documented. The degree of association between use areas was then examined to define herd unit boundaries, and fifteen herd units were identified. The implications of managing on a herd unit basis, and a management unit basis, are discussed.

INTRODUCTION

The grouping of animals is related to a variety of causes that include feeding, migration, reproduction, and defense against predation (Whittenberger 1981). Although ungulate groupings are frequently referred to as herds, there appears to be no formal definition of the term. The use of "herd" in current literature is so generalized that it denotes almost any assemblage of large animals and can imply either a social cohesiveness, an attachment of individuals to specific geographic areas, or both.

Reports by several authors (Brazda 1953, Anderson 1958, Picton 1960, Tanner 1965, Knight 1970, Craighead et al. 1972, and Waldrip and Shaw 1979) indicate that elk tend to seasonally return to the same areas year after year. Information from an Arizona Game and Fish Department (AGFD) study of elk marked with visibility collars (1974,75 - 1982,83) is in agreement.

Several studies suggested that a high exchange rate of individuals occurs among elk groups on all seasonal ranges (Harper 1964, Franklin et al. 1975, Struhsaker 1967). Shoemith (1979) concluded, during a Montana study, that the only

recognizable social unit was the family, limited to the cow, her calf, and possibly her yearling offspring. There was a high exchange rate for both family units and individuals among groups on summer and winter range. Likewise, migrations to and from seasonal home ranges did not occur "en masse" by "organized" groups. However, there was evidence of repeated or habitual use of seasonal ranges.

Thus, herd integrity may best be addressed by examining the degree to which elk return to a geographic location over time. It is this "geographical" aspect of herd integrity, herd unit boundaries or Game Management Unit (GMU) boundaries (as opposed to the social composition of groups), upon which the current Arizona management options are dependent. For our purposes then, the degree of "fidelity to seasonal use areas" was a more important criterion than degree of social cohesiveness. In this study we approached the problem only from the geographical standpoint.

Hunt management for Arizona's elk is based on annually allocating a limited number of elk permits to individual game management units (GMU) (Figure 1). Hunting seasons are a mixture of general firearms, archery, and muzzleloader hunts with different beginning and ending dates.

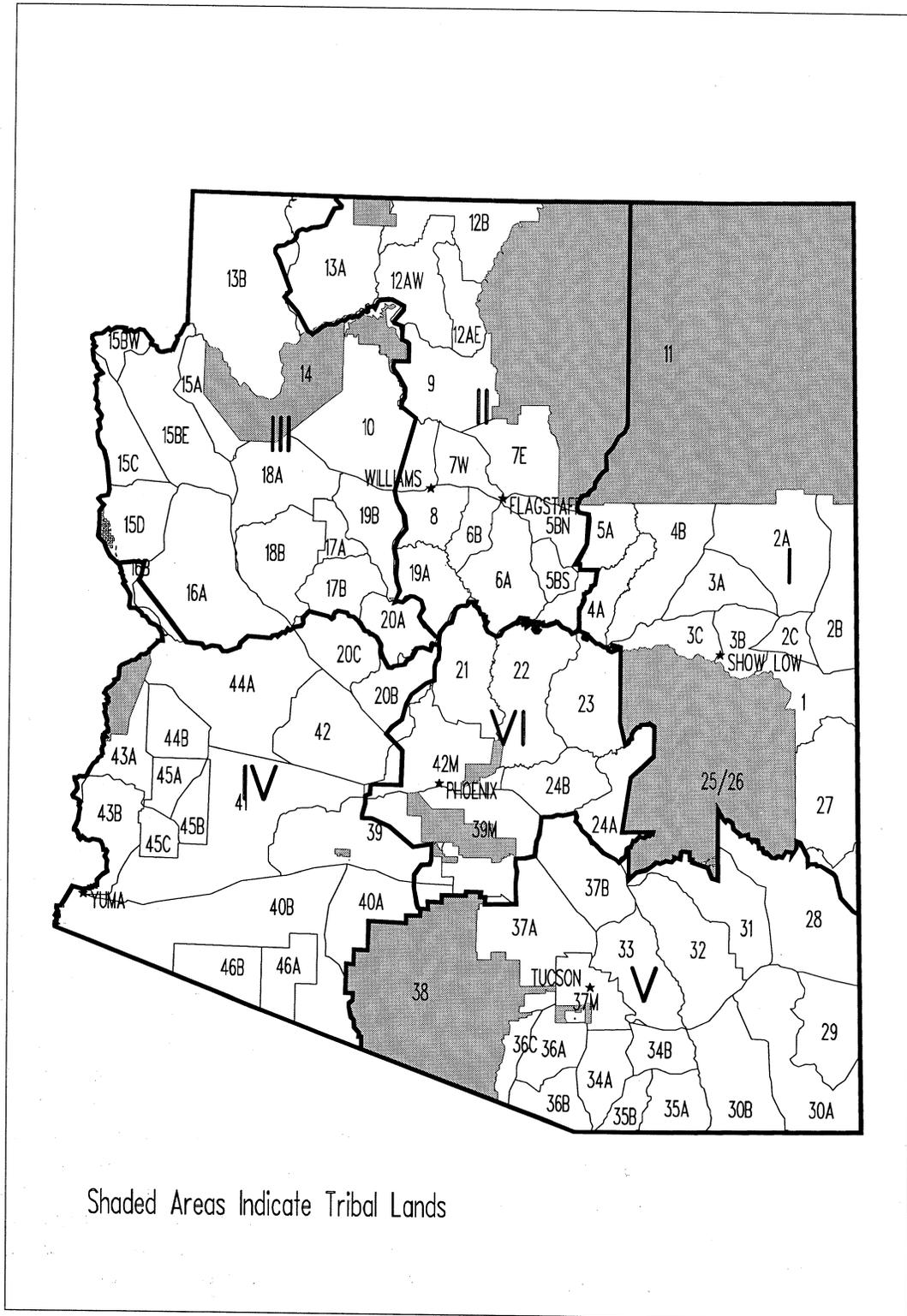


Figure 1. Arizona Game and Fish Department Game Management Units (GMU) and Administrative Regions.

Because most Arizona elk migrate and frequently cross GMU boundaries, understanding their movement patterns is necessary if quota hunting within individual management units is to be successful. For instance, an elk herd could inadvertently be subjected to 2 hunts if adjacent units are hunted at different times and a migration occurs between them.

A closely related problem concerns the application of elk survey data. In some cases, elk may be surveyed in 1 GMU and hunted in another; therefore, the survey results may not reflect population characteristics of the elk being hunted in a particular GMU. Detailed seasonal use data is needed to enable managers to deal with this problem. Because of these problems, we needed information on the feasibility of managing Arizona's elk on a herd unit basis as opposed to arbitrarily delineated management units.

Migration studies of Arizona elk were conducted as early as the mid 1970s. In 1974 an investigation was initiated under Federal Aid Project W-53-R Work Plan 3, Job 1 to determine the discreteness of elk herds along the Mogollon Rim. That study provided useful information on the movements of certain local populations. However, more specific information was needed on degree of population exchange between areas, times of migration, and definition of herd units, if they existed. This study evolved out of those initial efforts, and its objectives were to:

- Identify areas of seasonal use and determine the fidelity of elk to those areas.
- Determine the timing and regularity of elk migrations.
- Identify boundaries of discrete elk herds, if present, and determine the degree of herd integrity .
- Determine whether herd units cross current game management unit boundaries.



STUDY AREA

The radio-telemetered elk involved in this study ranged from the Tusayan area on the south rim of the Grand Canyon, south to Williams, Arizona, then east along the Mogollon Rim to the Arizona/New Mexico border (Figure 2). This area encompassed an elevational range of approximately 1460-2850 m. It was composed primarily of Ponderosa pine (*Pinus ponderosa*) and mixed conifer forests (Pase and Brown 1982:43) at higher elevations, and pinon/juniper (*Pinus edulis/juniperus* spp.) woodland (Brown 1982:52) at lower elevations.

METHODS

Capture and Telemetry

We captured elk in portable box traps (Clover 1956) during both summer and winter (Figure 2). Between January 1985 and June 1989, 105 mortality-sensing radio transmitters (Telonics, Mesa, Arizona) were placed on 3 male and 102 female elk in 11 GMUs. We chose capture sites primarily on the recommendations of Wildlife Managers and Regional Game Specialists. Attempts were made to sample all major elk concentrations within each GMU by installing a maximum of 5 collars per trap site. Captures were conducted at the time of year when the greatest numbers of elk were present on each respective seasonal range.

Subsequently, 3,092 radio telemetry locations were obtained from fixed-wing aircraft equipped with twin 3-element yagi antennas mounted on the wing struts and a single rotary H-type antenna mounted on the belly of the plane. Observations were made at 1 month intervals and recorded on 7.5' U.S.G.S. topographic quadrangles, with a locational accuracy within 400 m considered acceptable. Results of that investigation were reported in Brown (1990).

Except for the Christopher Mountain area in the northern portion of GMU 23, elk in the areas between GMU's 4A and 1 (Figure 1) were not studied. Likewise, a small area near Rogers Lake in GMU 6B, and the majority of Anderson mesa in 5BN did not receive adequate attention.

From 1991 to 1994, we captured and radio-tracked 140 female elk in those areas not studied in the earlier investigation. Procedures were the same as in the first study except that aerial net gunning from helicopters was used to supplement

the box trapping.

Radio-tracking followed the same schedule and produced over 3,000 locations from May 1991 to January 1994.

Prior to analysis for this report, the two data sets were joined into a single set of over 6000 locations. This was necessary because some areas received use by elk from both studies.

At the request of AGFD Region 6 personnel, 18 of the previously mentioned 140 radios were installed on female elk below the Mogollon Rim during summer when the major herds had migrated to areas above the Rim. Those radio-marked elk provided over 390 locations. They were analyzed separately from the main data set because locations from this group produced data non-representative of the main data set.

The White Mountain Apache Tribe Game and Fish Department provided us with radio-tracking data from elk captured on the Reservation. Game Biologist Joe Jojola (pers. commun.), reported that about 90% of those elk were female, and the remainder were 1.5 to 3.5 year old males.

Personnel with the Apache Game and Fish Department located those elk from aircraft at 2 to 3 week intervals. We selected all elk within that data set that had completed a migration from 1 seasonal range to another ($n = 27$). Each elk was radio-tracked for a period of 6 to 10 months. Collectively, they provided 446 locations which were analyzed separately from the main data set.

Determination of Seasonal Use Areas

Over 6000 locations, from all radio-marked elk across all years, were plotted with an Arc/Info geographical information system (GIS), from Environmental Systems Research Institute Inc., Redlands, California. Contours were then subjectively drawn around all elk location clusters. Knowledge of regional elk behavior and topography, gained during the radio-tracking phase of the study, was used to assist in defining boundaries between adjacent clusters.

Similar seasonal maps were constructed for the periods of January-March (winter) and June-August (summer). Preliminary analysis of telemetered elk movements indicated that relatively little migratory activity would be encountered at those times. Therefore, most locations fell into either summer or winter use

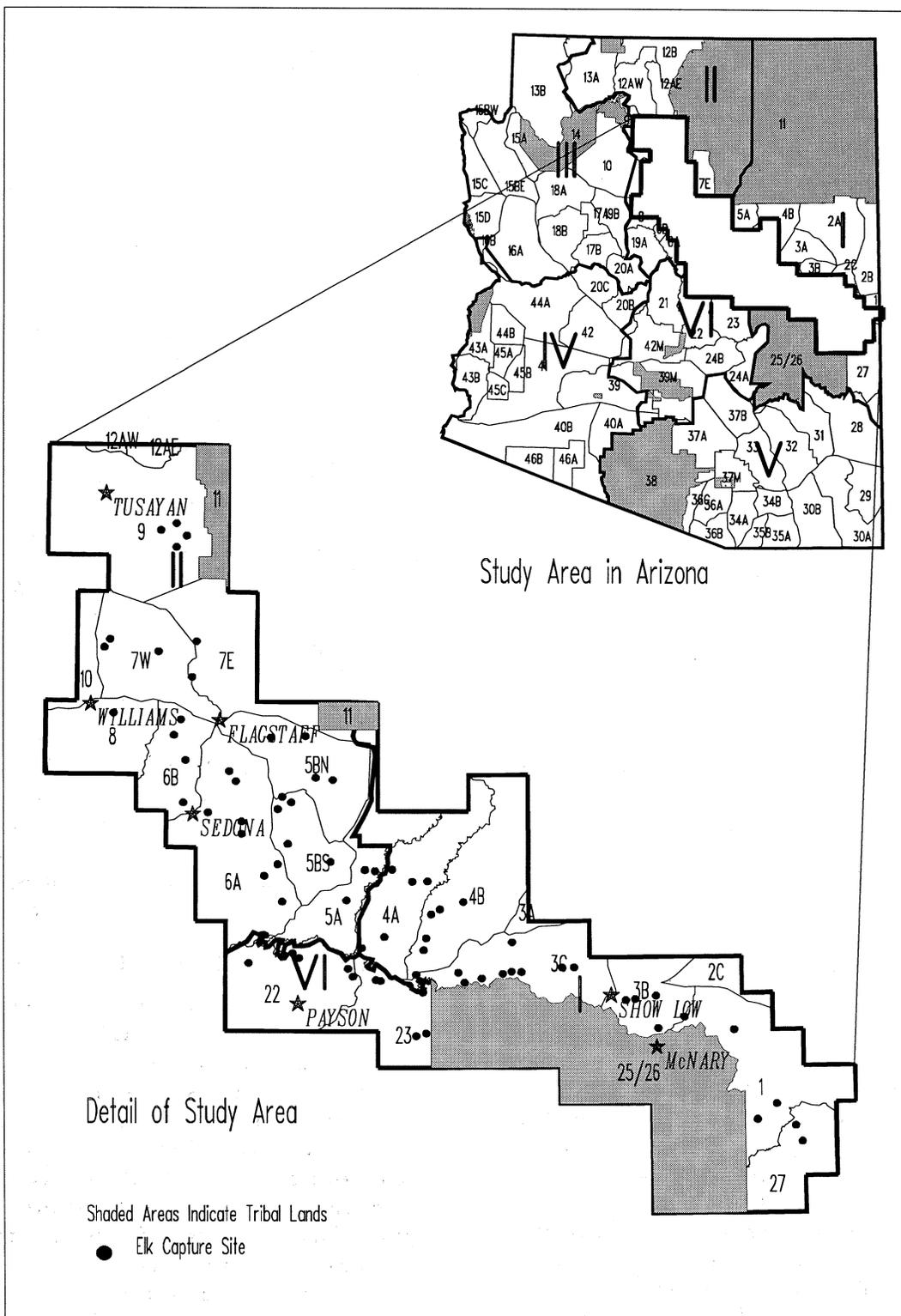


Figure 2. Study area boundary and locations of elk capture sites.

areas. These seasonal maps were also used as guidelines for dividing nondiscrete clusters (those known to encompass both summer and winter use areas) into 2 or more separate clusters. The boundary around a cluster of observations defined a use area. Each use area was then assigned an identification number for further analysis.

Seasonal Use Area Fidelity

Use areas were classified as either winter or summer based on the relative number of locations observed in January through March compared with June through August, respectively. I imposed an arbitrary rule that required 67% or more of the combined June through August and January through March locations to occur in either of those 2 time frames before that use area was classified as either a summer or winter use area. In some cases, "all season ranges" were identified when seasonal use was relatively equal between winter and summer.

Fidelity to a particular use area was evaluated by the degree that elk remained within that use area boundary during the appropriate season. All elk located at least once within a use area, during any month of the year, were considered a subpopulation. The movements of those elk were then examined during the appropriate season for the use area classification (winter or summer), and a fidelity index was calculated. The denominator was the total number of locations of a subpopulation during each period. The numerator was the number of those locations that occurred within the designated use area.

For example, consider that each of 6 specific elk were located at least once in Summer Use Area 7 during any month of the year, across all years. Those elk are considered the subpopulation for that use area. A fidelity rating reflects the tendency of that subpopulation to remain within that use area during the appropriate season. Fidelity ratings for individual use areas (as well as levels of population exchange between use areas during migration) were calculated from 2 3-month periods (January-March and June-August). Fidelity ratings (as opposed to migration patterns) only address locations within the proper season for the use area (summer use by summer use area populations or winter use by winter use area populations). Therefore, consider that during June-August, across all years, we obtained 58 locations on the Summer Use Area 7

subpopulation, but only 44 (76%) of those 58 locations occurred within Use Area 7. The fidelity index value for this particular summer use area is 76%. If most of the elk that ever occupied a seasonal use area rarely left that area during the season, then the index would approach a value of 1.00. Thus, the percentage value estimates the degree of fidelity to a seasonal use area, during the season of primary use, for the subpopulation of elk using each area (opposite seasons of use define the migration patterns).

Additionally, fidelity index values for June through August were compared with those of September. During late August and early September, 1 of the 2 annual elk classification counts is conducted to determine the prehunt bull-to-cow ratio data for the year. This comparison, then, questions the validity of applying cow elk distribution data, as reflected in the June-August fidelity ratings, to the late August and September period. Some hunting, as well as most of the breeding season, also occurs during September.

Migration Patterns

Migration patterns were determined by examining which winter use areas were occupied by elk from a given summer use area, and vice versa. Given the subpopulation of all individuals that occupied a certain summer use area, each use area that was occupied by those same individuals during January-March was identified. Then, the percentage of those January-March locations occurring within each of those use areas was calculated. The result indicates which use areas a summer use area subpopulation used during the winter, and estimates the percent of the subpopulation's time spent in each use area. Viewed collectively, these migrational index values indicate where and in what proportions all elk that used an area came from or went to during the opposite season.

Migration timing was determined by the proportion of elk migrating to or from each use area during each month of migration. If an individual was present on an area 11 out of 12 months, it was considered a non-migrant. An individual was considered to have "left" an area when it left that area for the rest of the season. It was considered to have "entered" an area when it entered and remained in that particular area for 2 or more consecutive months. If, for example, an

animal left Area 16 in March, entered Area 19 in April, returned to Area 16 in May and re-entered Area 19 in June to stay through October, then it was considered as having left Area 16 in May and entered Area 19 in June.

Exchange between GMUs was determined in the same manner as that discussed above. Given the subpopulation of all elk occupying a GMU, other units occupied by those elk were identified, and the percent of time spent in each (based on number of radio locations) was computed. Calculations were based on use across the entire year rather than 2 3-month periods.

Herd Units

Herd units were defined by combining use areas containing the largest number of common elk. Only the "across season" migration data were used (i.e., for summer use areas the January-March percentages were used and vice versa). The objective was to produce a block of use areas with the highest possible percentage of self-containment of across season observations. Such a block frequently contained several summer and winter use areas.



Elk in typical habitat.



RESULTS

The non-text portion of the Results section consists of 2 major divisions. Appendices A1 - A49 are the main statewide data set. Appendices B1 - B14 contain data from elk captured in Region 6 during the summer. Appendices C1 - C14 contain data from elk captured and radio-tracked by personnel of the White Mountain Apache Tribe Game and Fish Department.

Each of those divisions is divided into 2 sections. Appendices A1 - A17, B1 - B10, and C1 - C9 are tabular presentations of use area data. Appendices A18 - A49, B11 - B14, and C10 - C13 are maps of migration patterns between use areas, and have a 7.5' U.S.G.S. topographic quadrangle map background to facilitate reader orientation. I usually included >90% of the population exchange on these maps. However, due to space limitations, small levels of exchange (1% to 3%) were frequently left out. The reader is advised to consult the appropriate Appendix table for these smaller values.

Due to rounding-off errors, use area percentage totals in Appendices A1 - A17, B1 - B10, and C1 - C9 may not total 100%, but should fall within the range of 98% - 103%.

Information on migration patterns between use areas is organized by herd units. Herd units are addressed individually from the most westerly to the most easterly for those herd units above the Mogollon Rim, then from most westerly to most easterly for those which either lie below or extend across the Mogollon Rim.

Each herd unit is introduced by a general description of the area it encompasses. These descriptions frequently use names of places not on any map within this report. Therefore, the reader may find it helpful to refer to National Forest or U.S.G.S. topographic maps.

Seasonal Use Area Fidelity

We defined 97 individual use areas in 15 herd units within the main data set (Figure 3). We classified those into 33 summer, 40 winter, 22 all season, and 2 unclassified use areas (Appendix A1). The number of elk observed within each seasonal use area, and which comprised that area's subpopulation, is given in Appendix A2. Those values were listed separately to avoid confusion with the "working n-values" (number of locations), listed in most of the other tables.

From 1 to 17 individual use areas were used

by an individual area's subpopulation of elk during any given season (Appendices A3-A7). In several instances, individual fidelity values were relatively low. However, when closely associated use areas were combined, relatively high fidelity ratings were obtained, and the combination was considered 1 use area.

Consider for example Summer Use Areas 46 and 34 (Appendix A3). Individually, those have fidelity ratings of 34% and 73% respectively. However, they are obviously heavily associated. All of the telemetered elk that ever entered Use Area 34 were located in Unit 46 19 times, thus accounting for 14% of the observations from the Area 34 population. Likewise, 33% of the observations from the Area 46 population occurred in Area 34. When the two Use Areas (46 and 34) are combined as a single unit, a 78% (185 of 236 observations) self containment level occurs (Appendix A3). That exceeds the original values of 34% and 73%, and indicates that combining 46 and 34 into a single unit would be appropriate.

The year-round fidelity ratings for GMUs are given in Appendix A8. The mean fidelity value across all GMUs was 51% (range 5% to 92%).

Summer use area fidelity ratings (Appendices A3 and A7) changed very little when September observations were included with the June-August data (Appendix A9). Addition of the September data decreased the mean fidelity rating for summer use areas 1%. Mean September and mean October values by themselves were 8% and 14% lower than mean June-September values. This decline was the beginning of an annual downward trend as individuals began to migrate to winter range.

Migration Patterns

Generally, elk movements were restricted to a limited number of seasonal use areas, and elk habitually used the same summer and winter ranges (Appendices A10, A11 for summer and winter use areas and A6, A7 for all season use areas). In many cases, elk that occupied two separate winter use areas shared the same summer use area and vice versa. For example, consider Use Area 6 (Appendix A10). All elk that ever occupied Summer Use Area 6 were located 37 times during winter (January through March). Twenty-eight of these (76%) occurred in Use Area 4 and 24% occurred in Use Area 3. Likewise, of all elk that ever used Winter Use Area 4

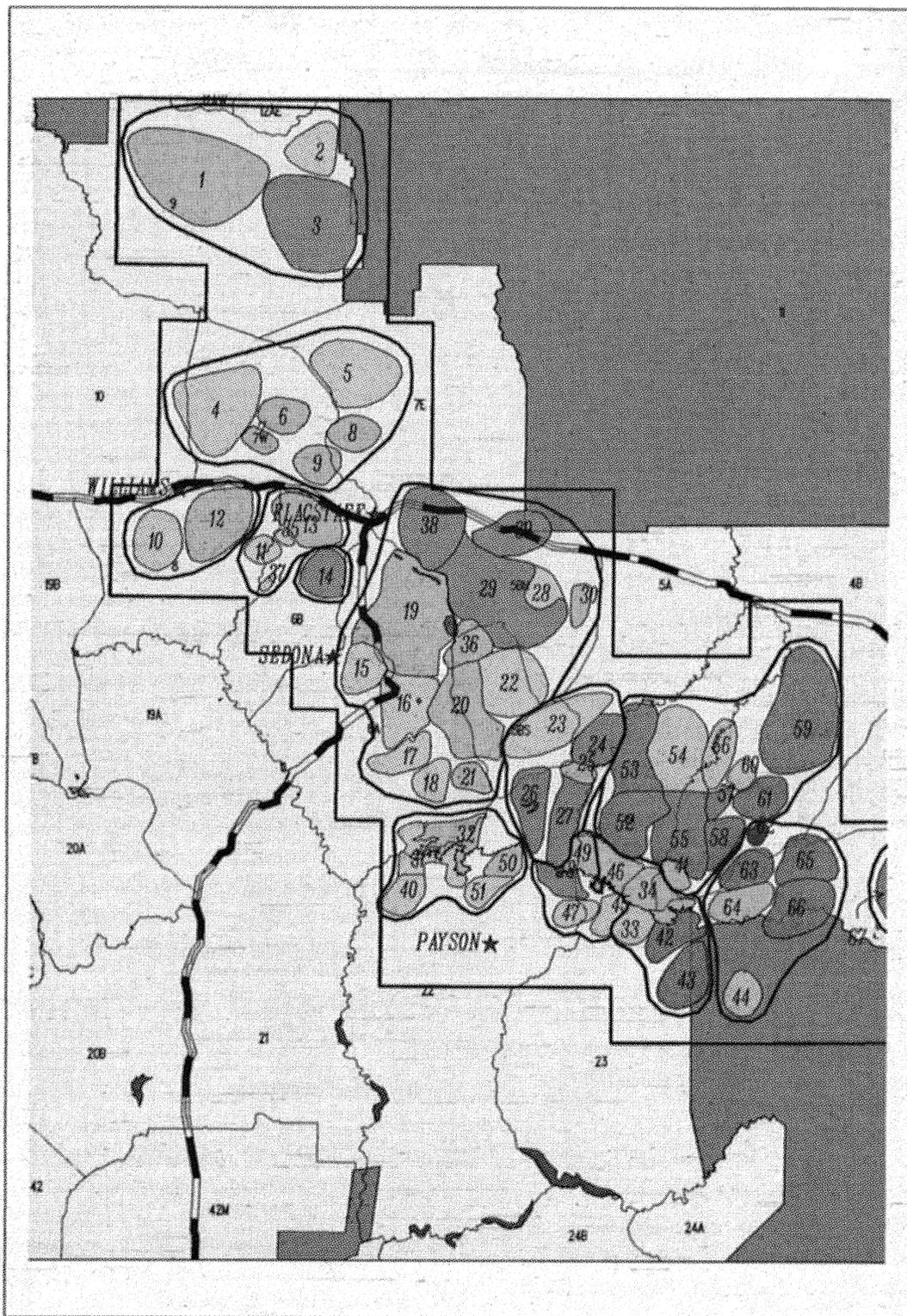


Figure 3. Seasonal use areas and herd units defined by the main data set.

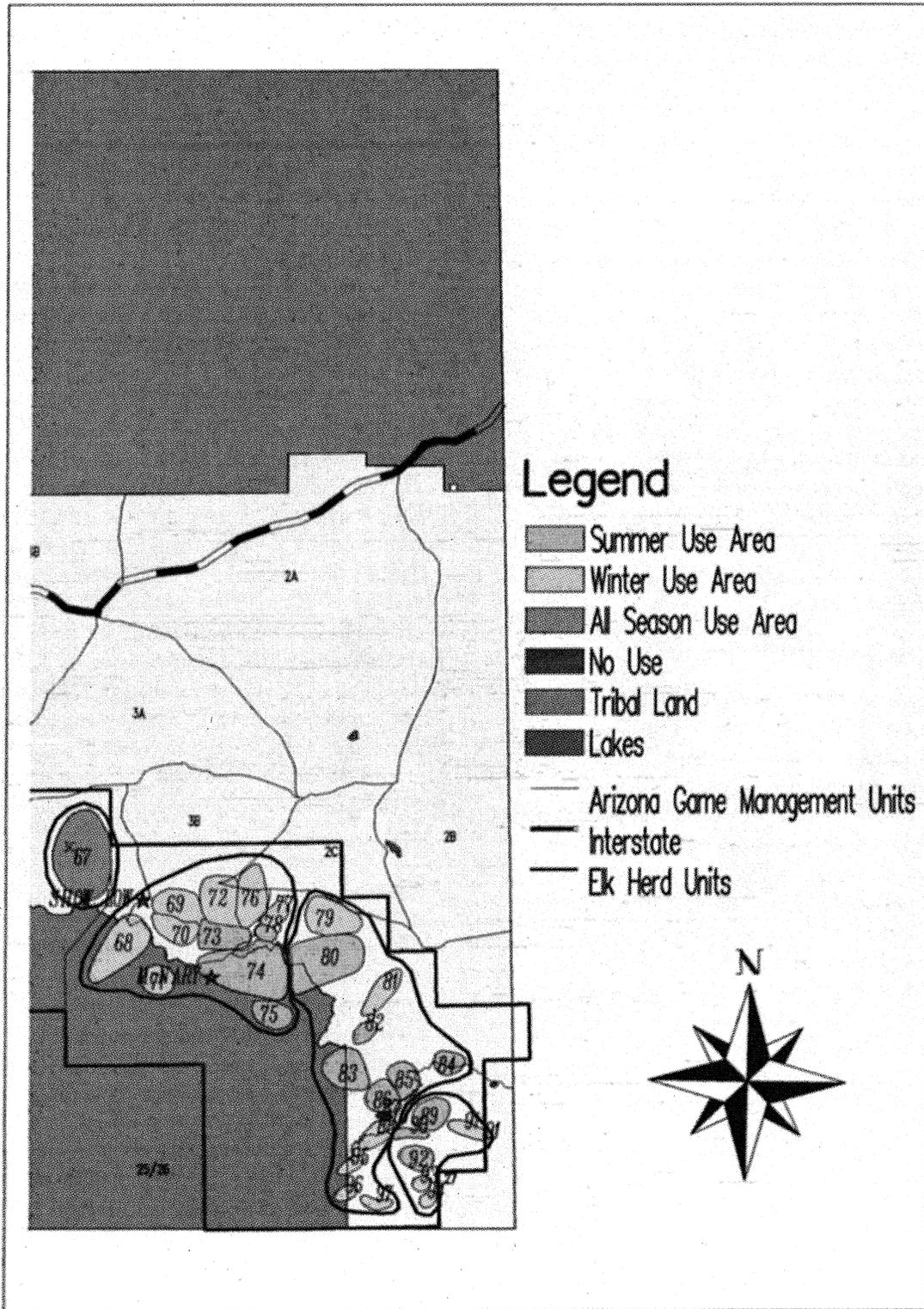


Figure 3. (continued)

(Appendix A11), 47% of their summer observations occurred in Summer Use Area 6, 29% occurred in Area 9 and 24% occurred in Area 7.

It was fairly common for a use area that elk were "migrating from" to be counted also as a destination, despite the narrow 3-month date frames used in the tabulations. Consider Summer Use Area 13 (Appendix A10). This calculation shows that 11 of the Use Area 13 population's January - March locations occurred within Area 13 (itself). That is the result of either partial (not all elk) migrations because of mild winters or short-lived reverse migrations caused by temporary weather reversals. Consequently, the reader may wish to exclude these calculations from consideration for any particular use area. If, for example, the 11 winter observations that occurred in Summer Use Area 13 were excluded (Appendix A10), then there would have been only 23 total winter observations, 100% of which occurred in Areas 11, 37, and 35.

Time of Migration

In general, the months most frequently used for spring and fall migrations were March, April, May, (Appendix A13) and October, November, December, respectively (Appendix A14). A considerable amount of movement was apparent throughout December, extending into January, and times of migration did vary somewhat from use area to use area (Appendices A15, A16, and A17). Most individuals were radio-tracked over a 2-1/2 year period. In 1 sense then, these tables present extremes obtained across years. Values span the time from when the earliest migrating animal entered an area to remain for the season, during the year of earliest migration, through the time when the latest migrating animal left, during the latest year of migration.

Herd Units

We identified 15 discrete elk herds (Figure 3) by combining seasonal use areas that were shared by the same elk. The boundaries of each herd unit were delineated by drawing a contour around its periphery. Following is a description of each herd unit, its level of self-containment, and in some cases, discussion of the interrelationships of its internal use areas.

Areas 1, 2, 3. This combination of use areas occurred in the Tusayan area just south of the

Grand Canyon. It was contained entirely within GMU 9. The population using Use Areas 1, 2, and 3 was a discrete "herd unit" being supplemented by animals from Use Areas 5 and 8 in GMU 7. Approximately 96% of the across season elk movement by the Use Area 1, 2, 3 population was self-contained within the herd unit boundary (Appendix A12).

Migration patterns are mapped in Appendices A18 and A19.

Areas 4, 5, 6, 7, 8, 9. This combination of use areas was north of I-40, and extended from the west side of the San Francisco Peaks to Hwy 64. It occupied portions of GMUs 7E and 7W. The population within GMU 7 (which contained Winter Use Areas 4 and 5, and Summer Use Areas 6, 7, 8, and 9) can be considered a herd unit; but some animals migrated from Unit 7 to Unit 9 in the fall, and about 75% of those represented a permanent, natural translocation. Seventy-six percent (n = 250, Appendices A10 and A11) of all locations of elk from this herd was self-contained within the herd unit boundary, and the remaining 24% occurred in Areas 1, 2, and 3. That value (24%) is somewhat misleading in that the transfer amounts, in a large part, to the previously mentioned translocation of animals from GMU 7 to Use Areas 1, 2, and 3 in GMU 9. Migration patterns are mapped in Appendices A20 and A21.

The combination of Summer Use Areas 6 and 7 shared a high level of across season movement (82%) with Winter Use Area 4 (Appendix A10). The association of Use Area 6 with Use Area 3 was through 1 animal that was captured in Area 8, migrated from there to All Season Use Areas 1, 2, and 3 each year, and entered Summer Use Area 6 briefly during 1 summer.

The 8-9 Use Area's primary across season transfer of animals was to Winter Use Area 5 (Appendix 10), with a noticeable amount of exchange involving Area 9 with Winter Use Area 4. There was an equally high level of exchange between Area 8 and the Use Area 1, 2, 3 combination, but no exchange between Summer Use Area 8 and Winter Use Area 4.

The association between Summer Use Area 8 and All Season Use Areas 1, 2, 3 was through Winter Use Area 5. Seven radios were installed at Bismark Lake in Use Area 8. Three of these animals consistently wintered in Use Area 5 and returned to Use Area 8 in the summer. The other 4 migrated through Area 5 into the 1, 2, 3

Area in GMU 9. One of the 4 wintered there each year and returned to Use Area 8 each summer. The other 3 remained in the 1, 2, 3 Area year-round.

A similar move was documented during the W-53-R study of elk marked with visibility collars. A single animal equipped with a visibility collar in GMU 7W was killed by a hunter in GMU 9. It is not known whether this animal represented a permanent translocation or was a seasonal migrant. The telemetry data indicate that permanent translocations, rather than seasonal migrations, dominated the movements between GMUs 7 and 9; GMU 7E was the primary contributor. However, time of capture could have been an influencing factor. The translocations occurred as a result of movements from summer to winter range that were not followed by return migrations. Obviously, in the case of a winter trapped population, animals could have transferred to GMU 9 before the capture.

Seventeen animals were radio instrumented in GMU 7. Six of these were captured in GMU 7W: only 1 during the summer and 5 during the winter. If a larger number of elk had been captured and collared in GMU 7W during the summer, some migration or translocation from GMU 7W to 9 might have been documented. However, the data indicate that only GMU 7E is a significant contributor to the Unit 9 population, and any estimate of the magnitude of this exchange must be based on the following.

Eleven animals were captured in 7E; 8 during the summer (all 4 that migrated to Unit 9 came from this group), and 3 during the winter. No animals captured in GMU 7W migrated to GMU 9. For summer and winter combined, 36% of the animals captured in GMU 7E migrated to GMU 9; 27% of those captured remained in GMU 9. For summer captures only, GMUs 7E and 7W combined, 44% of the animals captured migrated to GMU 9; 33% of those captured remained in Unit 9. No animals that were radio instrumented in GMU 9 migrated to GMU 7.

Migration patterns are mapped in Appendices A20 and A21.

Areas 10, 12. This combination of use areas laid just south and southeast of Bill Williams Mtn., and was entirely within GMU 8. The population using Areas 10 and 12 exhibited a 100% self containment level during the times used for data analysis, the January - March and June - August periods (Appendix A12), and can be

considered a herd unit.

No radio locations for this group were obtained north of Highway 1-40, which is the northern boundary of GMUs 8 and 6B. However, according to Dennis Darr, Wildlife Program Manager A.G.F.D. Region 2 (pers. commun.), numerous road killed elk have been documented on I-40 between Williams and Flagstaff; this indicates the level of elk exchange between GMU 7 and GMUs 8 and 6B may be significant.

Migration patterns are mapped in Appendices A22 and A23.

Areas 11, 13, 35, 37. This combination of use areas included the Rogers Lake area, Navajo Army Depot, Sycamore Point, and Ott Lake areas. Those areas laid primarily within GMU 6B, but included portions of GMU 8.

The population using Winter Use Areas 11, 35, 37, and Summer Use Area 13 should be considered a herd unit. Eighty-six percent of all locations of elk that ever occupied Areas 11, 13, 35, and 37 occurred within that combination of use areas (Appendix A12). The remaining 14% was comprised of 10 locations that occurred in Use Area 12, and 1 that occurred in Use Area 14.

Both the Area 11 and 35 combination, and Area 13, cross the boundary between GMUs 6B and 8.

Winter Use Areas 11 and 35 can be considered a single wintering area with a 59% seasonal fidelity rating (Appendix A4). Winter Use Area 37 (Ott Lake) is a separate wintering area with a 100% seasonal fidelity rating. It is primarily associated with Winter Use Area 13 (Appendix A11).

The primary across season movement for the population in Winter Use Area 11 and 35 was to Use Area 13 (72%, Appendix A11). Therefore, a fairly strong migration pattern is established between Areas 11 and 13. The additional use documented for the Area 11 population was due to a single animal that normally summered in Area 12 and wintered in Area 10. This animal was radio-tracked over a 37-month period, and it entered Winter Use Area 11 long enough to contribute 1 observation. By contributing a single observation to the area, that animal became part of the Area 11 subpopulation and brought all of its observations into the picture, even though its association with that group was minimal. These periodic forays into adjacent areas are not uncommon and need to be acknowledged on a

broad scale. However, the single observation in this case, as well as those occurring in other use areas, may be considered an outlier.

Additionally, that single observation in Use Area 11 was made during October, which is outside the date frames used in the migration analysis. Therefore, it was not recognized as migrating from Use Area 12 to Use Area 11, and no indication of that is given in Appendices A10 and A22. Only the aftermath of its return migration (10 locations in Use Area 12 during June, July, and August) was recognized (Appendices A11 and A23).

No radio locations for this group were obtained north of Highway I-40. However, 4 road kills involving unmarked elk, along the northern boundary of Use Area 13, were reported by Bob Barsch (AGFD Wildlife Manager, pers. commun.). Additionally, during our study, an animal wearing an ear tag, which was installed at the Navajo Army Depot (Area 13) 5 years earlier, was killed by an automobile on I-40, just west of the Army Depot. During the W-53-R visibility collar study, additional movement from the Army Depot (Use Area 13) to GMUs 7 and 8 was documented. Visibility collars were installed on 126 elk at this location. Between 1978 and 1983, this group provided 3 return sightings in GMU 7E (Use Areas 5, 8); 3 in GMU 7W (Use Areas 6, 7); 2 more just north of I-40; and 5 in GMU 8 (Use Area 12). These sightings suggest some level of exchange between Use Area 13 and GMU 7.

The 1974 AGFD study of elk marked with visibility collars documented a substantial exchange of elk between the Navajo Army Depot in Use Area 13, and the Rogers Lake area. Radio-tracking data from the latter phase of our study is in agreement, and Use Area 13 herd was expanded from its original size, as reported in Brown (1990), to include the Rogers Lake area.

Migration routes are mapped in Appendices A22 and A23.

Area 14. This use area was in the Fry Park area of GMU 6B. The population using Area 14 should probably be regarded as a discrete herd unit, although its overall level of self containment was only 55%. Appendices A6 and A7 show a 16% and 8% level of exchange with the Area 11, 13, 35, 37 combination. This is the result of the movements of 2 elk. When Use Area 14 data were incorporated into the 11, 13, 35, 37 combination, that group's level of self containment declined from 86% to 73%

(Appendix A12). Additionally, there was some "transient" activity through Area 14. A considerable amount of its subpopulation's time (33%) was spent in Area 19 during the summer (Appendix A7), and in Area 16 (26%) in the winter (Appendix A6). However, there is a similarity to the situation that was described for Areas 11 and 13 (see page 10). Three "outside animals" entered Area 14 and contributed 1 observation each, then moved on and never returned. Subsequently, they were included in the subpopulation, but were transients rather than migrants that truly belong to the Area 14 subpopulation. The remaining elk were nonmigrants with 100% fidelity to Area 14.

Migration routes are mapped in Appendices A22 and A23.

Areas 15, 16, 17, 18, 19, 20, 21, 22, 28, 29, 30, 36, 38, 39.

This combination of use areas extended from Hwy 89A on the west to as far east as Twin Arrows. It extended from slightly north of I-40, south to the Tin Roof area (south of Apache Maid Mtn.), and includes the Lake Mary, Stoneman Lake, and Happy Jack areas. This is a large area that involved portions of GMUs 6A, 5BN, 5BS, and 7E. That herd unit, minus the Anderson Mesa Use Areas (28, 29, 30, 36, 38, 39), had a 93% level of self containment (Appendix A12).

No single use area contributed more than 67% of its population's time to any other area. For 1 area, the highest level of across season exchange with any other area was only 36%. However, 972 observations were recorded for the subpopulation of all of these areas, and (908) occurred within the herd unit boundary. When data from the recently defined Anderson Mesa Use Areas was incorporated into that herd unit, the level of self containment remained the same (93.6%). The Anderson Mesa combination, by itself, had only a 68% level of self containment. Area 20 subpopulation's across season movements involve 10 other use areas, none of which received more than 36% of the subpopulation's winter use (Appendix A10). In several cases, animals that used Area 20 during the summer, wintered in an area to the west for 1 year and then changed to a winter area on the east the following year, or vice versa.

Additionally, Use Areas 30 and 39 were classified as summer and all season use areas respectively, despite the fact that both occurred at the outer extremity of what would normally be

considered winter range. In each case a single animal was responsible. In Area 30, 1 elk spent its summers in the bottom of Canyon Diablo near Meteor Crater. In Area 39 a single radio-marked elk spent most of its time, during both summer and winter, in the bottom of Padre Canyon near Angell, Ariz.

Migration patterns are mapped in Appendices A24-A29.

Areas 23, 24, 25, 26, 27. This combination of use areas occurred in the extreme southeast corner of Region 2. It contained the Duke Tank Mesa and Blue Ridge Reservoir areas, and occupied portions of GMUs 5BS and 5A. The interaction between populations from Areas 23, 24, 25, 26, and 27 indicated that they can be considered a herd unit (Appendix A12). No single area contributed more than 57% of its subpopulation's across season observations to any other area (Appendices A6, A7, A10, A11). However, when those use areas were combined, 86% of their populations across season use (462 of 535 observations) was self contained (Appendix A12).

Migration patterns are mapped in Appendices A28-A31.

Areas 41, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61

These use areas defined the boundaries of a herd unit (Figure 3) that had 91% self containment year-round (Appendix A12).

The western boundary of this combination of use areas approximated the courses of Leonard Canyon and Clear Creek. It extended north as far as McCauley Sinks and east to Dry Lakes, then southwest toward Forest Lakes Estates. The southern boundary was approximately 9.7 km (6 mi) north of the Mogollon Rim. This combination of use areas occupied portions of GMUs 4A and 4B.

The western boundary of that combination of use areas approximated the western boundary of Region 1. A small exchange of individuals across this regional boundary was documented (Appendix 6). However, that exchange (between Use Areas 24, 25, and 27 of Region 2, and Use Areas 52 and 53 in Region 1) was so small that the movements were not mapped in Appendices A32-A37. Those exchanges equalled only 1 or 2% of any individual use area population's locations.

The southern boundary of this herd unit followed the southern boundaries of Use Areas 52 and 41, and defined the southern extent of Region 1 elk, and the northern extent of Region 6 elk during the summer. This boundary is described

in more detail under results for the Region 6 herd units.

Areas 44, 63, 64, 65, 66. This combination of use areas extended from an area about 6.4 km (4 mi) east of Chediski Farms on the White Mountain Apache Reservation, north to the Black Canyon Lake area, 11 km (7 mi) east of Forest Lakes, then northeast to the Blevins Lake area, 5 km (3 mi) east of Heber. It was confined almost entirely to GMU 3C and the White Mountain Apache Reservation, with small portions of GMUs 3A and 4B included. Those use areas (Figure 3) defined the boundaries of a herd unit that was 85% self contained (Appendix A12).

A noticeable level of exchange occurred between this herd and Use Areas 56, 57, and 58 (Appendices A6 and A10). The Use Area 65 population was largely non-migratory, and exhibited use levels to itself of 62 and 64% (Appendices A6 and A7). Eleven percent of the Use Area 64 population's use went to Use Area 44 near Chediski Farms on the Reservation. Use of Reservation lands was confined to Use Area 44 and accounted for less than 2% of this herd unit's year-round activity (3 of 184 locations).

Migration patterns are mapped in Appendices A38 and A39.

Area 67. This single use area defined the Pinedale herd unit. It laid entirely within the boundaries of GMU 3C. This herd was non-migratory and 99% self contained (Appendices A12, A6, A7, A39 and A40).

Areas 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78. This combination of use areas extended from Show Low, east to the Vernon area, and south as far as the Horseshoe Cienega Lake area. It occupied portions of GMUs 3B, 2C, and 1. That combination of areas defined the boundaries of a group of elk (Figure 3) that was 98% self contained (Appendices A12, A10, A11). Therefore, our data suggest this group of use areas, and the following group as well, define individual herd units. However, contrary information is provided in the section on White Mountain Apache Game and Fish Department Data.

The elk using those use areas were heavily associated with Use Areas 68, 71, 74, and 75, which laid almost entirely within the Reservation (Figure 3). Nine percent of the January-March observations that occurred within this elk group's range (11 of 117 locations), and 59% of its June-August observations (81 of 137 locations) occurred

on Reservation lands. Year-round, 36% (92 of 254 locations) occurred on Reservation land.

Migration patterns are mapped in Appendices A40 and A41.

Areas 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 95, 96, 97.

The western boundary for this combination of use areas was 4.8 to 6.4 km (3 to 4 mi) east of Vernon, and its eastern boundary was near Alpine. The area extended from due east of Vernon on the north, south to the Baldy Bill Point area. This area occupied portions of GMUs 1, 27, and portions of the White Mtn. Apache Reservation.

That combination of use areas defined the boundaries for a group of elk (Figure 3) whose population was 94% self contained (Appendix A12, A10, and A11). The remaining 6% of that population's across season use occurred within the boundaries of the herd unit immediately to the west (Use Areas 68-78). Within season exchange was 17% during the summer (Appendix A3), and 3% during the winter (Appendix A4).

This herd unit was associated with the White Mountain Apache Reservation through portions of Use Areas 80, 83, 95, and 96. Seven percent of the January-March observations that occurred within this herd unit's boundaries (7 of 96 locations), and 23% of its June-August observations (22 of 96 locations) were on Reservation land. Year-round, 15% (29 of 192 locations) occurred on the Reservation.

Because this group of elk, as well as the preceding group (Areas 68-78), may be part of a larger herd unit, we combined their data on Reservation and non-Reservation use. For those two groups combined, 8% (18 of 213 locations) of the January-March locations, and 44% (103 of 233 locations) of the June-August locations occurred on the Reservation. An estimate for the entire year (based on January-March and June-August observations combined) was 27% (121 of 446 locations).

Migration patterns are mapped in Appendices A42 and A43.

Areas 89, 90, 91, 92, 93, 94. This combination of use areas extended from about 9.7 km (6 mi) north of Beaverhead, south through Hannagan Meadow to the Raspberry Peak area, east of Hwy 666. These areas occupied a portion of GMU 27, and defined the boundaries of a herd unit that appeared to be 100% self contained (Appendices A12, A10, A11).

Migration patterns are mapped in Appendices A44 and A45.

Areas 31, 32, 40, 50, 51. These use areas defined the boundaries of the western-most herd unit containing elk from Region 6. This combination of use areas contained Hardscrabble Mesa, Milk Ranch Point, and Baker Butte. This herd unit exhibited a 96% level of self containment (Appendices A12, A10, A11). It occupied portions of 2 GMUs, 6A in Region 2, and GMU 22 in Region 6.

Summer Use Area 50 was the primary area for across season population exchange with Winter Use Area 51. However, 46% (10 locations) of the Use Area 51 population's summer use occurred in Use Area 32, which is above the Mogollon Rim, and in Region 2.

Likewise, 84% (36 observations) from Winter Use Area 31, and 67% (12 observations) from Winter Use Area 40 went to Summer Use Area 32 (Appendix A11). This herd unit, whose members were all captured below the Rim during winter months, expended 70% of its time (58 of 83 observations) during summer months in GMU 6A of Region 2.

This activity extended north of the Rim to a point approximately 6.4 km (4 mi) north of Baker Butte.

Migration patterns are mapped in Appendices A46 and A47.

Areas 33, 34, 42, 43, 45, 46, 47, 48, 49. This combination of use areas extended from about 4.8 km (3 mi) west of Myrtle Point, east onto the White Mountain Apache Reservation. Above the Rim, the combination included portions of GMU's 4A, 4B, 5A, and 3C. Below the Rim, portions of GMU's 22, 23, and a small part of the western portion of the Apache Reservation are involved.

These use areas defined the boundaries of a herd unit that was 89% self contained (Appendix A12). A subdivision of this combination of use areas was attempted. Neither the 45, 47, 48, 49 combination (35% self contained), nor the 46, 33, 34, 42, 43 combination (80% self contained) rated as high as the larger area.

Summer Use Areas 34, 46, and 49 were all above the Rim. Seventy-three percent (217 of 297 observations) of the herd units across season use went to these use areas during summer months (Appendices A7 and A11).

Because there was an indistinct division in the location data points, the northern boundaries of

Use Areas 34, 46, and 49 were arbitrarily drawn to separate Region 1 elk from Region 6 elk during summer. Only 10% of the summer observations (31 of 298 locations) from the populations using Use Areas 34, 46, and 49, went to Use Areas 52, 55, and 41 immediately to the north in Region 1 (Appendix A3). Similarly, only 16% of the summer observations (63 of 406 locations) from the populations using Use Areas 52, 55, and 41 went to Use Areas 34, 46, and 49 (Appendices A3 and A7).

The northern boundary of Use Areas 34, 46, and 49 was 8.05 - 10.46 km (5.0 - 6.5 mi) north of the Mogollon Rim. That boundary can be better described as a line running from a point 8.05 km (5 mi) north of the dam at Willow Lake, westerly to points 8.86 km (5.5 mi) north of Woods Canyon Lake, 3.22 km (2 mi) north of Bear Canyon Lake and 3.22 km (2 mi) north of Knoll Lake.

Elk from Use Areas 42 and 43 of this herd unit entered the western edge of the White Mountain Apache Reservation. This entry was only 4.83 - 6.44 km (3 - 4 mi) (Figure 3), and did not reach Use Area 44 (Appendices A6 and A7).

Mapping and data analysis for the January-March and June-August periods, beginning June 1991 and ending August 1993, provided the following estimate of transfer across the Reservation boundary.

Three elk from Use Area 42 spent 4% of their time (1 out of 27 locations) during summer periods on the Reservation. One animal from Use Area 43 spent 11% of its time (1 out of 9 locations) on the Reservation. Combined, the elk from these 2 use areas spent 6% of their time during summer on the Reservation.

During winter, the 3 elk from Use Area 42 spent 22% of their time (4 out of 18 observations) on the Reservation. The single elk from Use Area 43 spent 33% of its time (2 of 6 locations) on the Reservation. Combined, the elk from the 2 Use Areas (42 and 43) spent 25% of their time during the winter on the Reservation.

Migration patterns are mapped in Appendices A48 and A49.

Data From Elk Captured in AGFD Region 6 During Summer

Information from these animals is presented in Figure 4, and under the following headings of Use Areas 101-115. Use Areas are classified as Summer, Winter, and All Season Use Areas in

Appendix B1. Appendix B2 lists the number of animals involved with each use area.

Areas 101, 102, 103. These use areas contained Strawberry, portions of Hardscrabble Mesa, and areas west of Baker Butte above the Mogollon Rim. This combination of use areas involved much of the same area that was included within Use Areas 31, 32, and 40 of the main data set. The population using the 101, 102, 103 combination exhibited a 78% level of self containment (Appendix A12).

Use Area 101 was above the Mogollon Rim in GMU 6A of Region 2. Thirty-nine percent of the Winter Use Area 103 population's summer activity occurred in Use Area 101 (Appendix B10). Thirty-nine percent of the All Season Use Area 102 population's summer use also went to Area 101 (appendix B7). Therefore, all summer captured animals from this group did not remain below the Rim throughout the year. Migration patterns are mapped in Appendices B11 and B12.

Areas 104, 105. These 2 use areas were below the Rim and just to the south and east of Milk Ranch Point. In general, they occupied the same areas as Use Areas 50 and 51 in the main data set. However, Areas 104 and 105 comprised a combination that was 100% self contained (Appendices A12, B9, B10). All elk from the 104, 105 sub-populations stayed below the Rim year-round.

Migration patterns are mapped in Appendices B11 and B12.

Areas 106, 107, 108, 109, 110, 111. This combination of use areas extended from a point 6.44 km (4 mi) west of Tonto Village, east to the Woods Canyon Lake area. In general, it occupied the same areas as Use Areas 45, 46, 47, 48, and 49 defined by the main data set. The population using the 106-111 combination of use areas exhibited a 91% level of self containment (Appendix A12).

Two of the use areas in this combination (106 and 109), were north of the Mogollon Rim. Nineteen percent of the summer locations (18 of 96 locations) from the Use Area 107, 108, 110, and 111 populations, occurred above the Rim in Use Areas 106 and 109.

Migration patterns are mapped in Appendices B11, B12, B13, and B14.

Areas 112, 113, 114, 115. This combination of use areas extended from the O W Point area, south into the Gentry Mtn. area, and east to Chediski Farms. The populations that used this

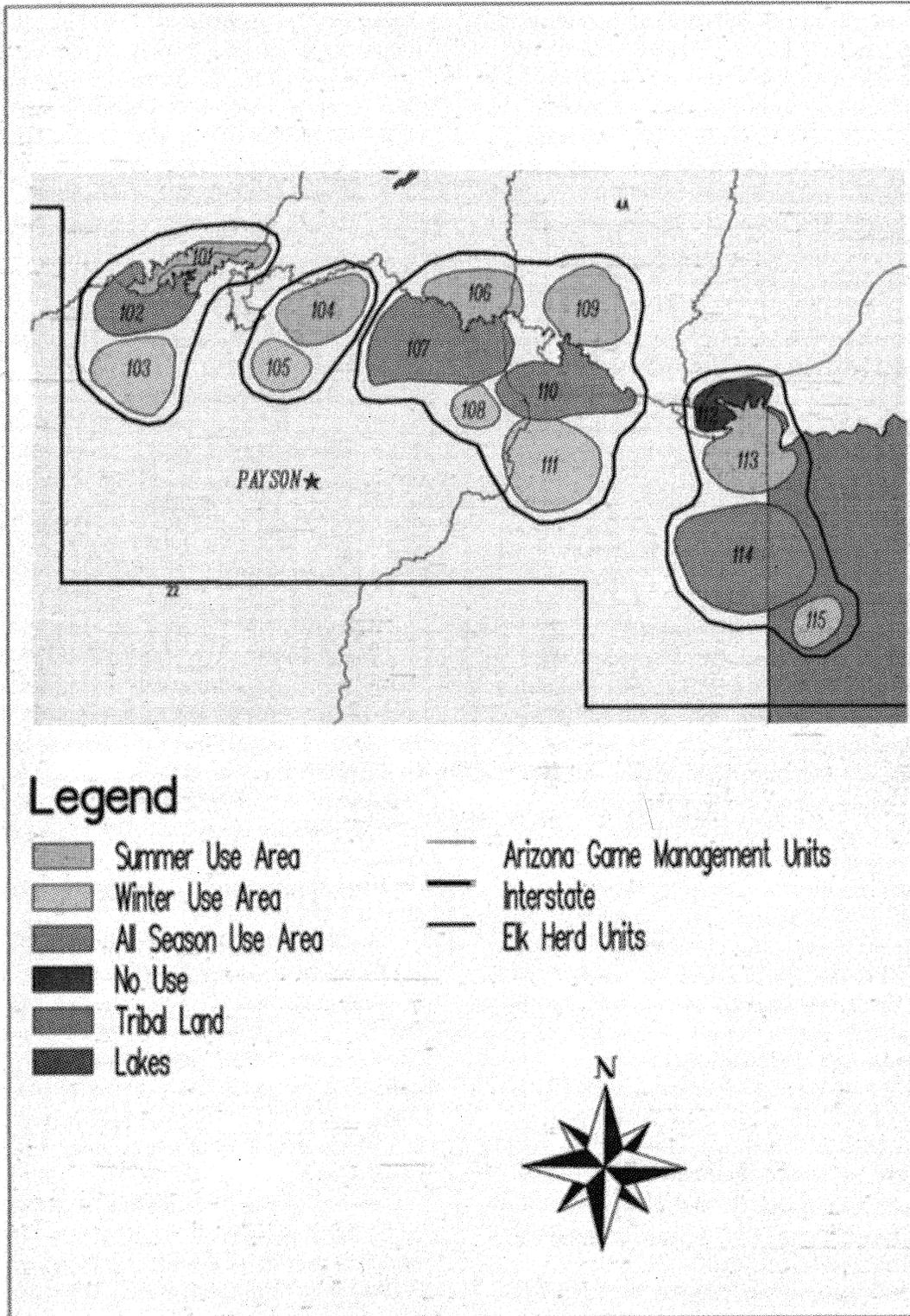


Figure 4. Seasonal use areas and herd units defined by data from elk captured in Region 6 during the summer.

combination of use areas exhibited a 100% level of self containment (Appendix A12).

Migration patterns are mapped in Appendices B13 and B14.

Use Area 112 laid above the Mogollon Rim. Only 2 observations occurred in this use area, and those were outside the June-August time frame used in the analyses. For all practical purposes then, the population from the 113, 114, and 115 use areas can probably be considered residents below the Rim during summer months.

Elk from Use Areas 113 and 114 of this combination, entered the western edge of the White Mountain Apache Reservation, with some use extended as far east as the Chediski Farms area (Figure 4, Appendices B6, B7, B9, and B10).

Data for the January-March and June-August periods, beginning June 1991 and ending August 1993, provided the following estimate of transfer across the Reservation boundary. Three elk from Use Area 113 spent all of their time during summer (21 of 21 locations) off the Reservation. Three elk from Use Area 114 spent 33% of their time (6 of 18 locations) on the Reservation. Combined, the elk from those 2 use areas spent 15% of their time during summer on the Reservation.

During winter, the 3 elk from Use Area 113 spent 22% of their time (4 of 18 locations) on the Reservation. The 3 elk from 114 spent 56% of their time (5 of 9 locations) on the Reservation. Combined, the elk from Use Areas 113 and 114 spent 27% of their time on the Reservation during the winter.

Data Provided By The White Mountain Apache Tribe, Game And Fish Department

The area encompassed by this data set extends from Vernon, south to the Baldy Bill Point area, and from Hawley Lake, east to the Escudilla Mountain area (Figures 5 & 6).

These data do not support the separation of Use Areas 68-78 from Use Areas 79-88 and 95-97 (within the main data set), to form 2 separate herd units. Instead, they suggest a single herd unit with a central summer range surrounded by several winter and a few all-season use areas (Appendix C14).

This group of use areas overlapped the boundary of the Use Area 89-94 herd unit in the southwest 1/4 of the Alpine quadrangle, and in the southeast 1/4 of the Buffalo Crossing

quadrangle (Appendices A44, and C14).

If we consider the population within those use areas as a single herd unit, 75% of its estimated year-round time (189 of 252 observations from the January-March and June-August periods combined) was spent on the Reservation. Fifty-three percent of the January-March observations (70 of 132 locations) occurred on the Reservation, and 99% of the June-August observations (119 of 120 locations) occurred on the Reservation.

Tabular presentations of data appear in Appendices C1-C9. Migration patterns are mapped in Appendices C10-C13.

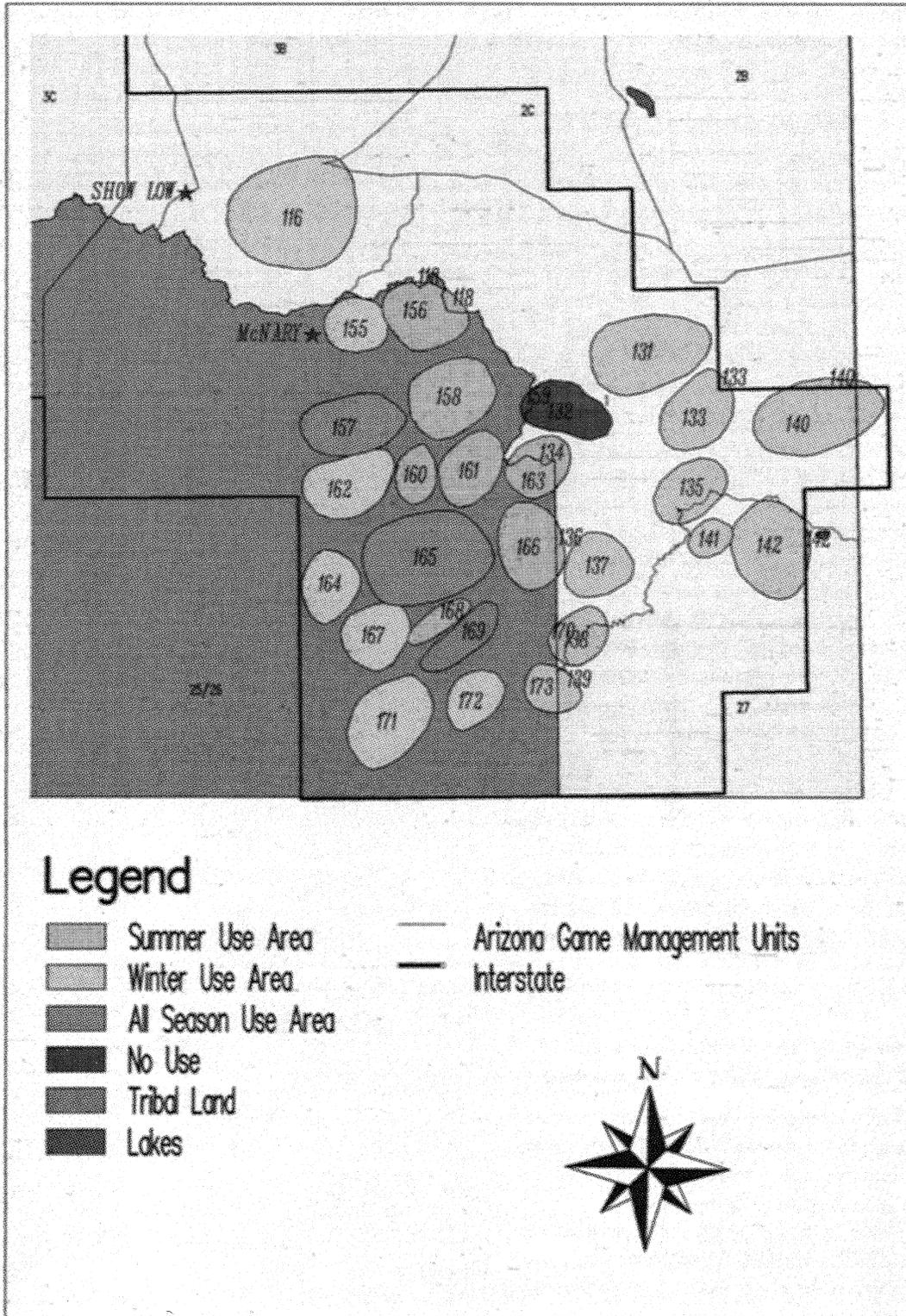


Figure 5. Seasonal use areas defined by elk captured on the White Mountain Apache Reservation and radio-tracked by Tribal Game and Fish Department personnel.

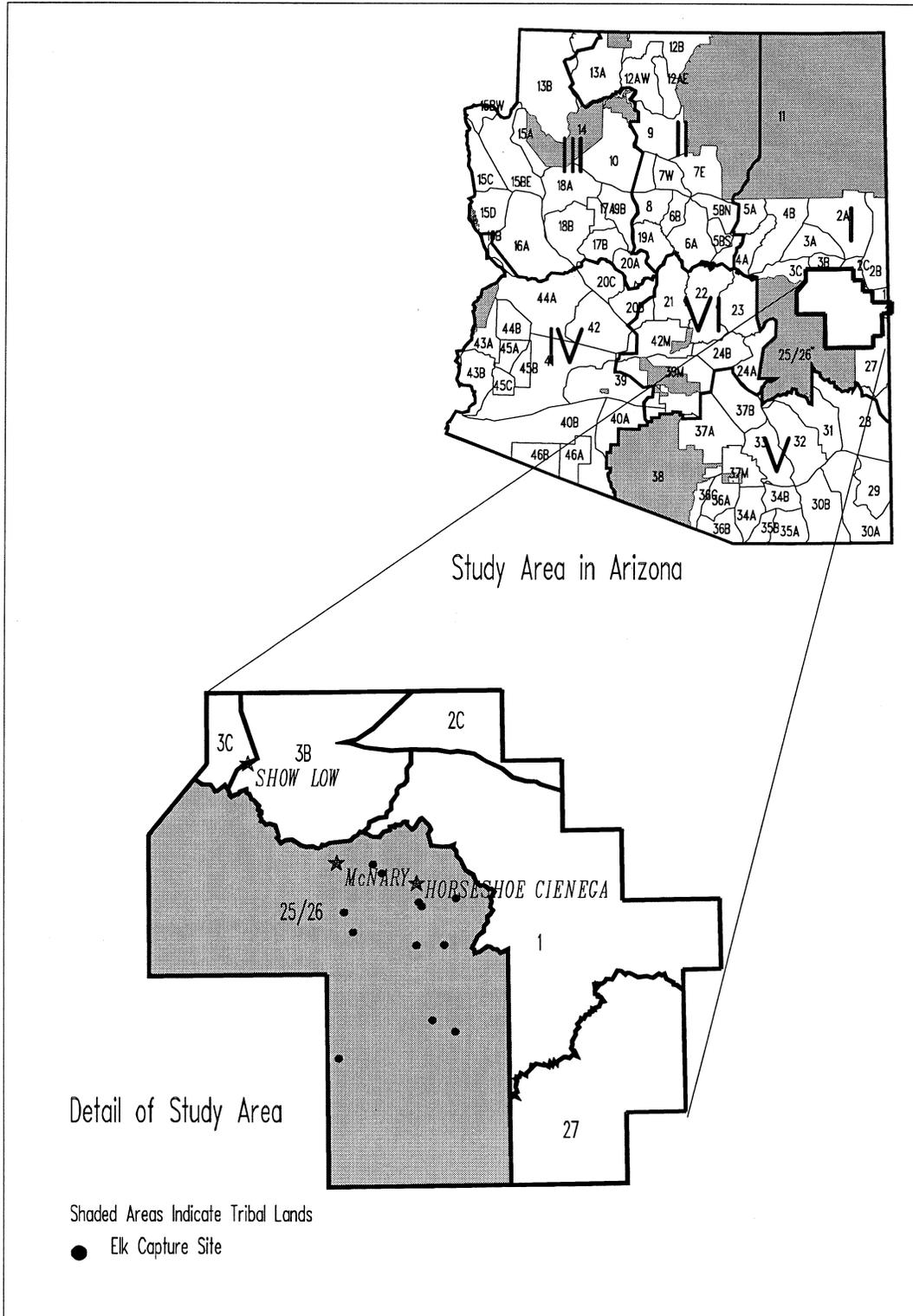


Figure 6. Elk capture sites used by personnel of the White Mountain Apache Tribe Game and Fish Department.



DISCUSSION

Haywood et al. (1987) described the seasonal movement patterns of mule deer on the North Kaibab. These animals moved to the periphery of their high elevation range in late summer where they remained until weather or some other factor induced them to move to lower winter range. Return migrations were not made until the following spring. Seasonal use areas were easily defined by least-sided convex polygons, and related to elevational ranges and calendar date frames.

Elk involved in the current study did not exhibit that migrational consistency. Weather patterns usually initiated the migration to winter range. However, a reversal of that weather pattern frequently resulted in a return migration to summer range, even during early winter. This reverse would have produced very broad seasonal home range polygons that included both summer and winter ranges. Any attempt to define seasonal use areas solely on the basis of date frames would have produced similar results. Additionally, a method that would readily yield information on levels of population exchange between areas was needed; therefore, a different approach was selected.

That approach, estimating the degree to which each use area's subpopulation utilized its own as well as other use areas, required that elk capture and radio installation followed certain guidelines. The first of those required that we distribute the radios in a uniform manner. To accomplish that, we used evenly distributed capture sites within elk concentrations, and limited radio installations to 5 units per capture site.

Additionally, time of radio installation was required to correspond to season of heaviest elk use on the area. This is probably most important on winter ranges which retain a small percentage of their winter herd as year-round residents. Installing radios on those resident elk during summer, would have produced data non-representative of the main herd.

In order to insure that our primary data set complied with the above constraints, data from elk captured in AGFD Region 6 during the summer, and data from elk captured and radio-tracked by personnel of the White Mountain Apache Tribe Game and Fish Department, were kept separate.

Shoemith (1979) determined that individual elk in a Montana study were found together only

"about as frequently as expected by chance." Other investigators (Harper 1964, Struhsaker 1967, and Knight 1970) also reported that the social structure within groups of elk is unstable and that individuals frequently move from 1 group to another. However, repeat or habitual use of seasonal home ranges has been reported (Murie 1951, Brazda 1953, Anderson 1958, Picton 1960, Tanner 1965, Knight 1970, Craighead et al. 1972, Shoemith 1979, and Waldrip and Shaw 1979). Murie believed that this habitual use is the result of behavior learned as calves.

In this study we did not use coefficient of association tests, Shoemith (1979) to determine the frequency of contact between individual elk. However, observations did not suggest any tendency for individuals occupying any use area to maintain any particular level of contact with other radio-marked individuals. But, there was a strong tendency for individuals to occupy the same seasonal use areas each year, and seasonal observations tended to clump into discrete clusters. Subsequently, there appeared to be a high degree of fidelity to particular geographical areas, but not to social groups within those areas.

Genetic isolation could be 1 consequence of a high degree of fidelity to any geographic area. The frequent exchange of individuals between seasonal use areas may be 1 of the primary mechanisms that prevents inbreeding. Even though we were able to identify units that in some cases appeared to be 95 to 100% self-contained, these units encompassed areas broad enough to hold a substantially large gene pool.

Within those herd unit boundaries there were usually 2 or more use areas that exchanged individuals, and within each use area were social aggregations that exchanged individuals on a frequent basis. Shoemith (1979) found that exchange of individuals between social groups was common even during the breeding season, with cows usually remaining in the same harem for less than 5 days.

Seasonal migrations are triggered by snow depth and forage availability. The most abrupt migrations witnessed during this study were induced by changes in weather during late fall or early winter. There is ample documentation that early winter snow accumulation is the most common triggering mechanism for migrations to winter range (Mitchell and Lauckhart 1948, Anderson 1958, Lovaass 1970, Picton and Picton

1975, and Schwartz and Mitchell 1945). Leege and Hickey (1977) report that in Idaho, 46-61 cm (around 1.5 to 2 ft) of snow accumulation was enough to induce elk to move. Although snow depths were not obtained during this study, it appeared that 30 cm (about 1 ft) of snow accumulation was enough to induce elk to move in Arizona.

As previously mentioned, a reversal of weather (usually rapid snow melt) on several occasions resulted in a reverse migration back to summer range. This movement may have been due to forage availability and daytime temperatures at higher elevations.

Ward et al. (1973) and Dalke et al. (1965) report that spring migrations back to summer range are controlled by the rate of green up and availability of new forage at higher elevations. Skinner (1925) and Dalke et al. (1965) have reported reverse spring migrations in response to local forage conditions. No reversal of the spring migration was witnessed during our study.

Although some elk are year-round residents in certain localities, the majority of Arizona's elk are migratory. This migration ensures forage availability at all times of the year and also distributes total grazing pressure over a larger area on a year-round basis. This latter aspect has been stressed by both Martinka (1969) and Craighead et al. (1972) as being very important to winter range maintenance in Idaho (i.e., providing adequate rest to the winter range plant community during the summer months). It is undoubtedly equally important in Arizona—particularly in areas with extensive cool season grass communities. The areas identified in this study as "All Season Use Areas" may have an increased vulnerability to range overuse, because elk are using them to a significant degree during both summer and winter.

Migration times are predictable only in a very general fashion. Certain range allotments are therefore more vulnerable than others to range overuse caused by annual fluctuations in migration time. Additionally, the management of hunting seasons is complicated by these same inconsistencies. Generally speaking, nearly all elk have left winter range by April 15, are on summer range by June 1, and are back on winter range during January.

The difference in fidelity rating averages for June-September, and September alone (Appendix A9), is not considered important enough to discredit the application of June-August

information to current management procedures. Some elk classification surveys are conducted in late August and early September. The 8% difference between the average June-September fidelity value and the September value represents the beginning of an annual downward trend as individuals begin to migrate to winter range. That 8% is derived from the use of an average for all of September. It can be considered an estimate applicable to the end of the survey period, because surveys are completed no later than the first half of September.

Fidelity to GMUs averaged only 51% (Appendix A8), while the average level of self containment for herd units was 90% (Appendix A12). Even so, the herd unit approach is not applicable to all facets of management. Herd unit boundaries do not correspond to readily identifiable geographic features (canyons, roads, etc.). Boundaries that are easily recognized by the public are a prerequisite for effective hunt management. Consequently, the herd unit approach may be better suited to the management of surveys and survey data than the overall management of hunts.

The exchange of elk between AGFD Regions 1 and 2 appeared negligible. However, the exchange between AGFD Region 6 and Region 1 is large enough to have major management implications. Likewise, the exchange between Region 6 and Region 2 could have significant management implications for elk in the western portion of Region 6. Elk that migrate out of Region 6 to spend their summers above the Mogollon Rim tend to remain within 6 miles of the main body of the Rim (this excludes major points that project southward).

The dividing line between the AGFD Region 6 elk population and those in Regions 1 and 2 can be described as follows. Beginning at a point directly north of the east end of Region 6, the line separating the majority of the Region 6 elk from those summering to the north, extends westerly through points that are approximately 8.05 km (5 mi) north of Willow Lake, 8.86 km (5.5 mi) north of Woods Canyon Lake, 3.22 km (2 mi) north of Bear Canyon Lake, and 3.22 km (2 mi) north of Knoll Lake. Approximately 3.22 km (2 mi) north of Knoll Lake this line turns southwest, follows West Leonard Canyon to the Mogollon Rim, about 1.61 km (1 mi) west of Myrtle Point. From there it follows the Rim to about 3.22 km (2 mi) east of Milk Ranch Point, then north to 8.05 km

(5 mi) north of Baker Butte, then west for approximately 16.1 km (10 mi). No significant across Rim movement was documented between the areas 1.61 km (1 mi) east of Milk Ranch Point and 3.22 km (2 mi) west of Myrtle Point.

Our only estimate of the extent of across Rim transfer by Region 6 elk during summer months comes from the main data set (data from elk captured in Region 6 during winter). The herd unit in the Milk Ranch Point area expended 70% of its time during summer months above the Rim. The herd unit that extended from the Myrtle Point area east onto the Reservation, spent 73% of its time during the summer months above the Rim. Combined, these two herd units spent 72% of their time, during the summer (275 of 380 observations), above the Rim.

Data from elk captured in Region 6 during the summer were generally compatible with the herd unit boundaries defined by the main data set. Summer captured elk did, however, extend their range about 3 miles farther into the western portion of the Reservation than their winter captured counterparts.

Indian Reservation use by Region 6 elk in the main data set was confined to Use Areas 42 and 43. Reservation use, by the population from Use Areas 42 and 43 combined, was less during the summer (6%) than in the winter (25%). During both seasons, Reservation use by elk from Use Area 42 appeared to be less than that from Use Area 43.

Reservation use by elk captured in Region 6 during the summer followed the same pattern. Reservation use was less during summer (15%) than in winter (27%) by the populations from Use Areas 113 and 114 combined. During both seasons, Reservation use by elk in the northernmost of the 2 Use Areas (113) appeared to be less than use by elk from Use Area 114. Generally, Reservation use by summer captured elk was greater than that by winter captured elk.

The western portion of the Reservation was also used by elk from the herd unit comprised of populations from Use Areas 44, 63, 64, 65, and 66. Reservation use by that herd unit was light, comprising less than 2% of the herd unit's year-round activity.

The population occupying Use Areas 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, and 78 used the White Mountain Apache Reservation more than any other group within the main data set. During the summer, 59% of that population's use

occurred on Reservation lands. Winter use was only 9%, and the year-round average was 36%.

The group occupying Use Areas 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 95, 96, and 97, used Reservation lands to a lesser degree than the preceding group. Seven percent of its summer use, 23% of its winter use, and 15% of its year-round use occurred on Reservation land.

The elk southeast of Show Low, defined by Appendix C14, appear to be a single herd unit. The combination of Use Areas 68-78 with 79-88 and 95-97 increased the level of population self containment from 98% and 94% respectively, to 100% (Appendix A12). The addition of data supplied by the White Mountain Apache Tribe, Game and Fish Department provided information on the southern half of this herd unit.

Reservation use within the data set provided by the White Mountain Apache Tribe exceeded Reservation use within our main data set. Fifty-three percent of the January-March, 99% of the June-August, and 75% of the year-round use within that data set occurred on the Reservation. The sample size of the Apache data set ($n = 252$) is only about half the size of our main data set (Use Areas 68-78, 79-88, and 95-97). Nevertheless, the Apache data provides a valuable estimate of Reservation and non-Reservation use by this herd unit. The more centralized locations of its capture sites resulted in more uniform distribution of radio locations.

The lower portion of the Alpine quadrangle (Appendix C14) appears to contain a seasonal range classification error that is the result of an abnormality within the White Mountain Apache data set. The portion of the Alpine quadrangle west of Hwy 666 and extending to the bottom of that quadrangle should be classified as summer range.

The overlap in herd units in the southwest 1/4 of the Alpine quadrangle and the southeast 1/4 of the Buffalo Crossing quadrangle (Appendices A44, A45, and C14) is not considered serious. The level of self containment for both herd units should still be above 90%.

We identified herd units by combining spring and fall migration data from progressively larger numbers of use area populations, until the highest level of year-round self containment was obtained. In some cases that approach may have defined geographical boundaries larger than managers care to work with. However, if the manager is willing to accept a smaller level of self containment, the

existing herd unit can sometimes be subdivided into smaller groups. That can be done by recombining the numbers of observations listed in the tabular appendices, re-calculating the percentages of those observations that occur within the new aggregation of use areas, and also recalculating the percentages that occur in other individual use areas. Within the main data set, Appendices A10 and A11 provide the necessary data for summer and winter use areas. Appendices A6 and A7 contain data for all season use areas.



Cow and yearling elk feeding.



MANAGEMENT OPTIONS

Survey And Set Harvest Levels By GMU Only

This approach to management has some definite administrative advantages. GMU boundaries are clearly defined (usually by roads) and easily recognized by the general public.

The main disadvantage is that elk herds can inadvertently be exposed to more than 1 hunt if the date frames for hunting seasons are not the same across all GMUs. However, uniform starting and ending dates for hunts can prevent any group of elk from being exposed to more than 1 general firearms hunt, even though they may migrate across a GMU boundary. Worth additional mention is that archery and muzzle-loader hunts occur at earlier dates than the general firearms hunts. The possibility then exists for a group of elk to be exposed to a primitive weapon hunt in one GMU and a general firearms hunt in another. Even so, this point may be of little importance. Most GMUs have primitive weapon hunts that are themselves restricted to uniform date frames. These precede periods of major migration. Thus, the possibility of any herd being inadvertently exposed to more than one primitive weapon hunt is eliminated. Additionally, the effects of the primitive weapon hunts can be evaluated separately from the effects of the general firearms hunts.

Another disadvantage of this approach is that elk can be surveyed in one area and harvested in another. Additionally, survey data from a particular GMU may involve more than one herd.

Delineate Elk Hunt Boundaries According To Elk Herd Boundaries

Each herd is surveyed, and harvest levels are based on individual herd data. Clearly this is the most desirable option from the biological standpoint. However, it may be impossible to administer because of the lack of recognizable (to the public) geographical features that would define herd unit boundaries.

Establish Uniform Hunt Dates for Adjacent GMUs That Provide Habitat To The Same Herd

Managers coordinate survey activities so that data would be compatible with the herd unit boundaries. Any combination of GMUs that contains the same herd unit could be hunted

during different date frames than an adjacent set of GMUs that support a different herd, because few elk would cross into GMUs that supported a different herd unit. The potential to inadvertently expose individual elk to more than one hunt would be minimized. Permit allocation and harvest levels would be set by considering a block of GMUs that contained a herd unit. This approach should satisfy both biological and administrative requirements in those areas where it can be applied.

Establish Uniform Hunt Dates Across All GMUs, And Coordinate Surveys For Each Herd Separately

Although this option lacks the flexibility provided by the previous option, it is probably the easiest to implement and can be applied to all GMUs. It satisfies all biological and administrative requirements.

Special Control Hunts

If special hunts are used to control locally high concentrations of elk on winter range, such hunts might be most effective if conducted in January, weather and road conditions permitting. During December, a substantial amount of movement is still in progress during years of late migration.



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Appendix A1. Seasonal use area designation based on $\geq 67\%$ of elk location observations occurring within each use area during winter (January-March) or summer (June-August).

Area	Winter		Summer		Designation	Area	Winter		Summer		Designation
	%	(No.)	%	(No.)			%	(No.)	%	(No.)	
1	24	(7)	76	(22)	Summer	50	0	(0)	100	(12)	Summer
2	92	(22)	8	(2)	Winter	51	100	(12)	0	(0)	Winter
3	38	(40)	62	(64)	All Season	52	37	(54)	63	(92)	All Season
4	100	(37)	0	(0)	Winter	53	62	(38)	38	(23)	All Season
5	100	(34)	0	(0)	Winter	54	74	(39)	26	(14)	Winter
6	0	(0)	100	(21)	Summer	55	36	(39)	64	(68)	All Season
7	0	(0)	100	(11)	Summer	56	90	(18)	10	(2)	Winter
8	0	(0)	100	(48)	Summer	57	55	(6)	45	(5)	All Season
9	0	(0)	100	(16)	Summer	58	64	(7)	36	(4)	All Season
10	100	(32)	0	(0)	Winter	59	37	(7)	63	(12)	All Season
11	100	(18)	0	(0)	Winter	60	71	(5)	29	(2)	Winter
12	8	(5)	92	(55)	Summer	61	50	(17)	50	(17)	All Season
13	29	(11)	71	(27)	Summer	62	0	(0)	0	(0)	None
14	41	(34)	59	(49)	All Season	63	41	(9)	59	(13)	All Season
15	87	(26)	13	(4)	Winter	64	15	(5)	85	(28)	Summer
16	92	(85)	8	(7)	Winter	65	45	(38)	55	(47)	All Season
17	100	(49)	0	(0)	Winter	66	53	(16)	47	(14)	All Season
18	92	(12)	8	(1)	Winter	67	44	(36)	56	(47)	All Season
19	10	(23)	90	(213)	Summer	68	100	(8)	0	(0)	Winter
20	5	(4)	95	(82)	Summer	69	90	(28)	10	(3)	Winter
21	29	(6)	71	(15)	Summer	70	86	(24)	14	(4)	Winter
22	69	(27)	31	(12)	Winter	71	100	(1)	0	(0)	Winter
23	73	(41)	27	(15)	Winter	72	81	(39)	19	(9)	Winter
24	43	(41)	57	(54)	All Season	73	26	(10)	74	(28)	Summer
25	29	(7)	71	(17)	Summer	74	3	(3)	97	(98)	Summer
26	46	(11)	54	(13)	All Season	75	0	(0)	100	(5)	Summer
27	52	(30)	48	(28)	All Season	76	80	(4)	20	(1)	Winter
28	100	(13)	0	(0)	Winter	77	100	(8)	0	(0)	Winter
29	45	(25)	55	(30)	All Season	78	0	(0)	100	(1)	Summer
30	0	(0)	100	(5)	Summer	79	100	(26)	0	(0)	Winter
31	67	(12)	33	(6)	Winter	80	28	(17)	72	(43)	Summer
32	20	(9)	80	(37)	Summer	81	100	(3)	0	(0)	Winter
33	94	(45)	6	(3)	Winter	82	0	(0)	100	(7)	Summer
34	11	(12)	89	(97)	Summer	83	0	(0)	100	(13)	Summer
35	67	(2)	33	(1)	Winter	84	0	(0)	100	(9)	Summer
36	12	(9)	88	(63)	Summer	85	18	(3)	82	(14)	Summer
37	100	(3)	0	(0)	Winter	86	25	(1)	75	(3)	Summer
38	49	(17)	51	(18)	All Season	87	0	(0)	0	(0)	None
39	53	(9)	47	(8)	All Season	88	100	(11)	0	(0)	Winter
40	100	(13)	0	(0)	Winter	89	32	(6)	68	(13)	Summer
41	17	(2)	83	(10)	Summer	90	0	(0)	100	(3)	Summer
42	64	(23)	36	(13)	All Season	81	100	(6)	0	(0)	Winter
43	54	(7)	46	(6)	All Season	92	0	(0)	100	(4)	Summer
44	100	(3)	0	(0)	Winter	93	100	(5)	0	(0)	Winter
45	100	(15)	0	(0)	Winter	94	100	(7)	0	(0)	Winter
46	5	(2)	95	(35)	Summer	95	100	(3)	0	(0)	Winter
47	86	(6)	14	(1)	Winter	96	100	(7)	0	(0)	Winter
48	57	(29)	43	(22)	All Season	97	100	(8)	0	(0)	Winter
49	6	(2)	94	(29)	Summer						

Appendix A2. Number of telemetered elk comprising each use area's subpopulation.

Area	Winter January-March	Summer June-August	Area	Winter January-March	Summer June-August
1	4	4	50	4	4
2	5	5	51	4	4
3	9	9	52	25	26
4	6	6	53	16	17
5	9	9	54	17	18
6	6	6	55	21	20
7	2	2	56	13	12
8	10	10	57	11	10
9	6	6	58	7	7
10	5	5	59	2	2
11	8	8	60	4	3
12	5	5	61	6	6
13	8	8	62	0	0
14	9	9	63	5	5
15	5	5	64	7	7
16	25	26	65	10	10
17	13	13	66	9	10
18	6	6	67	7	7
19	30	30	68	4	3
20	15	16	69	15	14
21	4	4	70	13	13
22	11	11	71	1	0
23	12	14	72	20	20
24	7	14	73	19	18
25	7	8	74	23	22
26	9	9	75	2	2
27	12	12	76	4	4
28	3	3	77	1	1
29	11	11	78	1	1
30	1	1	79	6	6
31	5	6	80	8	8
32	6	7	81	1	1
33	10	10	82	1	1
34	16	16	83	3	3
35	2	2	84	1	1
36	12	12	85	3	3
37	1	1	86	4	4
38	3	3	87	0	0
39	4	4	88	4	4
40	3	3	89	2	2
41	11	10	90	4	4
42	7	7	91	2	2
43	2	2	92	2	2
44	1	1	93	2	2
45	6	6	94	2	2
46	14	14	95	3	3
47	5	6	96	2	2
48	8	8	97	1	1
49	9	9			

Appendix A3. Summer use by summer use area populations. Distribution of elk observations among summer (June-August) use areas used by elk that originated from a given summer use area. Observations are presented as percentages of all summer observations, with the number of observations presented in parentheses.

Summer Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
1	60 (22)	3 35 (13)	2 5 (2)			37
6	48 (21)	7 25 (11) 3 5 (2)	8 18 (8)	9 5 (2)		44
7	79 (11)	9 14 (2)	6 7 (1)			14
8	62 (48)	1 27 (21)	3 7 (5)	9 4 (3)		77
9	47 (16)	8 53 (18)				34
12	100 (55)					55
13	93 (27)	14 3 (1)	35 3 (1)			29
19	80 (213)	36 7 (18) 16 2 (6)	29 5 (14) 15 2 (4)	38 3 (9) 21 1 (2)		266
20	54 (82)	36 28 (42) 21 3 (4) 16 1 (1)	22 7 (11) 19 2 (3) 18 1 (1)	26 4 (6) 23 1 (2)		152
21	83 (15)	18 6 (1)	19 6 (1)	32 6 (1)		18
25	33 (17)	27 39 (20)	24 29 (15)			52
30	100 (5)					5
32	77 (37)	31 13 (6)	231 8 (4)	50 2 (1)		48
34	73 (97)	46 14 (19) 33 2 (3)	42 8 (10)	41 3 (4)		133
36	41 (63)	19 45 (69) 20 3 (5)	29 5 (8) 16 1 (2)	22 4 (6)		153
41	14 (10)	55 44 (31) 52 9 (6) 58 1 (1)	34 16 (11) 57 6 (4)	42 9 (6) 54 1 (1)		70
46	34 (35)	34 33 (34) 53 5 (5) 55 1 (1)	52 18 (18) 41 3 (3)	49 5 (5) 33 2 (2)		103
49	47 (29)	48 36 (22) 52 2 (1)	46 15 (9)	27 2 (1)		62
50	71 (12)	32 18 (3)	31 12 (2)			17
64	68 (28)	63 32 (13)				41

Appendix A3. (continued)

Summer Use Area	Self		Area			Area			Area			Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
73	22	(28)	74	60	(78)	72	7	(9)	75	4	(5)	130
			80	3	(4)	70	2	(3)	69	2	(2)	
			76	1	(1)							
74	62	(98)	73	17	(26)	80	9	(14)	72	3	(5)	157
			75	3	(5)	70	3	(4)	69	2	(3)	
			76	1	(1)	78	1	(1)				
75	33	(5)	74	40	(6)	80	27	(4)				15
78	10	(1)	74	90	(9)							10
80	57	(43)	74	13	(10)	85	12	(9)	82	9	(7)	76
			75	7	(5)	83	3	(2)				
82	78	(7)	83	22	(2)							9
83	43	(13)	84	30	(9)	82	23	(7)	86	3	(1)	30
84	90	(9)	83	10	(1)							10
85	50	(14)	84	32	(9)	80	7	(2)	86	7	(2)	28
			83	4	(1)							
86	8	(3)	85	36	(14)	83	28	(11)	84	23	(9)	39
			80	5	(2)							
89	93	(13)	90	7	(1)							14
90	23	(5)	89	59	(13)	92	18	(4)				22
92	50	(4)	90	50	(4)							8
6 & 7	76	(44)	8	14	(8)	9	7	(4)	3	3	(2)	58
8 & 9	76	(85)	1	19	(21)	3	5	(5)				111
36 & 19	87	(363)	29	5	(22)	38	2	(9)	16	2	(8)	419
			22	1	(6)	20	1	(5)	15	1	(4)	
			21	1	(2)							
46 & 34	78	(185)	52	8	(18)	42	4	(10)	41	3	(7)	236
			33	2	(5)	49	2	(5)	53	2	(5)	
			55	.5	(1)							
73, 74, 75, 78	84	(262)	80	7	(22)	72	4	(14)	70	2	(7)	312
			69	2	(5)	76	1	(2)				
82, 83, 84, 85, 86	97	(112)	80	3	(4)							116
89, 90, 92	100	(44)										44

Appendix A4. Winter use by winter use area populations. Distribution of elk observations among winter (January-March) use areas used by elk that originated from a given winter use area. Observations are presented as percentages of all winter observations, with the number of observations presented in parentheses.

Winter Use Area	Self		Area		Area		Area		Total No. Locations
	%	(No.)	%	(No.)	%	(No.)	%	(No.)	
2	61	(22)	1	19 (7)	3	17 (6)	5	3 (1)	36
4	100	(37)							37
5	67	(34)	1	14 (7)	2	14 (7)	3	6 (3)	51
10	87	(32)	12	14 (5)					37
11	47	(18)	13 12	29 (11) 3 (1)	10	16 (6)	35	5 (2)	38
15	68	(26)	19	21 (8)	16	8 (3)	23	3 (1)	38
16	56	(85)	17 22 14 28	18 (27) 3 (4) 1 (2) 1 (1)	19 36 20	11 (17) 3 (4) 1 (2)	23 15 29 23	3 (1) 5 (7) 2 (3) 1 (1)	153
17	49	(49)	24 21 36	18 (18) 5 (5) 2 (2)	16 22	9 (9) 5 (5)	18 20	8 (8) 4 (4)	100
18	30	(12)	17 31	30 (12) 8 (3)	21 20	15 (6) 3 (1)	32 51	13 (5) 3 (1)	40
22	38	(27)	17 23 29	25 (18) 7 (5) 3 (2)	16 19	13 (9) 3 (2)	36 20	9 (6) 3 (2)	71
23	44	(41)	24 15 21 14	12 (11) 8 (7) 3 (3) 1 (1)	16 18 17	9 (8) 5 (5) 2 (2)	26 19 22	9 (8) 5 (5) 2 (2)	93
28	65	(13)	29	25 (5)	16	5 (1)	36	5 (1)	20
31	34	(12)	40	37 (13)	32	26 (9)	51	3 (1)	35
33	64	(45)	45 55	19 (13) 1 (1)	34	14 (10)	52	1 (1)	70
35	33	(2)	11	67 (4)					6
37	100	(3)							3
40	72	(13)	31	17 (3)	32	11 (2)			18
44	100	(3)							3
45	47	(15)	52 24 48	19 (6) 3 (1) 3 (1)	55 33 49	13 (4) 3 (1) 3 (1)	53 34	6 (2) 3 (1)	32

Appendix A4. (continued)

Winter Use Area	Self											Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
47	24	(6)	48	44	(1)	45	32	(8)				25
51	60	(12)	32	25	(5)	31	15	(3)				20
54	33	(39)	52	21	(25)	55	17	(20)	53	16	(19)	118
			56	8	(9)	57	2	(2)	58	2	(2)	
			29	1	(1)	61	1	(1)				
56	24	(28)	55	26	(19)	54	23	(17)	52	8	(6)	74
			58	7	(5)	53	4	(3)	57	3	(2)	
			29	1	(1)	60	1	(1)	61	1	(1)	
			63	1	(1)							
60	21	(5)	61	33	(8)	59	29	(7)	57	8	(2)	24
			55	4	(1)	56	4	(1)				
68	44	(8)	70	39	(7)	69	11	(2)	71	6	(1)	18
69	34	(28)	70	29	(24)	72	22	(18)	73	7	(6)	82
			68	5	(4)	74	2	(2)				
70	33	(24)	69	36	(26)	72	16	(12)	73	7	(5)	73
			68	6	(4)	74	3	(2)				
71	50	(1)	68	50	(1)						2	
72	36	(39)	69	19	(21)	70	15	(16)	73	9	(10)	109
			77	7	(8)	68	6	(7)	76	4	(4)	
			74	3	(3)	79	1	(1)				
76	16	(4)	72	44	(11)	77	32	(8)	73	4	(1)	25
			79	4	(1)							
77	80	(8)	72	10	(1)	76	10	(1)			10	
79	52	(26)	80	34	(17)	72	6	(3)	81	6	(3)	50
			76	2	(1)							
81	33	(3)	79	33	(3)	80	33	(3)			9	
88	31	(11)	97	23	(8)	96	20	(7)	85	9	(3)	35
			86	9	(3)	95	9	(3)				
91	50	(6)	89	50	(6)						12	
93	42	(5)	94	58	(7)						12	
94	58	(7)	93	42	(5)						12	
95	11	(3)	88	41	(11)	96	26	(7)	85	11	(3)	27
			86	11	(3)							
96	39	(7)	88	44	(8)	85	6	(1)	86	6	(1)	18
			95	6	(1)							

Appendix A4. (continued)

Winter Use Area	Self % (No.)	Area	% (No.)	Area	% (No.)	Area	% (No.)	Total No. Locations
97	100 (8)							8
11 & 35	59 (26)	13	25 (11)	10	14 (6)	12	2 (1)	44
17 & 18	58 (81)	24 22 31	13 (18) 4 (5) 2 (3)	21 20 36	8 (11) 4 (5) 1 (2)	16 32 51	6 (9) 4 (5) 1 (1)	140
31 & 40	77 (41)	32	21 (11)	51	2 (1)			53
54 & 56	43 (83)	55 53 61	20 (39) 11 (22) 1 (2)	52 57 60	16 (31) 2 (4) .5 (1)	58 29 63	4 (7) 1 (2) .5 (1)	192
68 & 71	55 (11)	70	35 (7)	69	10 (2)			20
70 & 69	66 (102)	72 74	19 (30) 3 (4)	73	7 (11)	68	5 (8)	155
72 & 76	43 (58)	69 73 79	16 (21) 8 (11) 1 (2)	70 68	12 (16) 5 (7)	77 74	12 (16) 2 (3)	134
72, 76, 77	58 (84)	69 68	15 (21) 5 (7)	70 74	11 (16) 2 (3)	73 79	8 (11) 1 (2)	144
79 & 81	59 (35)	80	34 (20)	72	5 (30)	76	2 (1)	59
93 & 94	100 (24)							24
95 & 96	40 (18)	88	42 (19)	85	9 (4)	86	9 (4)	45
88, 95, 96	72 (58)	97	10 (8)	85	9 (7)	86	9 (7)	80
88, 95, 96, 97	84 (74)	85	8 (7)	86	8 (7)			88

Appendix A5. Year-round use by all season use area populations. Distribution of January-March and June-August elk observations among use areas used by elk that originated from a given all season use area. Observations are presented as percentages of the total January-March and June-August observations, with the number of observations presented in parentheses.

All Season Use Area	Self											Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
3	63	(104)	1 5	18 1	(29) (1)	2	15	(24)	8	5	(8)	166
14	55	(83)	19 11	22 2	(33) (3)	16 37	12 2	(18) (3)	13 36	7 1	(11) (1)	152
24	65	(95)	25 49 26	10 4 1	(15) (6) (2)	52 23 27	8 3 1	(11) (5) (2)	53 17 46	5 1 1	(7) (2) (1)	146
26	21	(24)	27 19	39 1	(45) (1)	23 24	33 1	(38) (1)	25	5	(6)	115
27	43	(58)	25 24 17	13 7 1	(18) (9) (1)	23 48 19	12 7 1	(17) (9) (1)	26 49	12 6	(16) (8)	137
29	33	(55)	36 19 22 56	20 8 3 1	(33) (14) (5) (1)	38 55 16 57	12 8 1 1	(20) (13) (1) (1)	39 28 54	10 5 1	(17) (8) (1)	169
38	95	(35)	19	5	(2)							37
39	35	(17)	29	53	(26)	19	12	(6)				49
42	35	(36)	34 41	36 1	(37) (1)	33 46	15 1	(15) (1)	43	13	(13)	103
43	43	(13)	42	40	(12)	34	17	(5)				30
48	53	(51)	49 46 27	19 6 1	(18) (6) (1)	34 47	6 6	(6) (6)	42 45	6 2		96
52	42	(146)	53 34 49 61 57	18 5 2 1 1	(61) (18) (6) (3) (2)	54 46 41 24 33	13 4 1 1 .5	(45) (12) (3) (2) (1)	55 59 56 45 60	9 3 1 1 .5	(30) (10) (3) (2) (1)	345
53	26	(61)	52 46 56	42 5 1	(99) (11) (2)	54 49 57	16 3 .5	(38) (6) (1)	55 24 61	6 1 .5	(15) (2) (1)	236

Appendix A5. (continued)

All Season Use Area	Self		Area			Area			Area			Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
55	38	(107)	52	18	(51)	54	12	(32)	34	7	(18)	279
			56	6	(17)	41	4	(11)	59	4	(10)	
			58	3	(8)	53	3	(7)	57	3	(7)	
			60	1	(2)	61	1	(3)	45	1	(2)	
			29	.5	(1)	33	.5	(1)	46	.5	(1)	
			65	.5	(1)							
57	7	(11)	55	30	(45)	61	17	(25)	56	7	(11)	149
			59	7	(10)	58	6	(9)	46	6	(9)	
			54	4	(6)	64	4	(6)	52	3	(5)	
			60	3	(5)	53	2	(3)	29	1	(1)	
			41	1	(1)	63	1	(1)	65	1	(1)	
58	11	(11)	55	36	(35)	61	12	(12)	59	9	(9)	98
			57	7	(7)	56	6	(6)	60	5	(5)	
			54	4	(4)	64	4	(4)	63	2	(2)	
			29	1	(1)	41	1	(1)	65	1	(1)	
59	59	(19)	61	19	(6)	60	9	(3)	52	6	(2)	32
			57	3	(1)	58	3	(1)				
61	42	(34)	59	24	(19)	52	9	(7)	60	7	(6)	81
			54	5	(4)	55	4	(3)	57	4	(3)	
			56	3	(2)	58	3	(2)	53	1	(1)	
63	47	(22)	64	40	(19)	56	6	(3)	57	2		47
			58	2	(1)	65	2	(1)				
65	63	(85)	66	11	(15)	55	7	(9)	64	7	(9)	135
			63	6	(8)	58	4	(6)	56	2	(3)	
66	27	(30)	65	38	(43)	64	12	(13)	55	8	(9)	112
			63	5	(6)	58	5	(5)	67	5	(5)	
			56	1	(1)							
67	99	(82)	66	1	(1)						83	
26 & 27	57	(143)	23	22	(55)	25	10	(24)	24	4	(10)	252
			48	4	(10)	49	3	(8)	19	1	(2)	
			17	.5	(1)							
29 & 39	53	(115)	36	15	(33)	38	9	(20)	19	9	(20)	218
			55	6	(13)	28	4	(8)	22	2	(5)	
			16	.5	(1)	54	.5	(1)	56	.5	(1)	
			57	.5	(1)							
42 & 43	56	(74)	34	32	(42)	33	11	(15)	41	1	(1)	133
			46	1	(1)							

Appendix A5. (continued)

All Season Use Area	Self		Area			Area			Area			Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
52 & 53	63	(367)	54	14	(83)	55	8	(45)	46	4	(23)	581
			34	3	(18)	49	2	(12)	59	2	(10)	
			56	1	(5)	24	1	(4)	61	1	(4)	
			41	1	(3)	57	1	(3)	45	.5	(2)	
			33	.5	(1)	60	.5	(1)				
55, 57, 58	46	(240)	52	11	(56)	54	8	(42)	61	8	(40)	526
			56	6	(34)	59	6	(29)	34	3	(18)	
			41	2	(13)	60	2	(12)	53	2	(10)	
			46	2	(10)	64	2	(10)	29	.5	(3)	
			63	.5	(3)	65	.5	(3)	45	.5	(2)	
65 & 66	70	(173)	64	9	(22)	55	7	(18)	63	6	(14)	247
			58	4	(11)	67	2	(5)	56	2	(4)	

Appendix A6. Winter use by all season use area populations. Distribution of January-March elk observations among use areas used by elk that originated from a given all season use area. Observations are presented as percentages of all winter (January-March) observations, with the number of observations presented in parentheses.

All Season Use Area	Self		Area			Area			Area			Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
3	57	(40)	2	31	(22)	1	10	(7)	5	1	(1)	70
14	52	(34)	16	26	(17)	19	6	(4)	13	6	(4)	65
			11	5	(3)	37	5	(3)				
24	77	(41)	53	11	(6)	52	6	(3)	17	4	(2)	53
			49	2	(1)							
26	15	(11)	23	48	(35)	27	28	(21)	25	7	(5)	73
			24	1	(1)							
27	38	(30)	23	20	(16)	24	11	(9)	26	11	(9)	78
			25	9	(7)	48	8	(6)	17	1	(1)	
29	35	(25)	38	15	(11)	39	13	(9)	28	11	(8)	72
			55	7	(5)	36	8	(6)	22	7	(5)	
			57	1	(1)	16	1	(1)	56	1	(1)	
38	100	(17)									17	
39	41	(9)	29	59	(13)						22	
42	52	(23)	33	30	(13)	43	16	(7)	34	2	(1)	44
43	58	(7)	42	42	(5)						12	
48	67	(29)	42	14	(6)	47	14	(6)	45	5	(2)	43
52	34	(54)	53	24	(38)	54	21	(33)	55	6	(9)	157
			59	3	(4)	34	2	(3)	56	2	(3)	
			61	2	(3)	24	1	(2)	45	1	(2)	
			46	1	(2)	57	1	(2)	33	1	(1)	
			49	1	(1)							
53	36	(38)	52	30	(31)	54	26	(27)	24	2	(2)	105
			56	2	(2)	46	1	(1)	49	1	(1)	
			55	1	(1)	57	1	(1)	61	1	(1)	
55	30	(39)	54	18	(24)	52	18	(23)	56	12	(15)	131
			58	5	(6)	59	3	(4)	34	2	(3)	
			53	2	(3)	57	2	(3)	61	2	(3)	
			41	2	(2)	45	2	(2)	29	1	(1)	
			33	1	(1)	46	1	(1)	60	1	(1)	
57	9	(6)	55	23	(16)	61	19	(13)	56	13	(9)	69
			58	9	(6)	54	6	(4)	59	6	(4)	
			53	4	(3)	60	4	(3)	52	3	(2)	
			29	1	(1)	46	1	(1)	63	1	(1)	

Appendix A6. (continued)

All Season Use Area	Self			Area			Area			Total No. Locations		
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area		%	(No.)
58	16	(7)	55	27	(12)	56	14	(6)	61	13	(6)	
			60	9	(4)	54	7	(3)	57	7	(3)	
			59	7	(3)	29	2	(1)				
											45	
59	50	(7)	61	29	(4)	60	14	(2)	57	7	(1)	14
61	47	(17)	59	19	(7)	60	11	(4)	52	6	(2)	36
			54	6	(2)	56	6	(2)	57	6	(2)	
63	50	(9)	56	17	(3)	64	17	(3)	57	6	(1)	18
			58	6	(1)	65	6	(1)				
65	62	(38)	66	13	(8)	58	8	(5)	56	5	(3)	61
			63	5	(3)	55	3	(2)	64	3	(2)	
66	31	(16)	65	37	(19)	58	8	(4)	64	8	(4)	51
			63	6	(3)	55	4	(2)	67	4	(2)	
			56	2	(1)							
67	97	(36)	66	3	(1)						37	
26& 27	47	(71)	23	34	(51)	25	8	(12)	24	7	(10)	151
			48	4	(6)	17	1	(1)				
29 & 39	59	(56)	38	12	(1)	28	9	(8)	36	6	(6)	99
			22	5	(5)	55	5	(5)	16	1	(1)	
			56	1	(1)	57	1	(1)				
52, 53	62	(161)	54	23	(60)	55	4	(10)	24	2	(4)	262
			56	2	(5)	59	2	(4)	61	2	(4)	
			34	1	(3)	46	1	(3)	57	1	(3)	
			45	1	(2)	49	1	(2)	33	.5	(1)	
55, 57, 58	40	(98)	54	13	(31)	56	12	(30)	52	10	(25)	245
			61	9	(61)	59	4	(11)	60	3	(8)	
			53	2	(6)	34	1	(3)	29	1	(2)	
			41	1	(2)	45	1	(2)	46	1	(2)	
			29	.5	(1)	33	.5	(1)	63	.5	(1)	
65 & 66	72	(81)	58	8	(9)	64	5	(6)	63	5	(6)	112
			55	4	(4)	56	4	(4)	67	2	(2)	

Appendix A7. Summer use by all season use area populations. Distribution of June-August elk observations among use areas used by elk that originated from a given all season use area. Observations are presented as percentages of all summer (June-August) observations, with the number of observations presented in parentheses.

All Season Use Area	Self		Area			Area			Area			Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
3	67	(64)	1	23	(22)	8	8	(8)	2	2	(2)	96
14	56	(49)	19	33	(29)	13	8	(7)	16	1	(1)	87
24	58	(54)	25	16	(15)	52	9	(8)	23	5	(5)	93
			49	5	(5)	26	2	(2)	27	2	(2)	
			46	1	(1)	53	1	(1)				
26	31	(13)	27	57	(24)	23	7	(3)	19	2	(1)	42
			25	2	(1)							
27	48	(28)	25	19	(11)	26	12	(7)	49	12	(7)	58
			48	5	(3)	19	2	(1)	23	2	(1)	
29	31	(30)	36	28	(27)	19	14	(14)	38	9	(9)	97
			39	8	(8)	55	8	(8)	54	1	(1)	
38	90	(18)	19	10	(2)							20
39	30	(8)	29	48	(13)	19	22	(6)				27
42	22	(13)	34	61	(36)	43	10	(6)	33	3	(2)	59
			41	2	(1)	46	2	(1)				
43	33	(6)	42	39	(7)	34	28	(5)				18
48	42	(22)	49	34	(18)	34	11	(6)	46	11	(6)	53
			27	2	(1)							
52	49	(92)	53	12	(23)	55	11	(21)	34	8	(15)	188
			54	6	(12)	46	5	(10)	59	3	(6)	
			49	3	(5)	41	2	(3)	60	1	(1)	
53	18	(23)	52	52	(68)	55	11	(14)	54	8	(11)	131
			46	8	(10)	49	4	(5)				
55	46	(68)	52	19	(28)	34	10	(15)	41	6	(9)	148
			54	5	(8)	59	4	(6)	53	3	(4)	
			57	3	(4)	56	1	(2)	58	1	(2)	
			60	1	(1)	65	1	(1)				
57	6	(5)	55	36	(29)	61	15	(12)	46	10	(8)	80
			59	8	(6)	64	8	(6)	52	4	(3)	
			58	4	(3)	54	3	(2)	56	3	(2)	
			60	3	(2)	41	1	(1)	65	1	(1)	

Appendix A7. (continued)

All Season Use Area	Self		Area			Area			Area			Total No. Locations
	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
58	8	(4)	55	43	(23)	59	11	(6)	61	11	(6)	53
			57	8	(4)	64	8	(4)	63	4	(2)	
			41	2	(1)	54	2	(1)	60	2	(1)	
			65	2	(1)							
59	67	(12)	52	11	(2)	61	11	(2)	58	6	(1)	18
			60	6	(1)							
61	38	(17)	59	27	(12)	52	11	(5)	55	7	(3)	45
			54	4	(2)	58	4	(2)	60	4	(2)	
			53	2	(1)	57	2	(1)				
63	45	(13)	64	55	(16)						29	
65	64	(47)	55	10	(7)	64	10	(7)	66	10	(7)	74
			63	7	(5)	58	1	(1)				
66	23	(14)	65	39	(24)	64	15	(9)	55	12	(7)	61
			63	5	(3)	67	5	(3)	58	2	(1)	
67	100	(46)									46	
26 & 27	72	(72)	25	12	(12)	49	7	(7)	23	4	(4)	100
			48	4	(4)	19	2	(2)				
29 & 39	48	(59)	36	22	(27)	19	16	(20)	38	7	(9)	124
			55	6	(8)	54	1	(1)				
42 & 43	42	(32)	34	53	(41)	33	3	(2)	41	1	(1)	77
			46	1	(1)							
52 & 53	64	(206)	55	11	(35)	54	7	(23)	46	6	(20)	319
			34	5	(15)	49	3	(10)	59	2	(6)	
			41	1	(3)	60	.5	(1)				
55, 57, 58	51	(142)	52	11	(31)	59	6	(18)	61	6	(18)	281
			34	5	(15)	41	4	(11)	54	4	(11)	
			64	4	(10)	46	3	(8)	56	1	(4)	
			60	1	(4)	53	1	(4)	65	1	(3)	
			63	1	(2)							
65 & 66	69	(92)	64	12	(16)	55	10	(14)	63	6	(8)	135
			67	2	(3)	58	1	(2)				

Appendix A8. Distribution of year-round elk observations among game management units (GMU) occupied by elk that originated from a given GMU. Observations are presented as percentages of all observations, with the number of observations presented in parentheses.

GMU	Self % (No.)	GMU % (No.)	GMU % (No.)	GMU % (No.)	GMU % (No.)	Total No. Locations
1	60 (348)	3B 20 (114)	25/26 15 (87)	27 5 (31)		582
2C	5 (3)	3B 59 (34)	25/26 31 (18)	1 5 (3)		58
3B	54 (306)	25/26 35 (201) 23 2 (10)	1 6 (35) 2C 1 (3)	4A 2 (13)		568
3C	72 (488)	4B 10 (69) 25/26 4 (24)	23 10 (66) 22 .1 (1)	4A 5 (31)		679
4A	61 (790)	4B 17 (222) 3C 2 (20)	23 12 (149) 5A 2 (20)	22 7 (95) 3B .1 (1)		1297
4B	50 (418)	4A 30 (253) 25/26 .4 (3)	23 10 (81) 22 .1 (1)	3C 10 (80) 5BN .1 (1)		837
5A	55 (460)	22 16 (131) 6A 5 (42)	4A 12 (97) 23 .4 (3)	5BS 12 (97) 5BN .1 (1)		831
5BN	50 (250)	5BS 28 (138) 7E .8 (4)	6A 16 (79) 5A .2 (1)	4B 6 (29) 22 .2 (1)		502
5BS	45 (391)	6A 34 (292) 22 2 (14)	5A 14 (123) 6B .2 (2)	5BN 5 (42)		864
6A	65 (891)	5BS 13 (174) 22 3 (44)	5A 10 (141) 6B .1 (2)	5BN 8 (115)		1367
6B	72 (325)	6A 20 (89) 7E .2 (1)	8 8 (37)	5BS .4 (2)		454
7E	46 (181)	9 27 (107) 5BN 6 (24)	7W 10 (40) 8 3 (10)	6B 8 (30)		392
7W	61 (153)	7E 26 (64)	9 11 (27)	10 2 (5)		249
8	64 (227)	6B 36 (128)	7E .3 (1)			356
9	92 (318)	7E 7 (25)	11 1 (3)	7W .3 (1)		347
10	33 (5)	7W 67 (10)				15
11	7 (3)	9 93 (40)				43
22	52 (195)	5A 19 (71) 4A 4 (14) 3C 2 (6)	6A 11 (39) 23 3 (12) 5BS .3 (1)	5BN 8 (28) 4B 2 (7)		373
23	41 (213)	4A 38 (200) 22 4 (19) 3B .2 (1)	4B 9 (49) 25/26 2 (11)	3C 5 (26) 5A .4 (2)		521

Appendix A8. (continued)

GMU	Self % (No.)	GMU % (No.)	GMU % (No.)	GMU % (No.)	GMU % (No.)	Total No. Locations
25/26	29 (254)	3B 29 (253) 23 6 (53) 4B .1 (1)	1 24 (208) 27 1 (11)	3C 11 (92) 2C .1 (1)		873
27	49 (127)	1 48 (124)	25/26 4 (9)			260
MEAN	50.6 (1063)					

Appendix A9. The percent of elk locations, from a summer use area subpopulation, that occurred within that use area.

Summer Use Areas

Use Area	June -August		June-September		September		October	
	%	%	Difference ^a	%	Difference ^a	%	Difference ^a	
1	60	57	-3	50	-10	43	-17	
6 & 7	76	78	+2	88	+12	44	-32	
8 & 9	76	71	-5	48	-28	71	-5	
12	100	100	0	100	0	94	-6	
13	93	95	+2	100	+7	83	-10	
19 & 36	87	83	-4	55	-32	78	-9	
20	54	54	0	55	+1	23	-31	
21	83	83	0	No additional data				
25	33	30	-3	11	-22	11	-22	
30	100	100	0	100	0	100	0	
32	77	79	+2	88	+11	50	-27	
34 & 46	78	72	-6	52	-26	58	-20	
41	14	15	+1	17	+3	5	-9	
49	47	43	-4	32	-15	35	-12	
50	71	65	-6	33	-38	67	-4	
64	68	70	+2	75	+7	44	-24	
73, 74, 75, 78	84	82	-2	77	-7	68	-16	
80	57	59	+2	66	+9	54	-3	
82, 83, 84, 85, 86	100	100	0	100	0	100	0	
89, 90, 92	100	100	0	100	0	100	0	
Mean	73	72	-1	65	-8	59	-14	

^a Difference from the June-August percentage

Appendix A10. Fall Migration. Distribution of elk observations among winter (January-March) use areas used by elk that originated from a given summer (June-August) use area. Observations are presented as percentages of all winter observations, with the number of observations presented in parentheses.

Summer Use Area													Total No. Locations
	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	
1	2	52	(14)	1	26	(7)	3	19	(5)	5	4	(1)	27
6	4	76	(28)	3	24	(9)							37
7	4	100	(12)										12
8	5	57	(34)	3	20	(12)	1	12	(7)	2	12	(7)	60
9	5	55	(16)	4	45	(13)							29
12	10	87	(32)	12	14	(5)							37
13	11	53	(18)	13	32	(11)	37	9	(3)	35	6	(2)	34
19	16	45	(76)	15	15	(26)	19	14	(23)	29	9	(2)	169
	38	7	(11)	21	2	(3)	23	2	(3)	39	2	(15)	
	14	1	(2)	18	1	(2)	36	1	(2)	22	1	(3)	
	26	1	(1)	28	1	(1)						(1)	
20	17	36	(43)	22	19	(22)	23	16	(19)	16	10	(12)	118
	36	5	(6)	18	4	(5)	20	3	(4)	19	2	(2)	
	26	2	(2)	29	2	(2)	21	1	(1)				
21	18	52	(11)	21	29	(6)	17	19	(4)				21
25	27	49	(29)	24	32	(19)	25	12	(7)	26	5	(3)	59
	17	2	(1)										
30	28	100	(5)										5
32	40	32	(13)	31	29	(12)	32	22	(9)	18	10	(4)	41
	17	5	(2)	51	2	(1)							
34	33	43	(45)	42	22	(23)	45	12	(13)	34	11	(12)	106
	52	6	(6)	55	5	(5)	43	1	(1)	46	1	(1)	
36	16	46	(40)	22	14	(12)	17	10	(9)	29	10	(9)	87
	36	10	(9)	19	6	(5)	14	1	(1)	20	1	(1)	
	28	1	(1)										
41	55	42	(28)	42	18	(12)	52	10	(7)	56	10	(7)	67
	54	8	(5)	41	3	(2)	57	3	(2)	58	3	(2)	
	29	2	(1)	60	2	(1)							
46	33	24	(20)	52	23	(19)	53	19	(16)	45	16	(13)	83
	34	6	(5)	55	5	(4)	46	2	(2)	24	1	(1)	
	48	1	(1)	49	1	(1)	57	1	(1)				
49	48	57	(28)	47	12	(6)	53	10	(5)	52	8	(4)	49
	49	4	(2)	24	2	(1)	27	2	(1)	46	2	(1)	
	57	2	(1)										

Appendix A10. (continued)

Summer Use Area	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Total No. Locations
50	51	65	(11)	40	35	(6)							17
64	63	33	(9)	64	19	(5)	66	15	(4)	44	11	(3)	27
	56	11	(3)	57	4	(1)	58	4	(1)	65	4	(1)	
73	72	33	(34)	69	25	(26)	70	22	(23)	73	10	(10)	104
	68	5	(5)	74	3	(3)	76	2	(2)	71	1	(1)	
74	72	28	(36)	69	21	(27)	70	18	(24)	73	8	(10)	131
	68	6	(8)	77	6	(8)	79	4	(5)	80	4	(5)	
	76	3	(4)	74	2	(3)	71	1	(1)				
75	72	64	(7)	73	27	(3)	74	9	(1)				11
78	77	80	(8)	72	10	(1)	76	10	(1)				10
80	79	36	(25)	80	25	(17)	72	16	(11)	73	4	(3)	69
	81	4	(3)	88	4	(3)	85	3	(2)	86	3	(2)	
	95	3	(2)	69	1	(1)							
82	79	33	(3)	80	33	(3)	81	33	(3)				9
83	88	30	(8)	96	26	(7)	79	11	(3)	80	11	(3)	27
	81	11	(3)	85	4	(1)	86	4	(1)	95	4	(1)	
84	88	56	(5)	96	22	(2)	85	11	(1)	95	11	(1)	9
85	88	31	(8)	97	31	(8)	85	12	(3)	95	12	(3)	26
	86	8		96	8	(2)							
86	88	31	(11)	97	23	(8)	96	20	(7)	85	9	(3)	35
	86	9	(3)	95	9	(3)							
89	89	50	(6)	91	50	(6)						12	
90	94	29	(7)	89	25	(6)	91	25	(6)	93	21	(5)	24
92	94	58	(7)	93	42	(5)						12	
6 & 7	4	82	(40)	3	18	(9)						49	
8 & 9	5	56	(50)	4	15	(13)	3	13	(12)	1	8	(7)	89
	2	8	(7)										
19 & 36	16	45	(116)	19	11	(28)	15	10	(26)	29	9	(24)	256
	22	5	(13)	38	4	(11)	36	4	(11)	17	4	(9)	
	21	1	(3)	23	1	(3)	39	1	(3)	14	1	(3)	
	18	1	(2)	28	1	(2)	26	.5	(1)	20	.5	(1)	
34 & 46	33	34	(65)	45	14	(26)	52	13	(25)	42	12	(23)	189
	34	9	(17)	53	8	(16)	55	5.5	(9)	46	2	(3)	
	24	.5	(1)	43	.5	(1)	48		(1)	49	.5	(1)	
	57	.5	(1)										

Appendix A10. (continued)

Summer Use Area	Area	%	(No.)	Total No. Locations									
73, 74, 75, 78	72	30	(78)	69	21	(53)	70	18	(47)	73	9	(23)	256
	77	6	(16)	68	5	(13)	74	3	(7)	76	3	(7)	
	79	2	(5)	80	2	(5)	71	1	(2)				
82, 83, 84, 85, 86	88	30	(32)	96	17	(18)	97	15	(16)	85	8	(8)	106
	95	8	(8)	79	6	(6)	80	6	(6)	81	6	(6)	
	86	6	(6)										
89, 90, 92	94	29	(14)	89	25	(12)	91	25	(12)	93	21	(10)	48

Appendix A11. Spring Migration. Distribution of elk observations among summer (June-August) use areas used by elk that originated from a given winter (January-March) use area. Observations are presented as percentages of all summer observations, with the number of observations presented in parentheses.

Winter Use Area	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Total No. Locations
2	3	50	(24)	1	46	(22)	2	4	(2)				48
4	6	47	(21)	9	29	(13)	7	24	(11)				45
5	8	60	(40)	1	31	(21)	3	5	(3)	9	5	(3)	67
10	12	100	(55)										55
11	13	69	(24)	12	29	(10)	35	3	(1)				35
15	19	81	(17)	15	19	(4)							21
16	19	67	(193)	20	16	(45)	36	12	(35)	16	2	(7)	287
	22	2	(5)	15	.5	(1)	29	.5	(1)				
17	20	53	(66)	36	14	(17)	21	9	(11)	24	8	(10)	125
	25	7	(9)	22	6	(8)	27	2	(2)	19	1	(1)	
	32	1	(1)										
18	21	37	(15)	20	29	(12)	32	27	(11)	18	2	(1)	41
	19	2	(1)	31	2	(1)							
22	36	44	(45)	20	39	(40)	22	12	(12)	19	3	(3)	103
	23	3	(3)										
23	23	19	(15)	24	19	(15)	19	18	(14)	26	14	(11)	79
	21	11	(9)	27	9	(7)	25	6	(5)	15	1	(1)	
	16	1	(1)	18	1	(1)							
28	29	44	(10)	19	26	(6)	30	22	(5)	36	9	(2)	23
31	32	84	(36)	31	14	(6)	50	2	(1)				43
33	34	75	(66)	46	22	(19)	33	3	(3)				88
35	13	88	(7)	35	13	(1)							8
37	13	75	(3)	14	25	(1)							4
40	32	67	(12)	31	28	(5)	50	6	(1)				18
44	64	100	(6)										6
45	46	57	(24)	34	24	(10)	49	12	(5)	41	7	(3)	42
47	46	41	(15)	48	41	(15)	49	16	(6)	47	3	(1)	37
51	50	50	(11)	32	46	(10)	31	5	(1)				22
54	52	35	(52)	55	33	(49)	53	15	(22)	54	10	(14)	148
	57	3	(4)	41	2	(3)	56	1	(2)	46	1	(1)	
	58	1	(1)										

Appendix A11. (continued)

Winter Use Area	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Total No. Locations
56	55	53	(47)	52	14	(12)	64	11	(10)	54	8	(7)	88
	53	3	(3)	56	2	(2)	58	2	(2)	63	2	(2)	
	41	1	(1)	57	1	(1)	65	1	(1)				
60	59	50	(12)	61	25	(6)	52	8	(2)	58	8	(2)	24
	60	8	(2)										
68	73	35	(6)	74	35	(6)	72	18	(3)	69	6	(1)	17
	70	6	(1)										
69	74	73	(74)	73	18	(18)	70	4	(4)	69	3	(3)	102
	72	3	(3)										
70	74	70	(64)	73	20	(18)	70	4	(4)	69	3	(3)	92
	72	3	(3)										
71	No June, July, or August locations by this use area's population												
72	74	61	(83)	73	20	(27)	72	7	(9)	75	4	(5)	136
	80	3	(4)	69	2	(3)	70	2	(3)	76	1	(1)	
	78	1	(1)										
76	74	56	(15)	73	30	(8)	72	7	(2)	76	4	(1)	27
	78	4	(1)										
77	74	90	(9)	78	10	(1)						10	
79	80	74	(37)	82	14	(7)	74	8	(4)	83	4	(2)	50
81	82	78	(7)	83	22	(2)							9
88	85	36	(14)	83	28	(11)	84	23	(9)	86	8	(3)	39
	80	5	(2)										
91	89	93	(13)	90	7	(1)							14
93	90	50	(4)	92	50	(4)							8
94	90	50	(4)	92	50	(4)							8
95	83	34	(11)	84	28	(9)	85	28	(9)	80	6	(2)	32
	86	3	(1)										
96	83	52	(11)	84	43	(9)	86	5	(1)				21
97	85	71	(5)	86	29	(2)							7
11 & 35	13	72	(31)	12	23	(10)	35	5	(2)				43
17 & 18	20	47	(78)	21	16	(26)	36	10	(17)	32	7	(12)	166
	24	6	(10)	25	5	(9)	22	5	(8)	27	1	(2)	
	19	1	(2)	18	1	(1)	31	1	(1)				

Appendix A11. (continued)

Winter Use Area	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Area	%	(No.)	Total No. Locations
31 & 40	32	79	(48)	31	18	(11)	50	3	(2)				61
54 & 56	55 64 58	41 4 1	(96) (10) (3)	52 57 63	27 2 1	(64) (5) (2)	53 41 46	11 2 .5	(25) (4) (1)	54 56 65	9 2 .5	(21) (4) (1)	236
68 & 71	No combination due to lack of data for use area 71												
69 & 70	74 72	7 3	(138) (6)	73	19	(36)	70	4	(8)	69	3	(6)	194
72 & 76	74 80 78	60 2 1	(98) (4) (2)	73 69	21 2	(35) (3)	72 70	7 2	(11) (3)	75 76	3 1	(5) (2)	163
72, 76, 77	74 80 76	62 2 1	(107) (4) (2)	73 69	20 2	(35) (3)	72 70	6 2	(11) (3)	75 78	3 2	(5) (3)	173
79 & 81	80	63	(37)	82	24	(14)	74	7	(4)	83	7	(4)	59
77, 79, 81	80 78	54 1	(37) (1)	82	20	(14)	74	19	(13)	83	6	(4)	69
93 & 94	90	50	(8)	92	50	(8)							16
91, 93, 94	89	43	(13)	90	30	(9)	92	27	(8)				30
95 & 96	83 86	42 4	(22) (92)	84	34	(18)	85	17	(9)	80	4	(2)	53
88, 95, 96	83 86	36 5	(33) (5)	84	29	(27)	85	25	(23)	80	4	(4)	92
88, 95, 96, 97	83 80	33 4	(33) (4)	85	28	(28)	84	27	(27)	86	7	(7)	99

Appendix A12. Herd Units.

Main Data Set

Herd Unit (use area numbers)	% Self Containment	Source (Appendix)
1, 2, 3	95.9	A6, A7, A10, A11
4, 5, 6, 7, 8, 9	76.4	A10, A11
10, 12	100.0	A10, A11
11, 13, 35, 37	86.4	A10, A11
14	54.6	A6, A7
*11, 13, 35, 37, 14	73.4	A6, A7, A10, A11
*15, 16, 17, 18, 19, 20, 21, 22, 36	93.4	A10, A11
15, 16, 17, 18, 19, 20, 21, 22, 28, 29, 30, 36, 38, 39	93.6	A6, A7, A10, A11
*28, 29, 30, 36, 38, 39	68.1	A6, A7, A10, A11
23, 24, 25, 26, 27	86.4	A6, A7, A10, A11
41, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61	90.7	A6, A7, A10, A11
44, 63, 64, 65, 66	84.9	A6, A7, A10, A11
67	98.8	A6, A7
68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78	97.8	A10, A11
79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 95, 96, 97	94.3	A10, A11
68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 95, 96, 97	100.0	A10, A11
89, 90, 91, 92, 93, 94	100.0	A10, A11
31, 32, 40, 50, 51	95.7	A10, A11
*45, 57, 48, 49	34.8	A6, A7, A10, A11
33, 34, 42, 43, 45, 46, 47, 48, 49	89.1	A6, A7, A10, A11
Mean	90.3	

* Not used in calculation of mean

Data from elk captured in Region 6 during summer

Herd Unit (use area numbers)	% Self Containment	Source (Appendix)
101, 102, 103	77.8	B6, B7, B9, B10
104, 105	100.0	B9, B10
106, 107, 108, 109, 110, 111	91.3	B6, B7, B9, B10
112, 113, 114, 115	100.0	B6, B7, B9, B10

Appendix A13. Time of spring migration. Number of elk that left winter use areas and entered summer use areas each month.

	Left winter use area		Entered summer use area	
	No. of elk	%	No. of elk	%
Jan	1	1	1	1
Feb	16	9	5	3
Mar	48	25	47	30
Apr	64	35	58	37
May	40	21	21	13
Jun	9	5	20	13
Jul	5	3	4	3
Aug				
Sep	1	1		
	184	100	156	100

Appendix A14. Time of fall migration. Number of elk that left summer use areas and entered winter use areas each month.

	Left summer use area		Entered winter use area	
	No. of elk	%	No. of elk	%
Jul	1	1	1	1
Aug	2	1	3	1
Sep	12	8	8	4
Oct	27	17	20	11
Nov	51	33	61	33
Dec	33	21	67	37
Jan	25	16	18	10
Feb	5	3	5	3
	156	100	183	100

ELK SEASONAL RANGES AND MIGRATIONS

Appendix A15. The proportion of radio-marked elk migrating to or from each summer use area during each month of the migration period.

Summer use area	Spring month returned	%	Cum. %	No. of elk	Fall month left	%	Cum. %	No. of elk
6, 7	Apr	75	75	6	Oct	71	71	5
	May	13	88	1	Nov	29	100	2
	Jun	12	100	1				
8, 9	Mar	14	14	2	Sep	13	13	2
	Apr	79	93	11	Oct	19	32	3
	May	7	100	1	Nov	68	100	11
12	Mar	80	80	3	Dec	40	40	2
	Apr	20	100	2	Jan	60	100	3
13	Non Migrant	38	38	3	Jul	13	13	1
	Apr	50	88	4	Sep	13	26	1
	May	12	100	1	Oct	13	39	1
					Dec	25	64	2
					Non Migrant	36	100	3
19, 36	Feb	3	3	1	Aug	3	3	1
	Mar	55	58	17	Sep	3	6	1
	Apr	17	75	5	Oct	3	9	1
	May	6	81	2	Nov	24	33	7
	Jun	13	94	4	Dec	17	50	5
	Jul	6	100	2	Jan	37	87	11
					Feb	13	100	4
20	Mar	30	30	3	Oct	12	12	1
	Apr	60	90	6	Dec	44	56	4
	Jun	10	100	1	Jan	44	100	4
21	Feb	25	25	1	Sep	25	25	1
	Mar	50	75	2	Dec	50	75	2
	Apr	25	100	1	Jan	25	100	1
25	Jun	100	100	2	Sep	50	50	1
					Jan	50	100	1
30	May	100	100	1	Dec	100	100	1
32	Non Migrant	17	17	1	Oct	20	20	1
	Mar	17	34	1	Nov	20	40	1
	Apr	32	66	2	Dec	20	60	1
	Jun	17	83	1	Jan	20	80	1
	Jul	17	100	1	Non Migrant	20	100	1
34, 46	Non Migrant	6	6	1	Sep	16	16	3
	Feb	11	17	2	Oct	5	21	1
	Mar	29	46	5	Nov	53	74	10
	Apr	24	70	4	Dec	21	95	4
	May	24	94	4	Non Migrant	5	100	1
	Jun	6	100	1				

ELK SEASONAL RANGES AND MIGRATIONS

Appendix A15. (continued)

Summer use area	Spring month returned	%	Cum. %	No. of elk	Fall month left	%	Cum. %	No. of elk
41	Feb	25	25	1	Sep	25	25	1
	Apr	50	75	2	Oct	50	75	2
	Jun	25	100	1	Nov	25	100	1
49	Mar	29	29	2	Sep	17	17	1
	May	42	71	3	Oct	50	67	3
	Jun	29	100	2	Dec	33	100	2
50	Mar	50	50	1	Nov	50	50	1
	Apr	50	100	1	Dec	50	100	1
64	Mar	34	34	2	Oct	50	50	3
	Apr	33	67	2	Dec	50	100	3
	Jun	33	100	2				
73, 74, 75, 78	Mar	29	29	7	Aug	4	4	1
	Apr	29	58	7	Sep	4	8	1
	May	21	79	5	Oct	16	24	4
	Jun	17	96	4	Nov	64	88	16
	Jul	4	100	1	Dec	8	96	2
				Jan	4	100	1	
80	Non Migrant	33	33	2	Oct	17	17	1
	Jan	17	50	1	Dec	17	34	1
	Apr	33	83	2	Jan	17	51	1
	May	17	100	1	Feb	17	68	1
					Non Migrant	32	100	2
82, 83, 84, 85, 86	Non Migrant	17	17	1	Oct	17	17	1
	Mar	17	34	1	Dec	33	50	2
	Apr	17	51	1	Jan	33	83	2
	May	32	83	2	Non Migrant	17	100	1
	Jun	17	100	1				
89, 90, 92	Non Migrant	25	25	1	Nov	50	50	2
	Mar	25	50	1	Dec	25	75	1
	Apr	50	100	2	Non Migrant	25	100	1

Appendix A16. The proportion of radio-marked elk migrating to or from each winter use area during each month of the migration period.

Winter use area	Spring month left	%	Cum. %	No. of elk	Fall month returned	%	Cum. %	No. of elk
2	Mar	60	60	3	Oct	50	50	2
	Apr	40	100	2	Nov Feb	25	75	1
						25	100	1
4	Apr	60	60	3	Oct	60	60	3
	May	40	100	2	Nov	40	100	2
5	Mar	15	15	1	Sep	11	11	1
	Apr	71	86	5	Oct	22	33	2
	May	14	100	1	Nov	56	89	5
					Dec	11	100	1
10	Mar	80	80	4	Nov	40	40	2
	Apr	20	100	1	Dec	60	100	3
11, 35	Mar	14	14	1	Oct	29	29	2
	Apr	72	86	5	Nov	29	58	2
	May	14	100	1	Dec	42	100	3
15	Mar	40	40	2	Dec	80	80	4
	Apr	40	80	2	Jan	20	100	1
	May	20	100	1				
16	Mar	42	42	10	Non Migrant	5	5	1
	Apr	50	92	12	Sep	9	14	2
	May	4	96	1	Oct	14	28	3
	Non Migrant	4	100	1	Nov	41	69	9
					Dec	23	92	5
				Jan	8	100	2	
17, 18	Mar	34	34	4	Oct	17	17	2
	Apr	33	67	4	Nov	25	42	3
	May	33	100	4	Dec	25	67	3
					Jan	25	92	3
					Feb	8	100	1
								1
22	Mar	30	30	3	Non Migrant	10	10	1
	Apr	20	50	2	Oct	10	20	1
	May	30	80	3	Nov	40	60	4
	Jun	10	90	1	Dec	40	100	4
	Non Migrant	10	100	1				
23	Mar	50	50	5	Non Migrant	10	10	1
	Apr	40	90	4	Nov	10	20	1
	Non Migrant	10	100	1	Dec	80	100	8
28	May	100	100	2	Oct	100	100	2
31, 40	Feb	33	33	2	Nov	17	17	1
	Apr	50	83	3	Dec	66	83	4
	May	17	100	1	Jan	17	100	1

Appendix A16. (continued)

Winter use area	Spring month left	%	Cum. %	No. of elk	Fall month returned	%	Cum. %	No. of elk
33	Apr	33	33	2	Aug	16	16	1
	May	67	100	4	Sep	17	33	1
					Oct	17	50	1
					Nov	50	100	3
35	May	100	100	1	Nov	100	100	1
37	Apr	100	100	1	Dec	100	100	1
44	Apr	100	100	1	Dec	100	100	1
45	Mar	25	25	1	Sep	50	50	2
	Apr	25	50	1	Dec	25	75	1
	May	50	100	2	Jan	25	100	1
47	Feb	50	50	1	Dec	100	100	2
	Apr	50	100	1				
51	Apr	33	33	1	Nov	34	34	1
	Jun	67	100	2	Dec	33	67	1
					Feb	33	100	1
54, 56	Feb	45	45	10	Non Migrant	13	13	3
	Mar	32	77	7	Nov	8	21	2
	Apr	5	82	1	Dec	52	73	12
	May	5	87	1	Jan	23	96	5
	Non Migrant	13	100	3	Aug	4	100	1
60	Feb	25	25	1	Dec	67	67	2
	Apr	25	50	1	Jan	33	100	1
	Jul	25	75	1				
	Sep	25	100	1				
68, 71	May	50	50	2	Nov	25	25	1
	Jun	50	100	2	Dec	50	75	2
					Feb	25	100	1
69, 70	Feb	7	7	1	Sep	7	7	1
	Mar	13	20	2	Mar	13	20	2
	Apr	20	40	3	Nov	40	60	6
	May	20	60	3	Dec	33	93	5
	Jun	27	87	4	Jan	7	100	1
	Jul	13	100	2				
72, 76, 77, 79, 81	Feb	5	5	1	Jul	5	5	1
	Mar	19	24	4	Aug	5	10	1
	Apr	19	43	4	Sep	5	15	1
	May	48	91	10	Nov	61	76	13
	Jul	9	100	2	Dec	19	95	4
				Jan	5	100	1	

Appendix A16. (continued)

Winter use area	Spring month left	%	Cum. %	No. of elk	Fall month returned	%	Cum. %	No. of elk	
88, 95, 96, 97	Mar	25	25	1	Nov	25	25	1	
	Apr	50	75	2	Dec	25	50	1	
	May	25	100	1	Jan	25	75	1	
					Feb	25	100	1	
	91	Jan	50	50	1	Nov	50	50	1
		Apr	50	100	1	Jan	50	100	1
93, 94	Apr	100	100	2	Nov	100	100	2	

Appendix A17. The proportion of radio-marked elk migrating to or from each all season use area during each month.

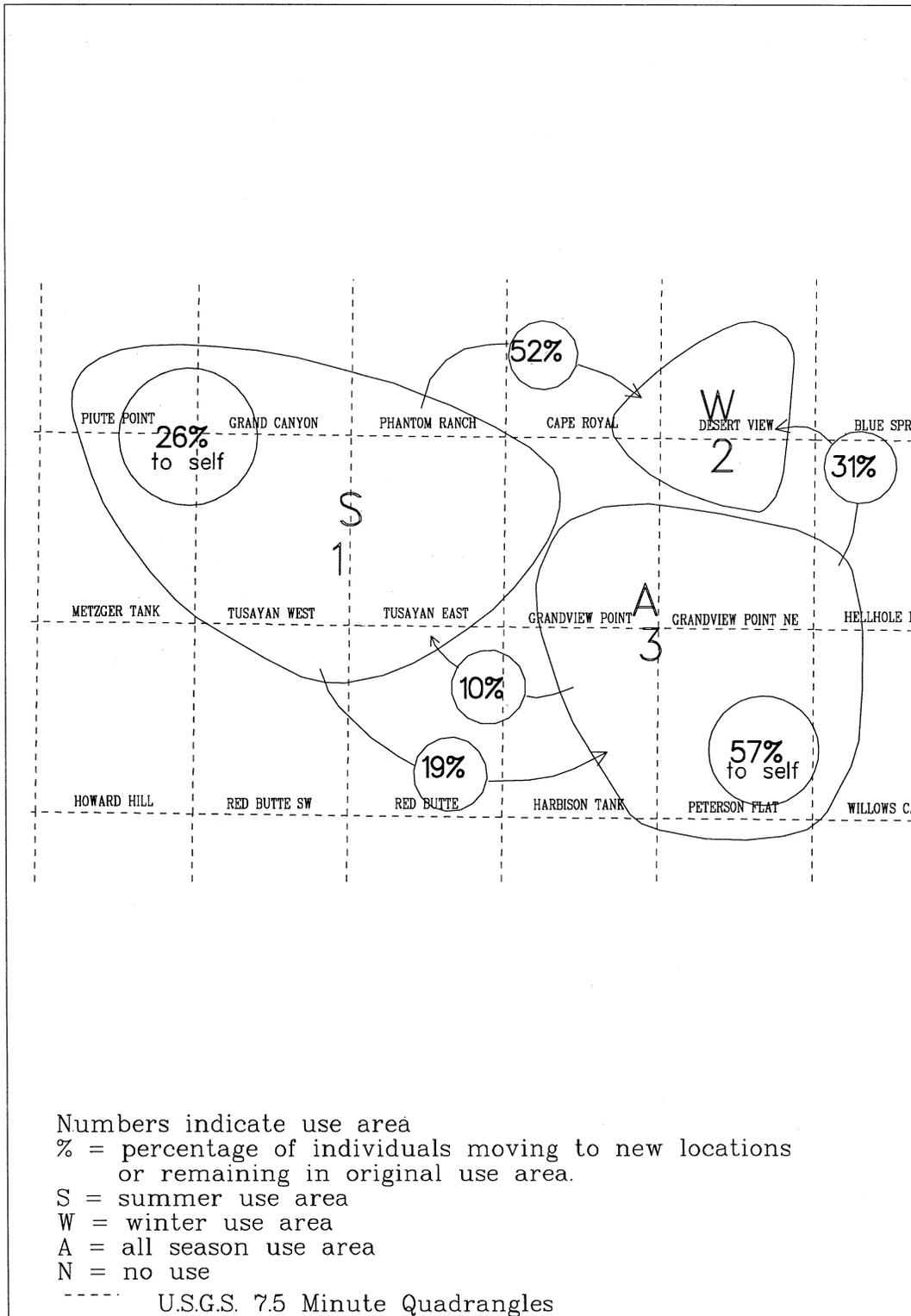
All season use area	Migration month returned	Into %	No. of elk	Migration month left	From %	No. of elk
1,3	Non Migrant	45	4	Oct	33	3
	Mar	22	2	Nov	11	1
	Apr	22	2	Dec	11	1
	May	11	1	Non Migrant	45	4
14	Non Migrant	80	4	Jan	20	1
	Mar	20	1	Non Migrant	80	4
24	Non Migrant	50	3	Feb	16	1
	Oct	16	1	Mar	17	1
	Nov	17	1	May	17	1
	Dec	17	1	Non Migrant	50	3
26, 27	Non Migrant	30	4	Jun	14	2
	Jan	8	1	Sep	7	1
	Feb	8	1	Oct	14	2
	Mar	30	4	Nov	14	2
	Apr	8	1	Dec	22	3
	May	8	1	Non Migrant	29	4
	Aug	8	1			
29, 39	Non Migrant	50	4	Jan	13	1
	Jan	13	1	Feb	12	1
	Mar	12	1	Mar	13	1
	Dec	25	2	Oct	12	1
				Non Migrant	50	4
38	Non Migrant	100	3	Non Migrant	100	3
42	Non Migrant	20	1	Apr	20	1
	Jul	20	1	Jun	20	1
	Sep	40	2	Aug	20	1
	Nov	20	1	Nov	20	1
				Non Migrant	20	1
43	Non Migrant	100	1			
48	Non Migrant	83	5	Jan	17	1
	Feb	17	1	Non Migrant	83	5
52	Non Migrant	32	7	Mar	8	2
	Feb	9	2	Apr	4	1
	Mar	32	7	Aug	4	1
	Apr	5	1	Sep	13	3
	Jun	4	1	Oct	13	3
	Jul	9	2	Nov	16	4
	Nov	9	2	Dec	13	3
				Non Migrant	29	7

Appendix A17. (continued)

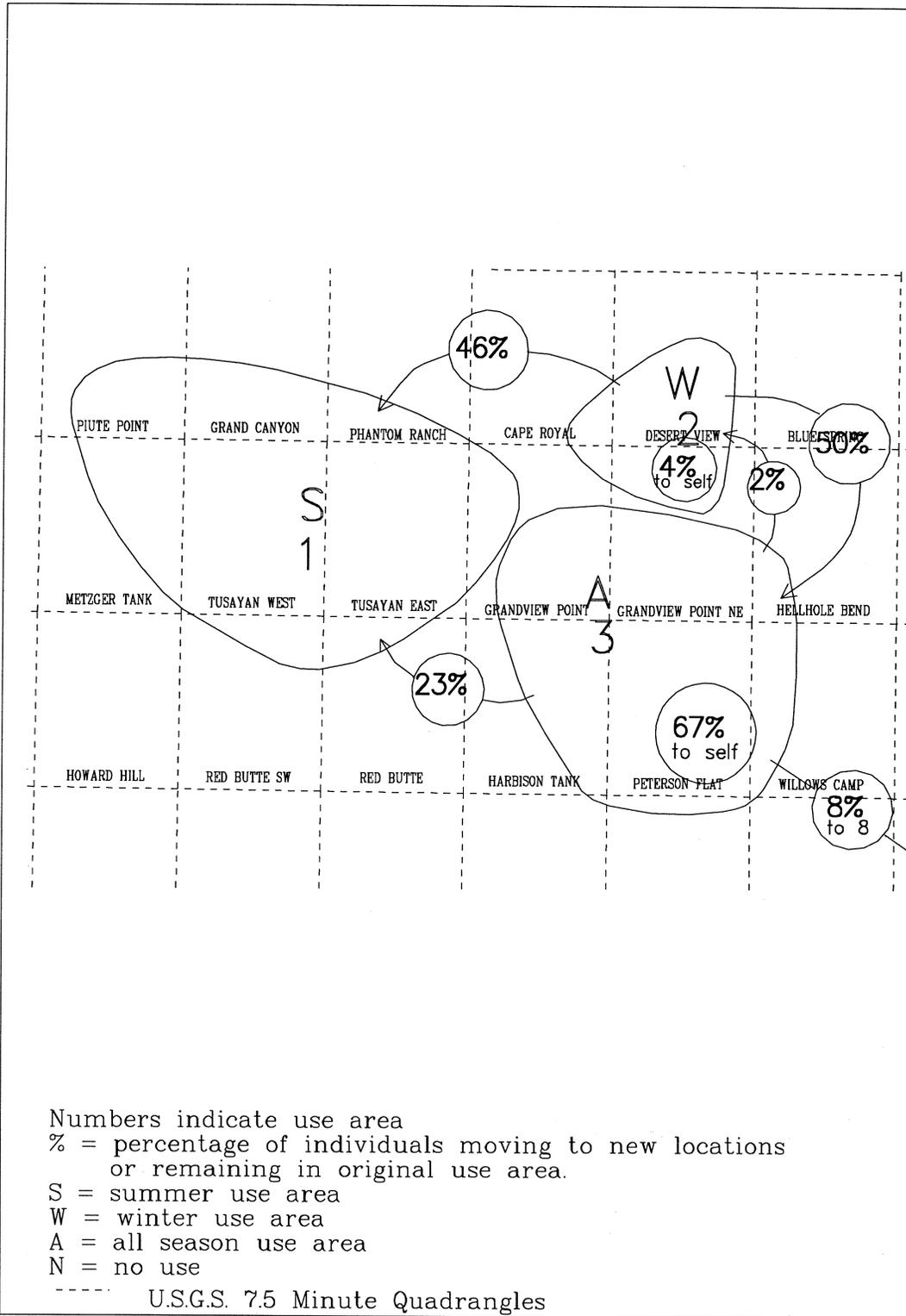
All season use area	Migration month returned	Into %	No. of elk	Migration month left	From %	No. of elk	
53	Non Migrant	17	2	Jan	8	1	
	Jan	8	1	Mar	22	3	
	May	17	2	May	14	2	
	Jul	8	1	Jun	14	2	
	Nov	17	2	Jul	14	2	
	Dec	33	4	Oct	14	2	
				Non Migrant	14	2	
55, 57, 58	Non Migrant	10	2	Jan	18	4	
	Jan	5	1	Feb	5	1	
	Feb	15	3	Mar	10	2	
	Mar	35	7	Apr	10	2	
	Jun	5	1	May	14	3	
	Jul	5	1	Sep	5	1	
	Aug	5	1	Oct	5	1	
	Sep	5	1	Nov	5	1	
	Nov	5	1	Dec	18	4	
	Dec	10	2	Non Migrant	10	2	
	59	Non Migrant	100	2			
	61	Non Migrant	50	2	Jan	25	1
Feb		25	1	Aug	25	1	
Mar		25	1	Non Migrant	50	2	
63	Non Migrant	50	2	Jan	25	1	
	May	25	1	Aug	25	1	
	Jun	25	1	Non Migrant	50	2	
65, 66	Non Migrant	73	8	Mar	9	1	
	Sep	18	2	Aug	9	1	
	Nov	9	1	Nov	9	1	
				Non Migrant	73	8	
67	Non Migrant	100	7				



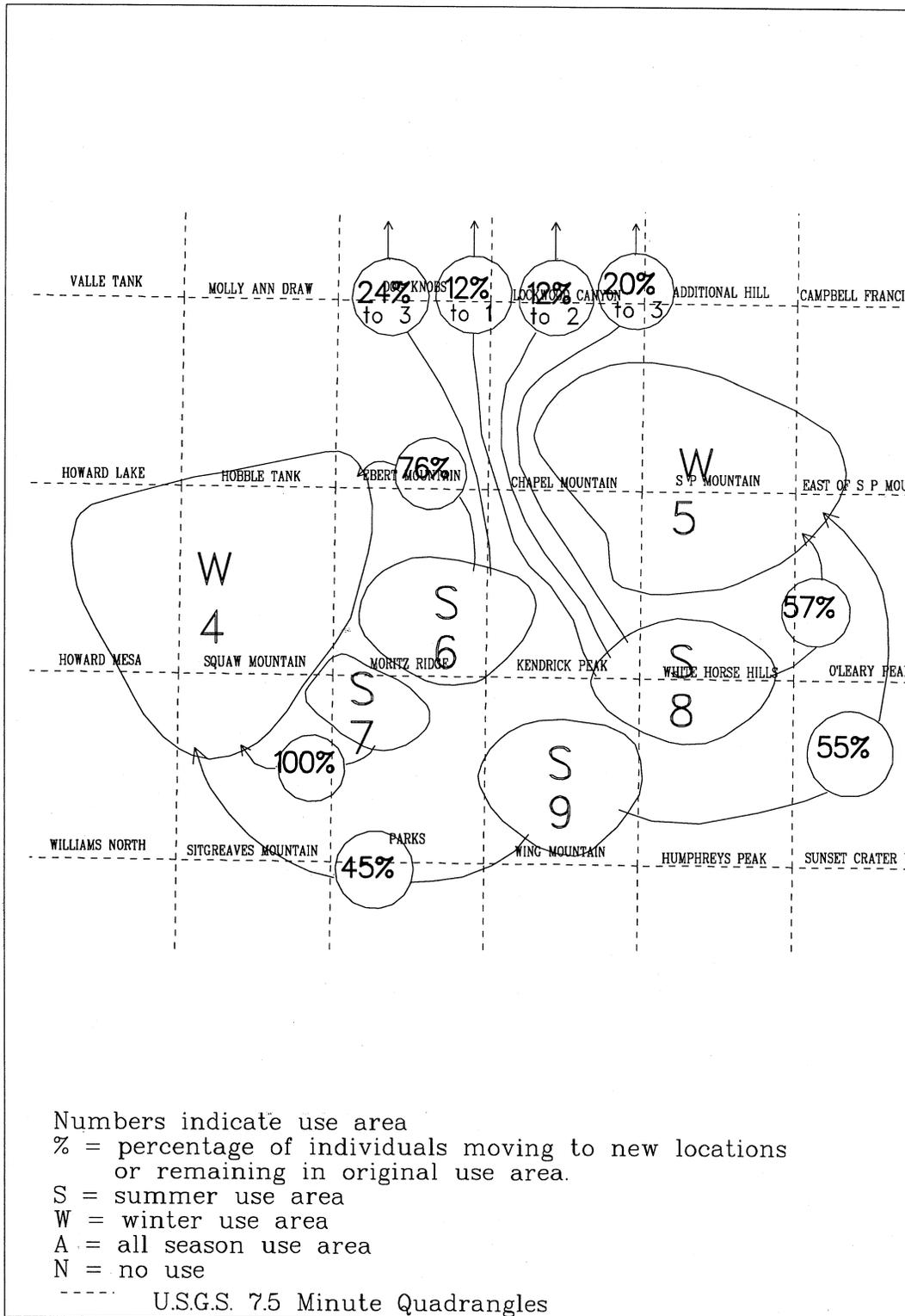
Bull elk feeding in mountain meadow.



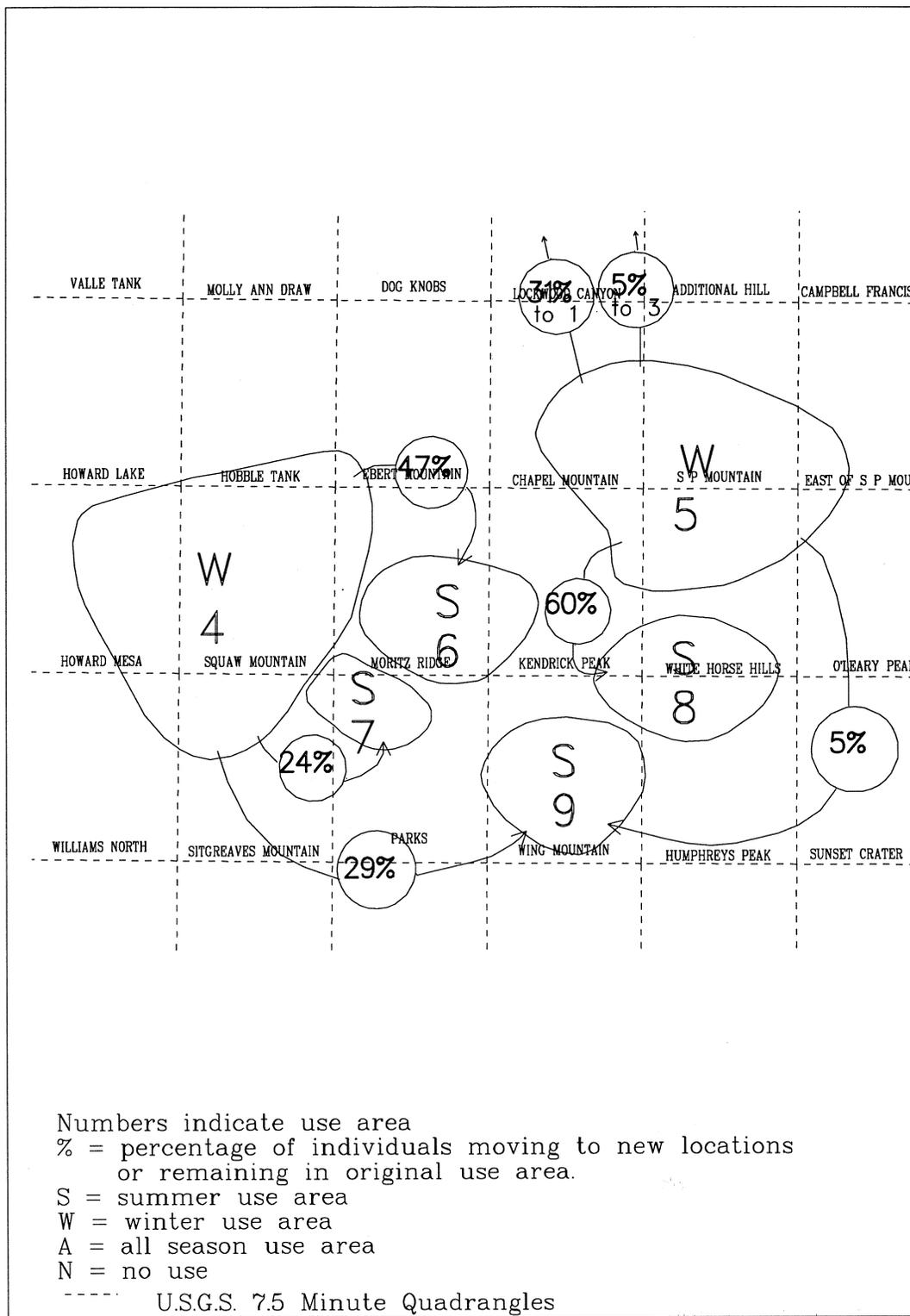
Appendix A18. Fall migration to winter use areas.
Source Appendices A6, A10.



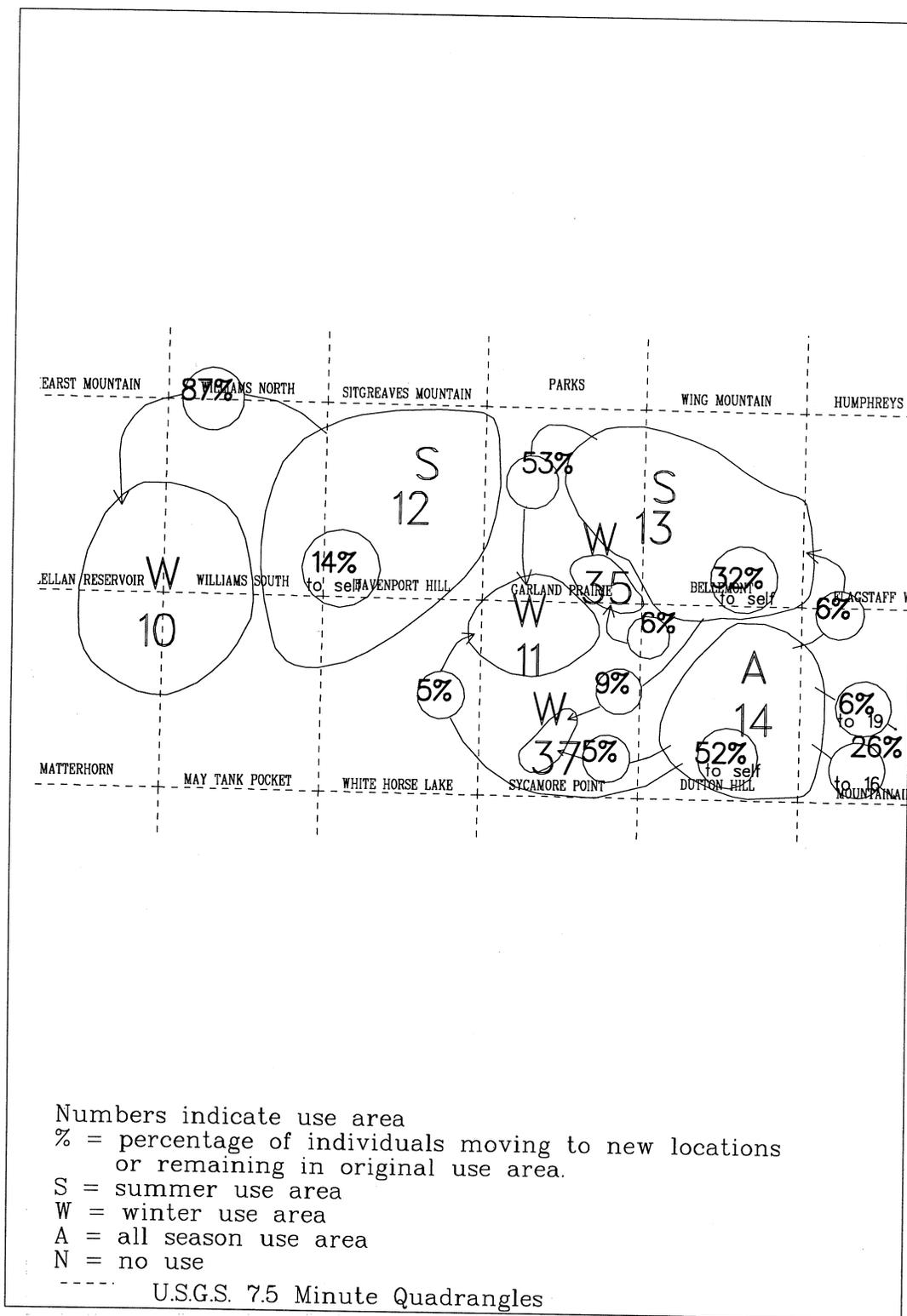
Appendix A19. Spring migration to summer use areas.
 Source Appendices A7, A11.



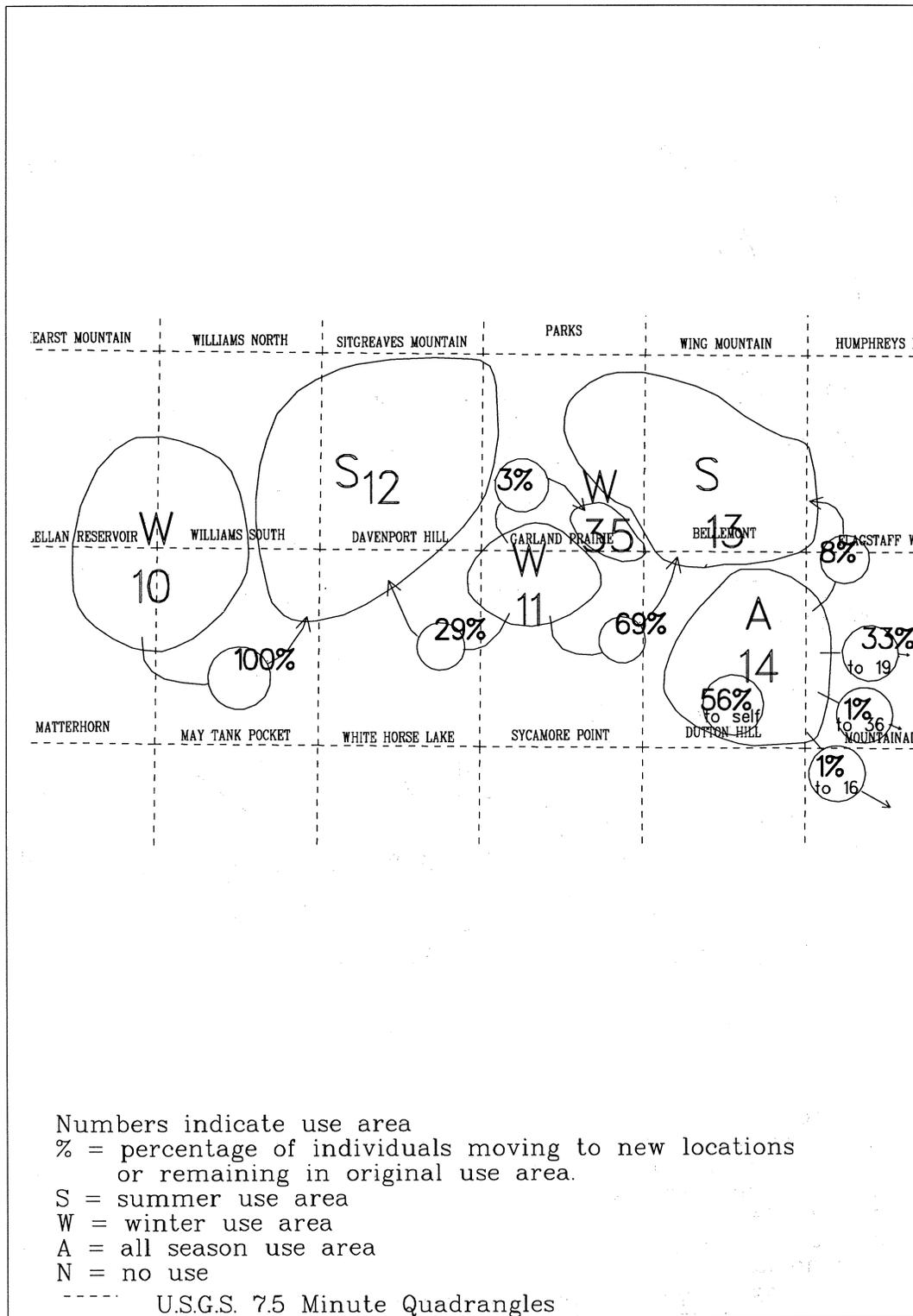
Appendix A20. Fall migration to winter use areas.
Source Appendix A10.



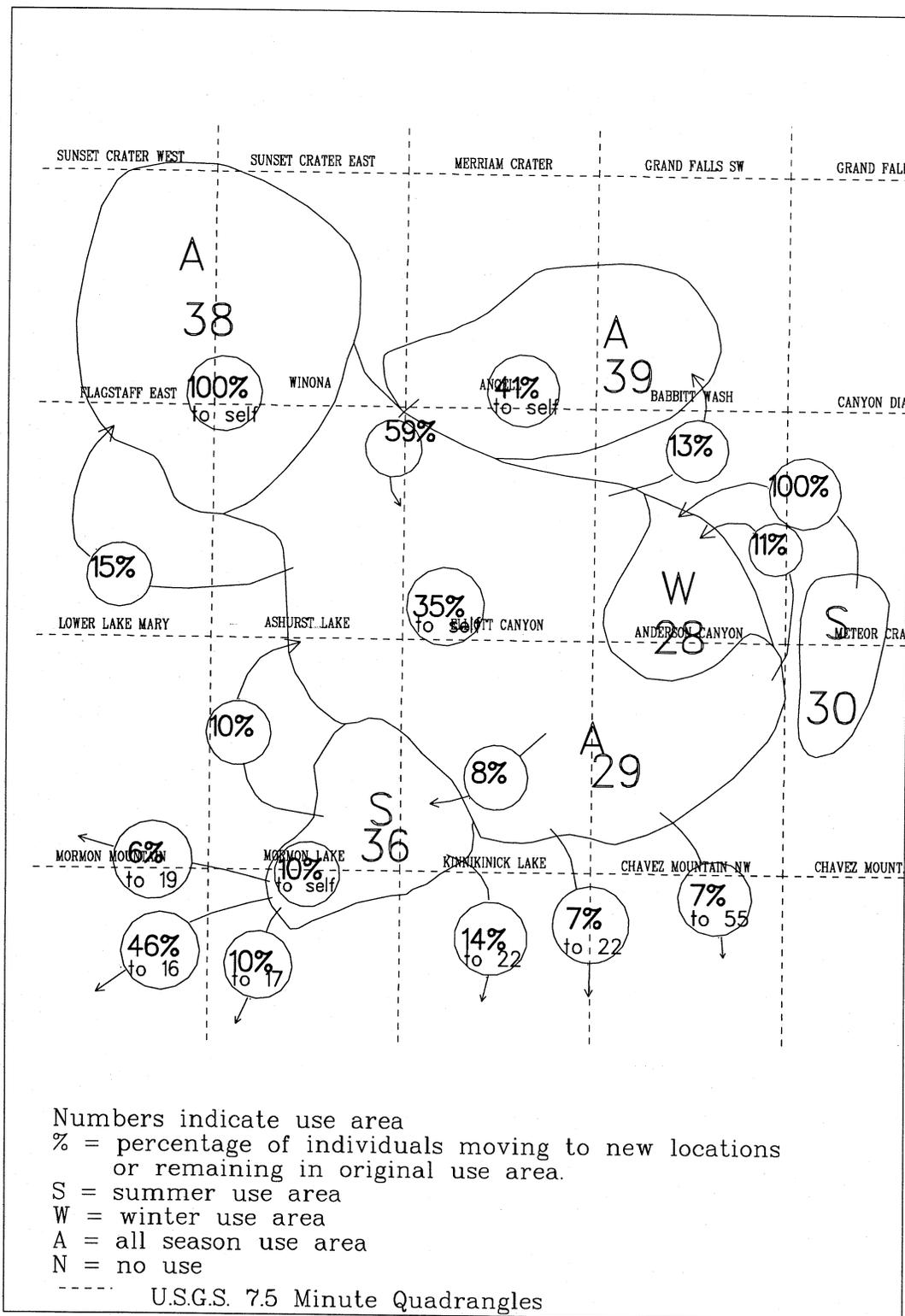
Appendix A21. Spring migration to summer use areas.
Source Appendix A11.



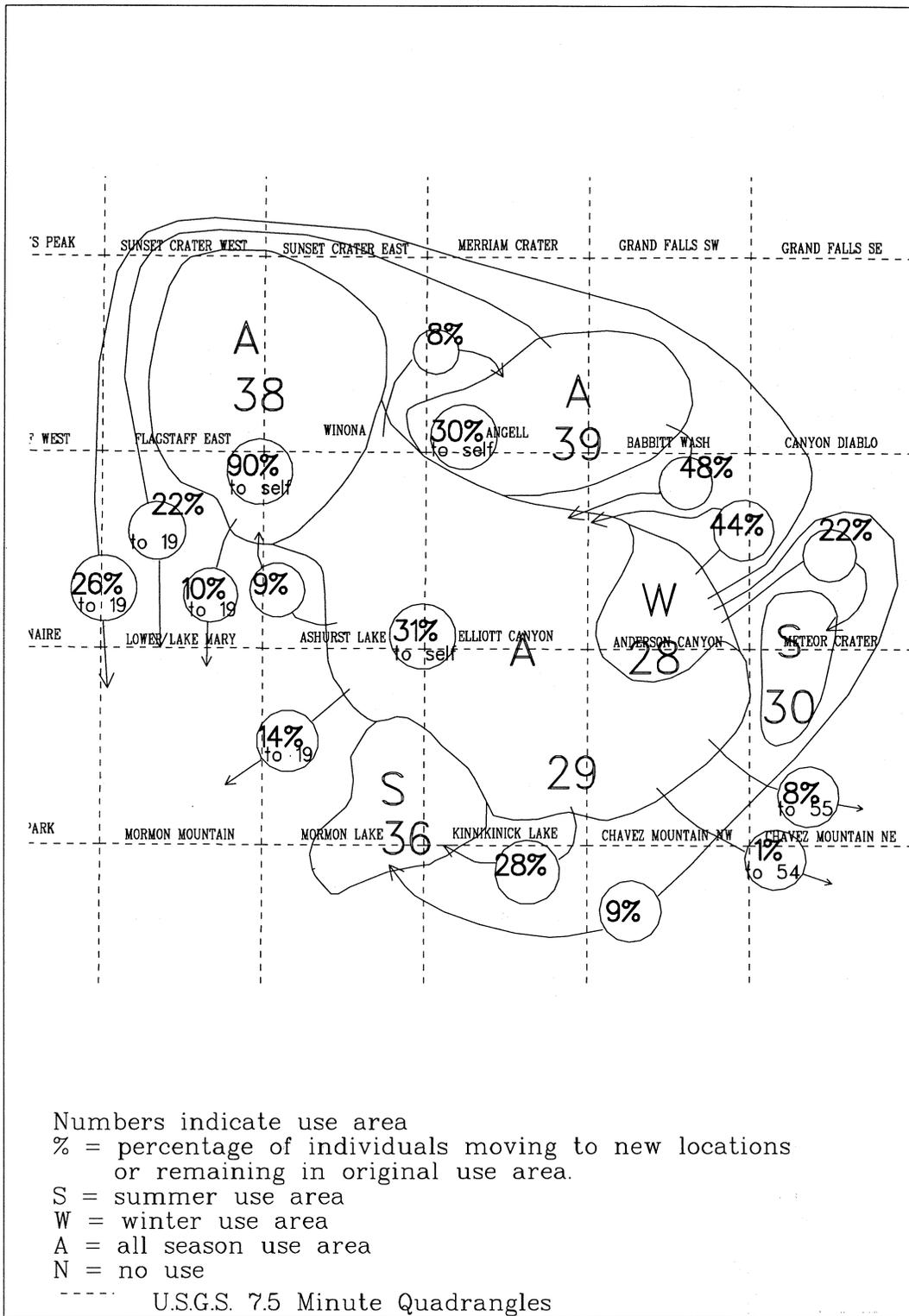
Appendix A22. Fall migration to winter use areas. Source Appendices A6, A10.



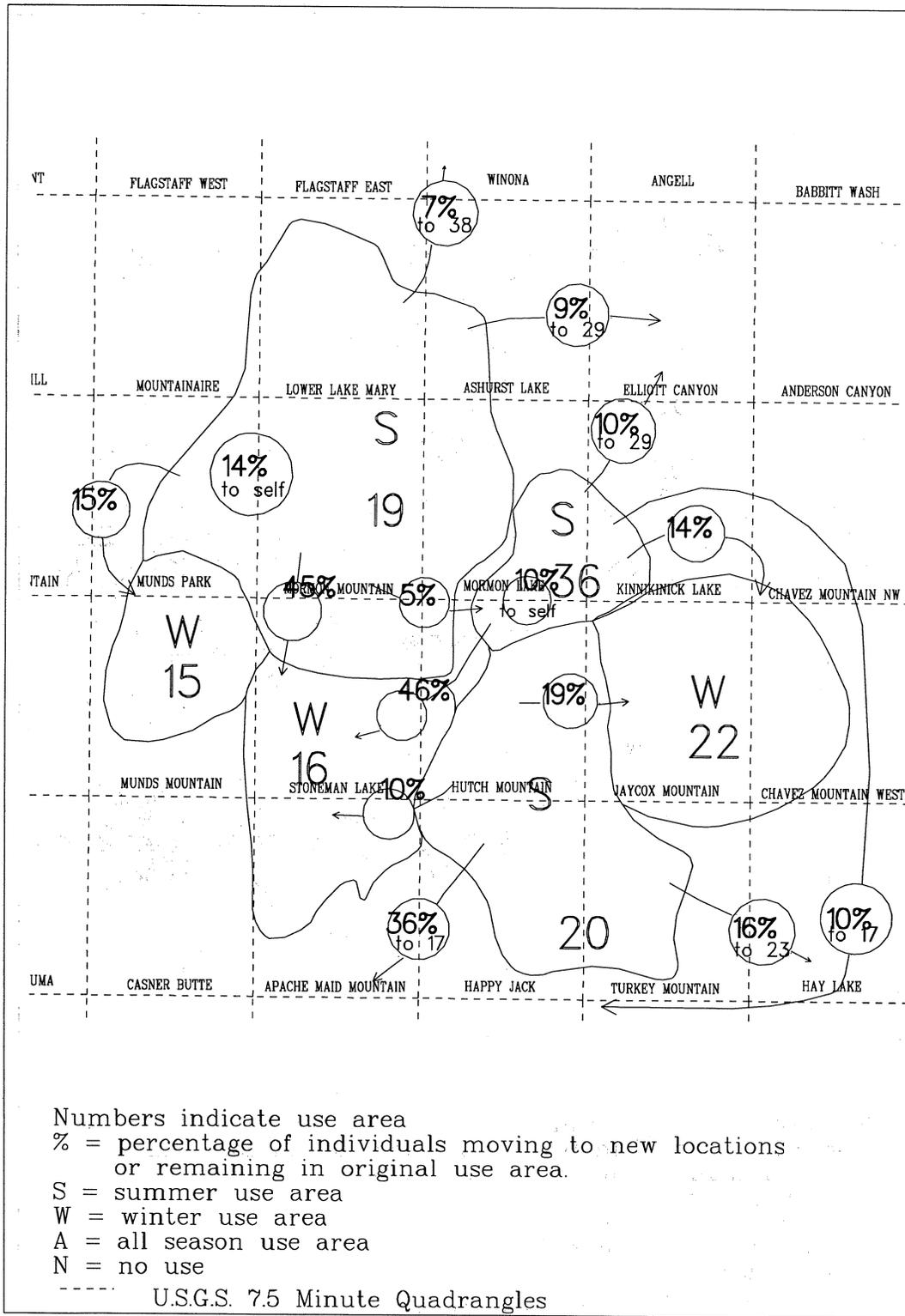
Appendix A23. Spring migration to summer use areas.
Source Appendices A7, A11.



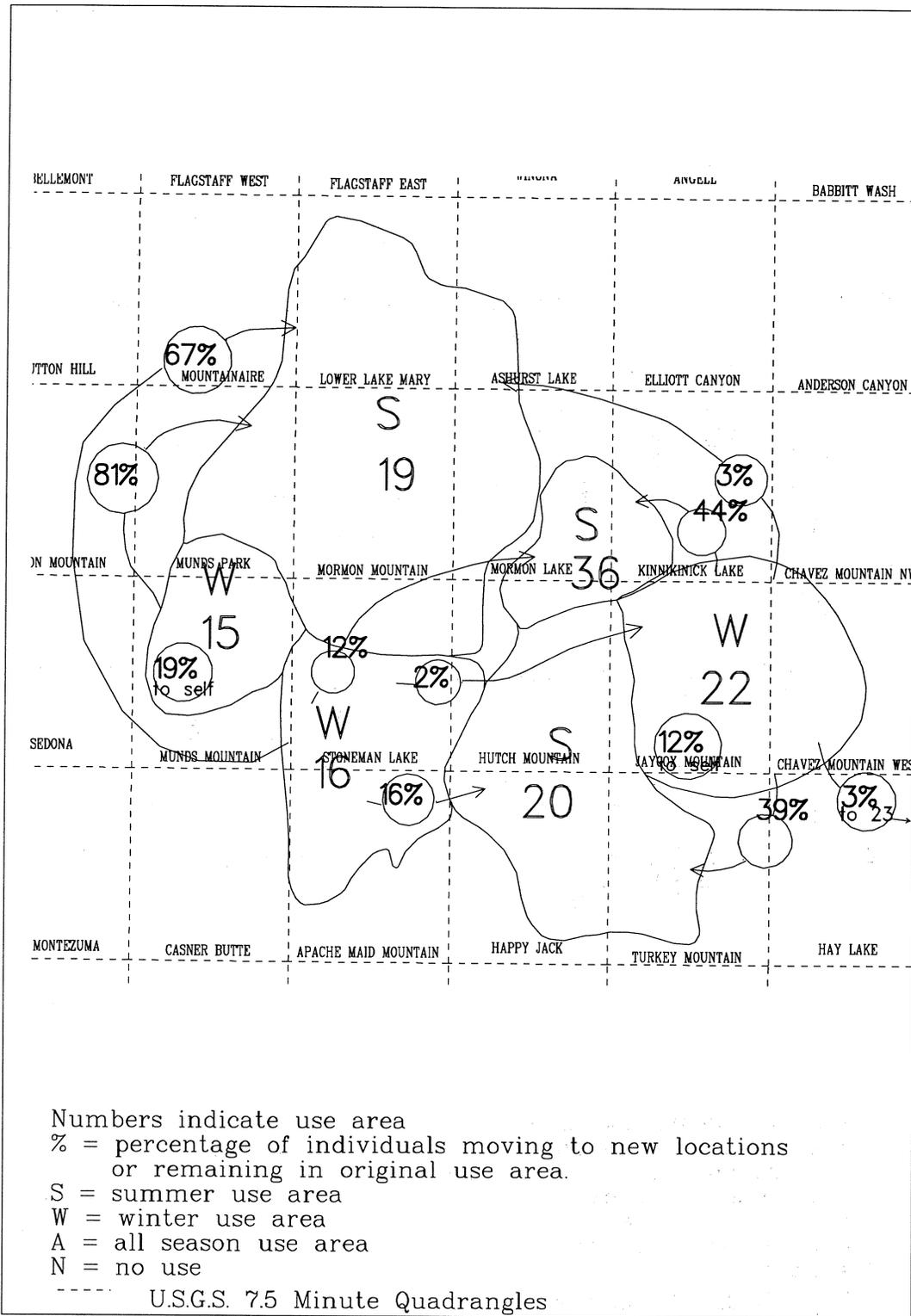
Appendix A24. Fall migration to winter use areas. Source Appendices A6, A10.



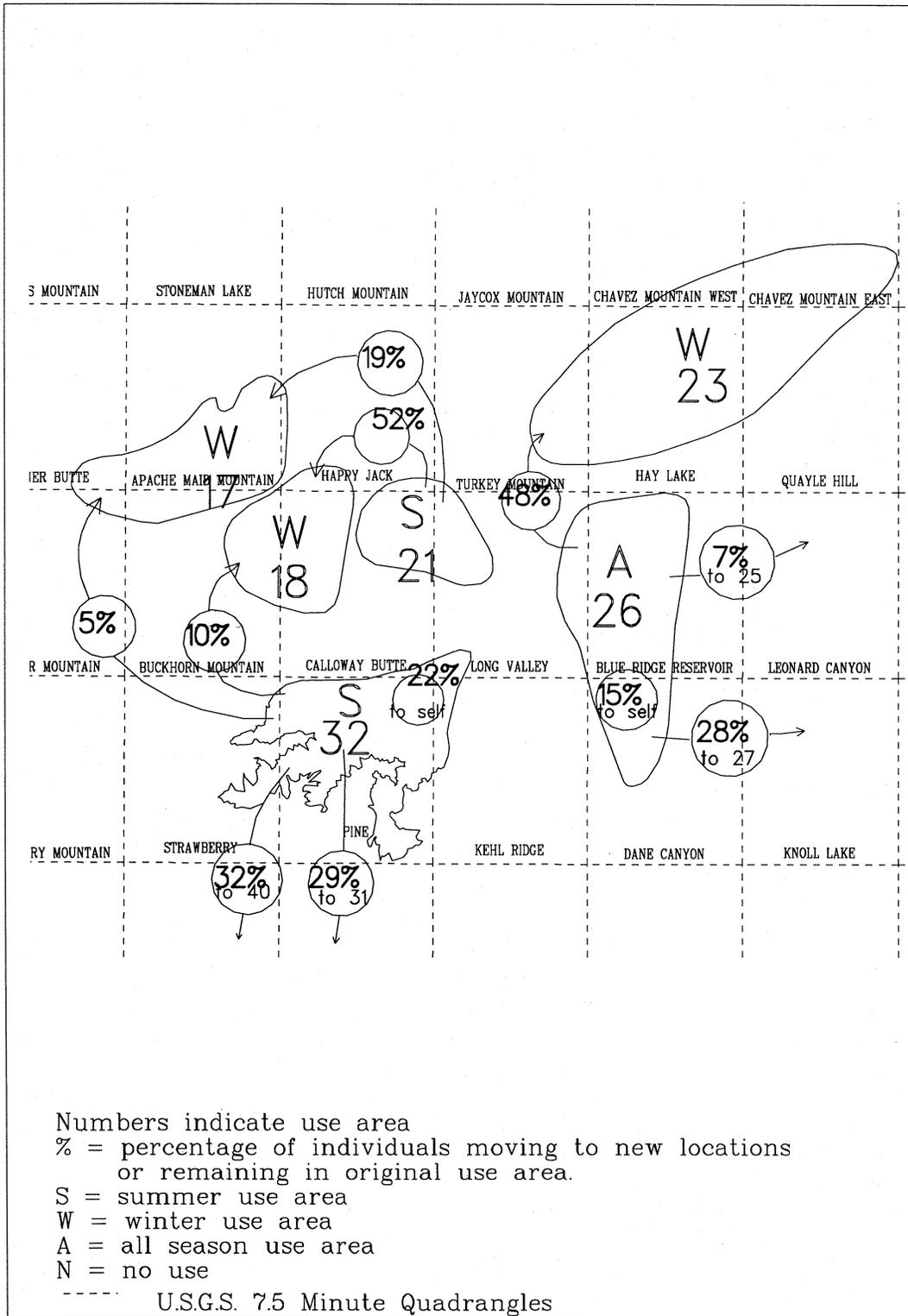
Appendix A25. Spring migration to summer use areas.
Source Appendices A7, A11.



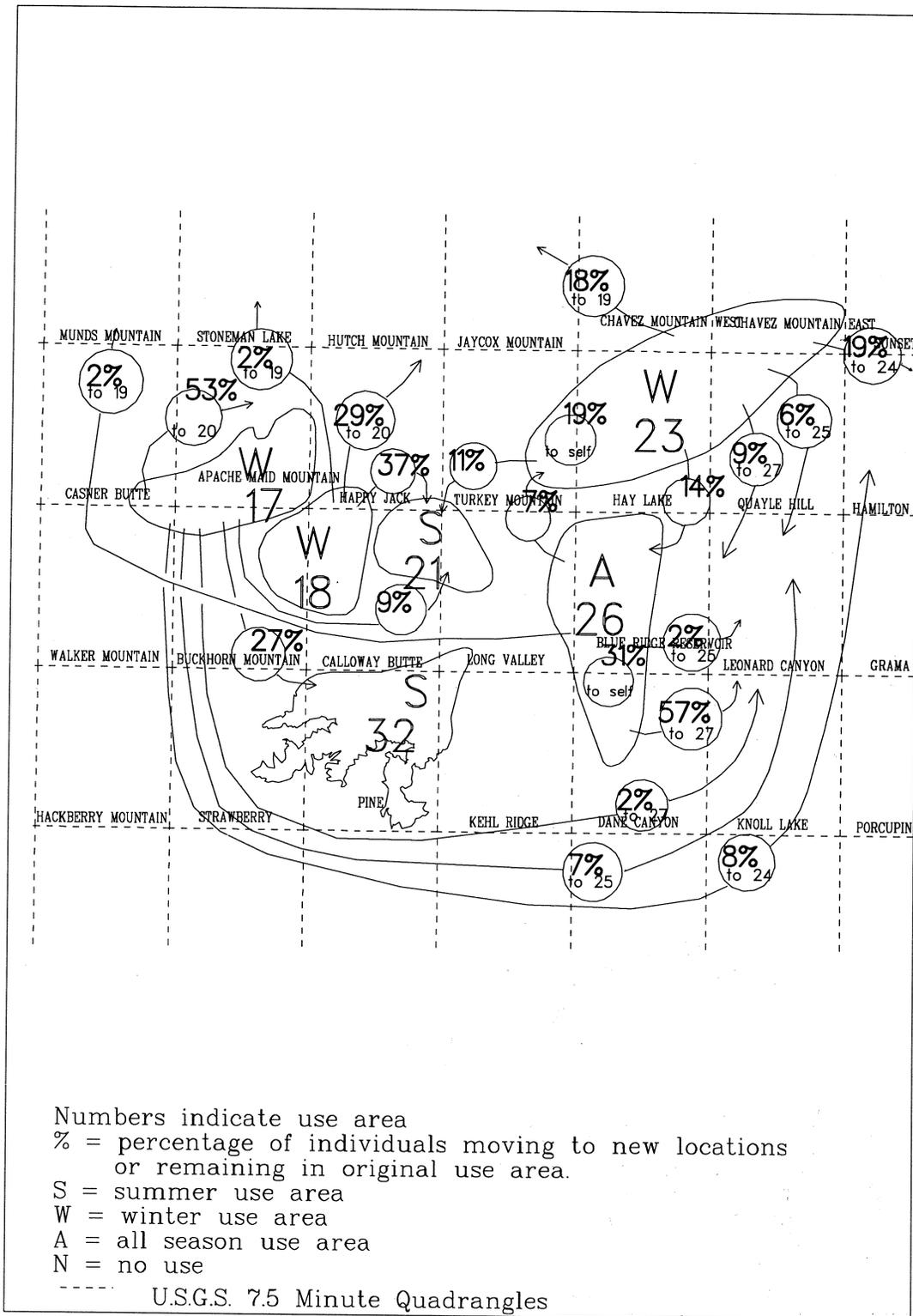
Appendix A26. Fall migration to winter use areas. Source Appendix A10.



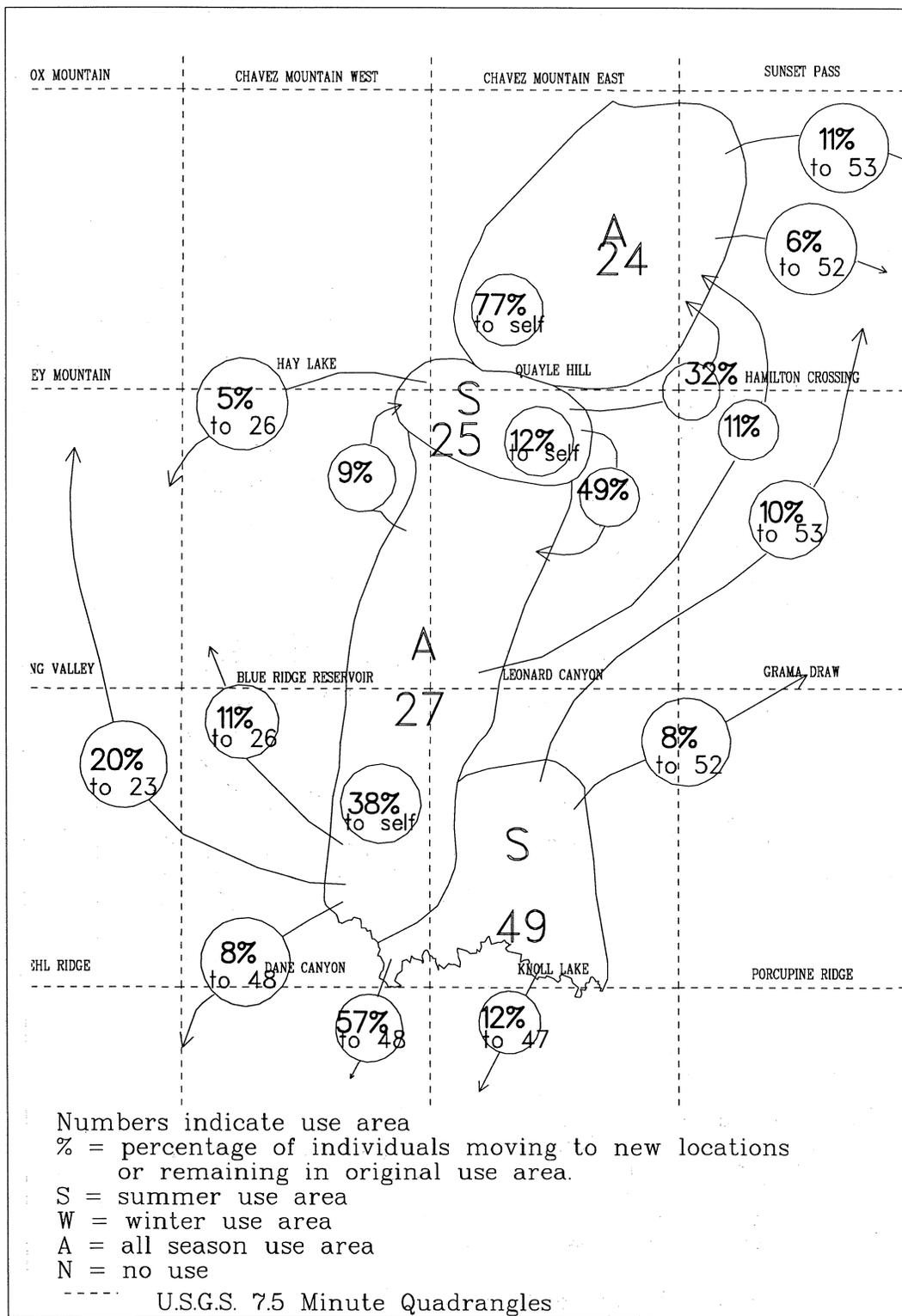
Appendix A27. Spring migration to summer use areas.
Source Appendix A11.



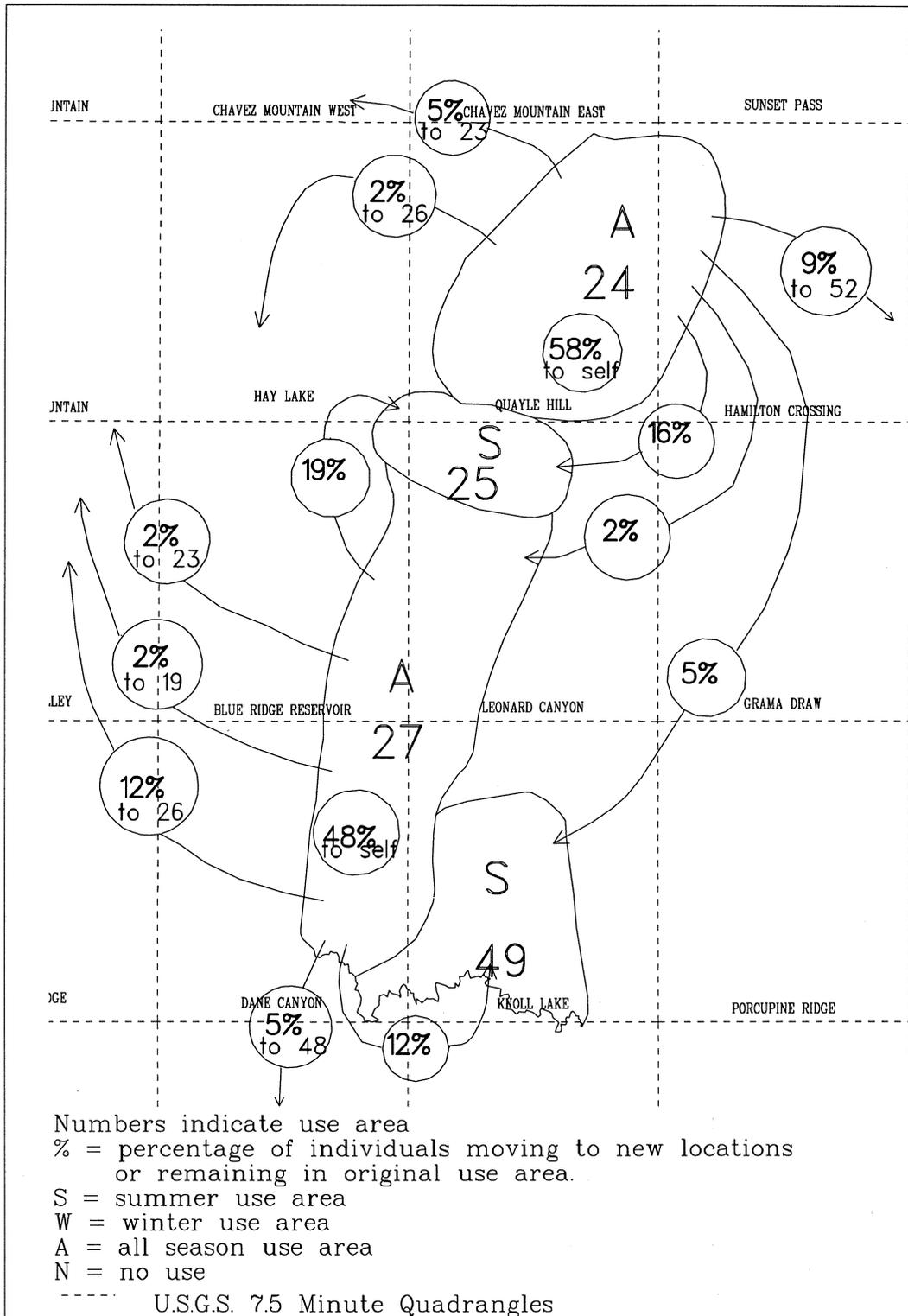
Appendix A28. Fall migration to winter use areas.
 Source Appendices A6, A10.



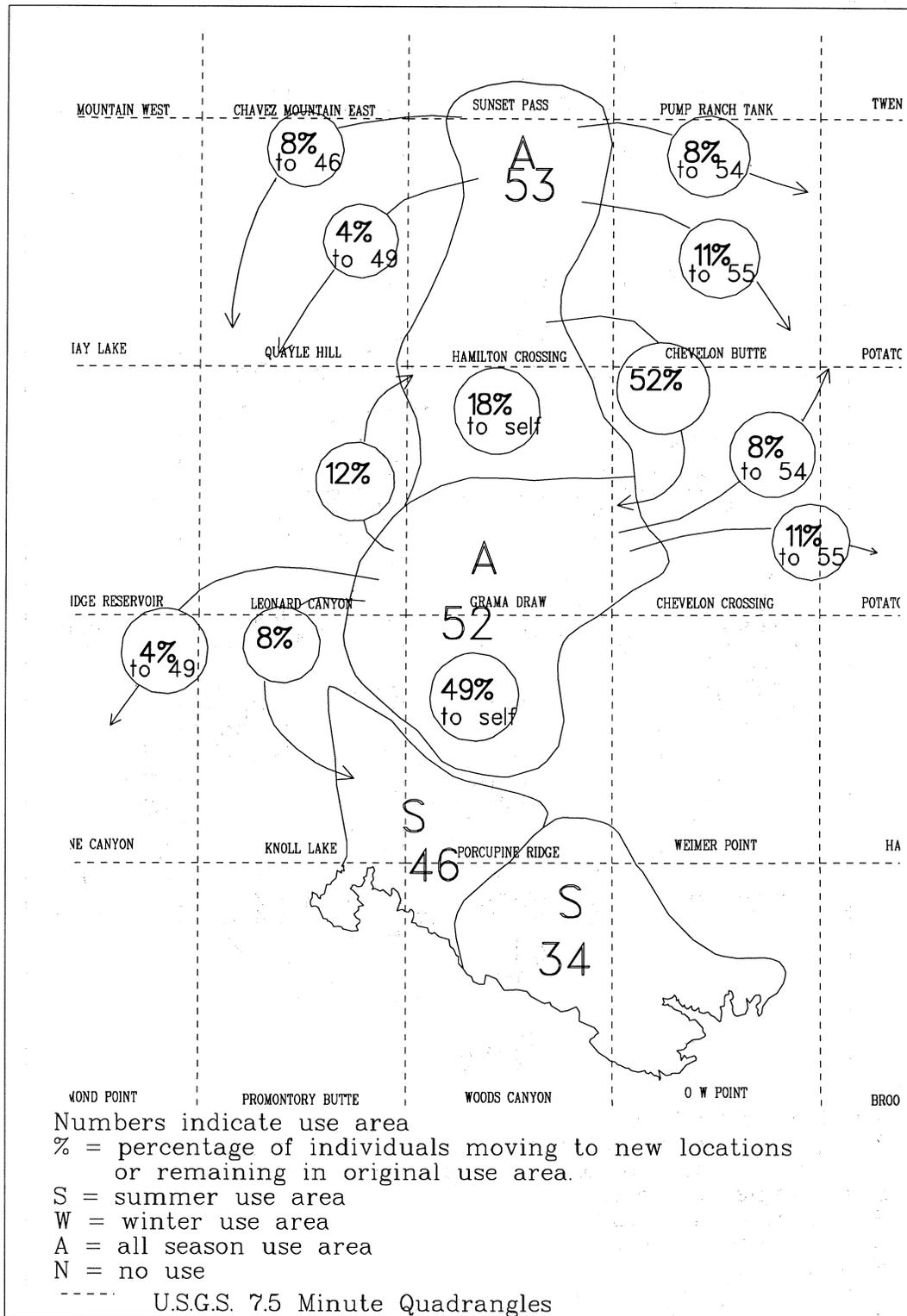
Appendix A29. Spring migration to summer use areas.
 Source Appendices A7, A11.



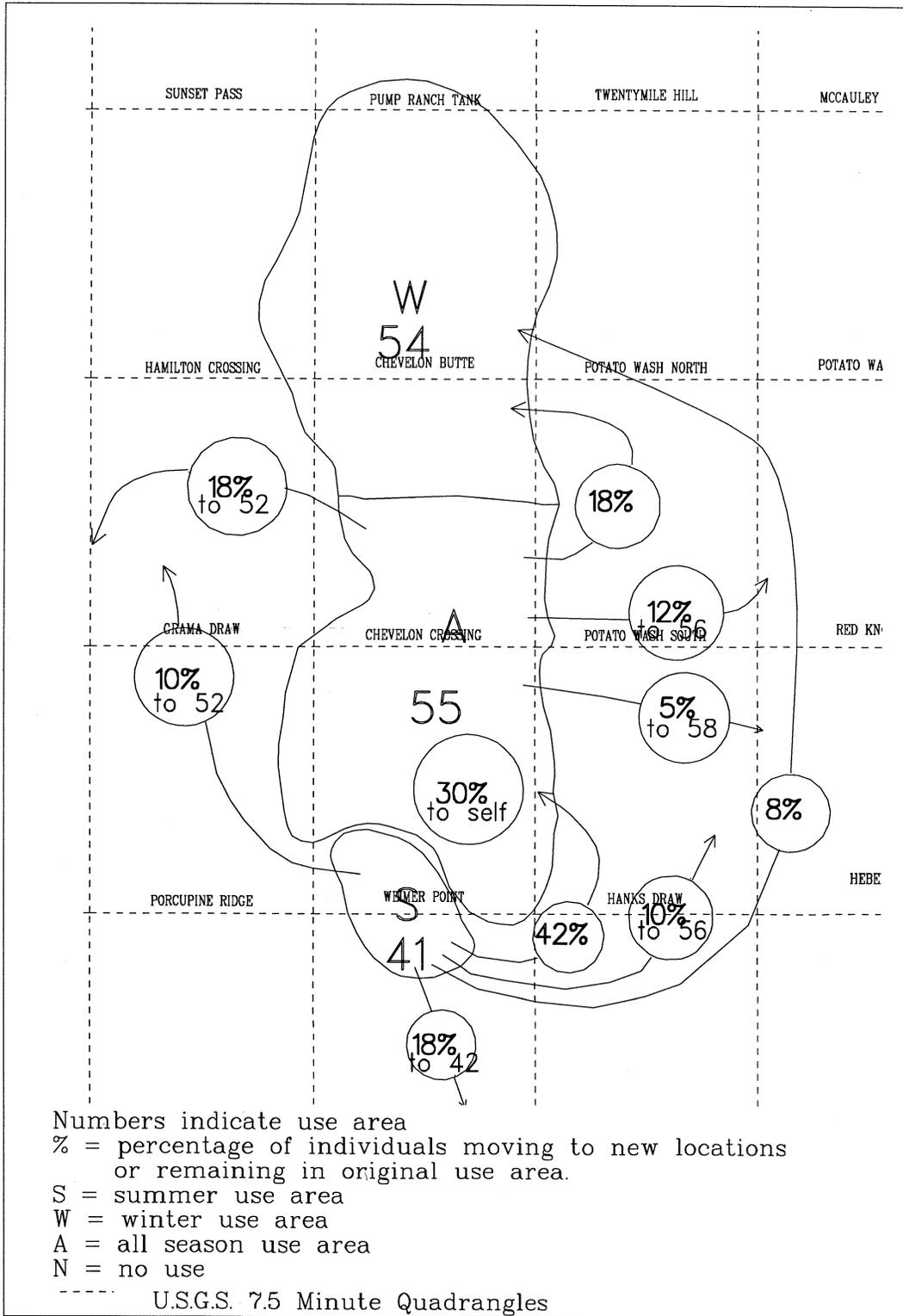
Appendix A30. Fall migration to winter use areas. Source Appendices A6, A10.



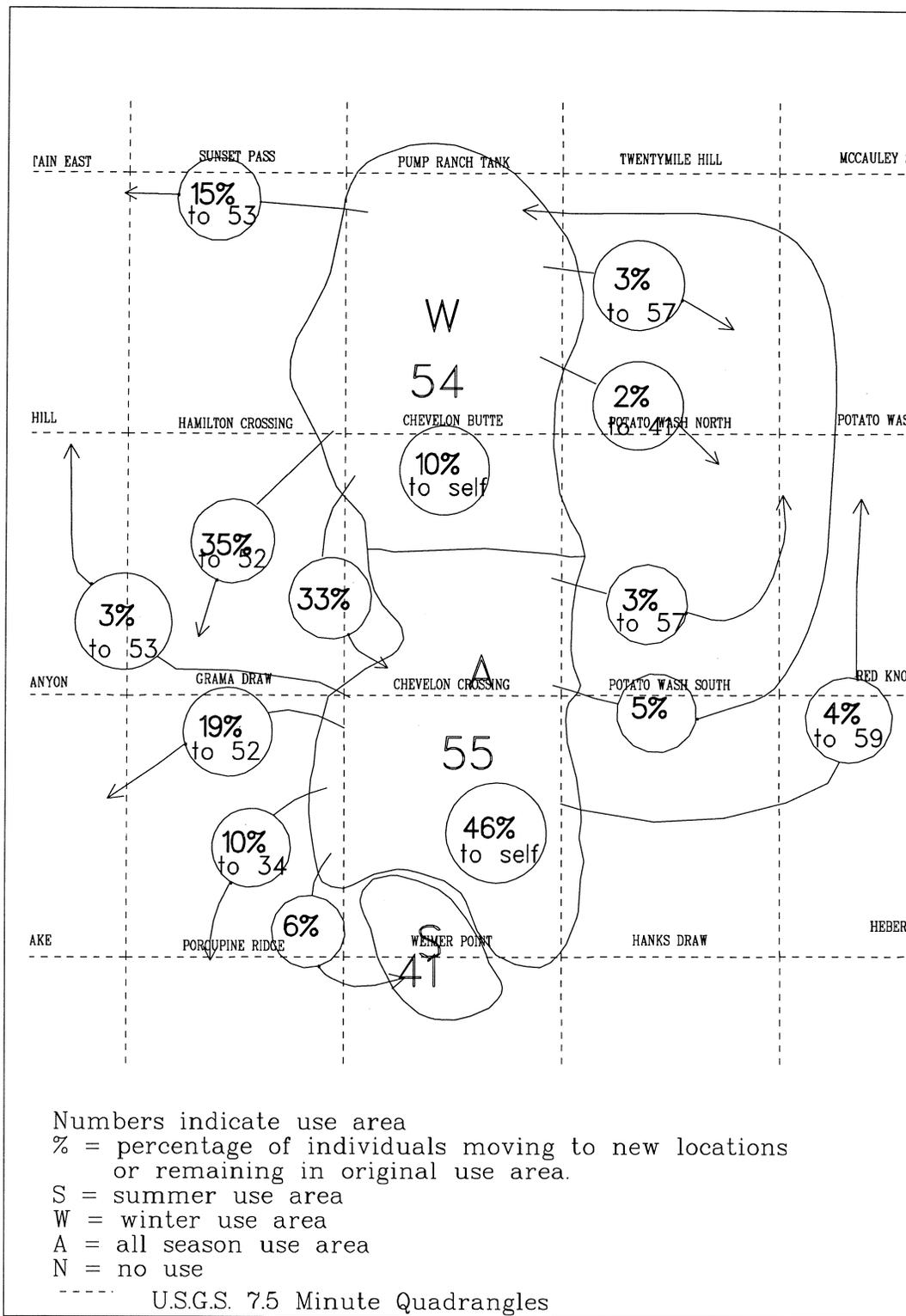
Appendix A31. Spring migration to summer use areas.
 Source Appendix A7.



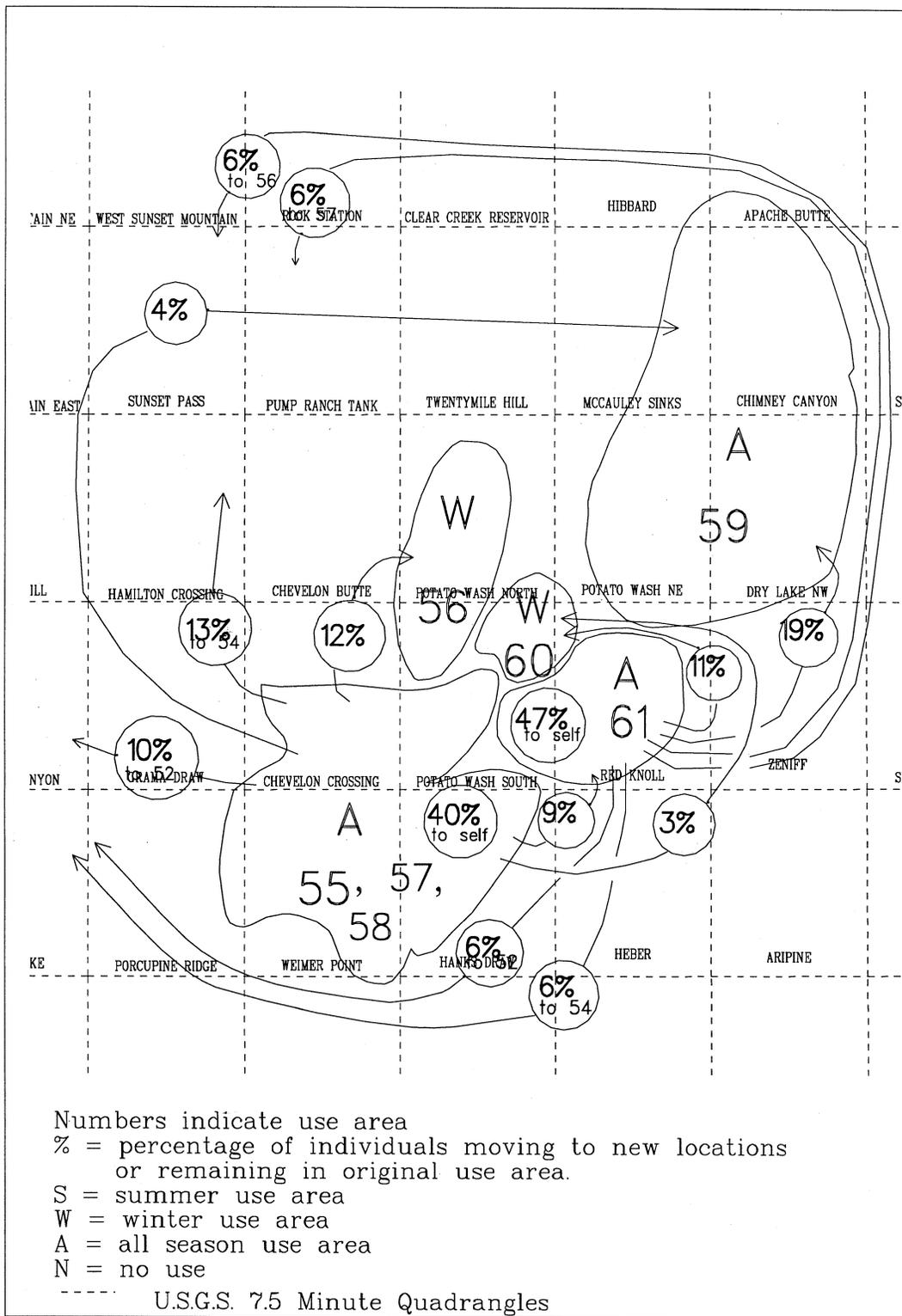
Appendix A33. Spring migration to summer use areas.
Source Appendix A7.



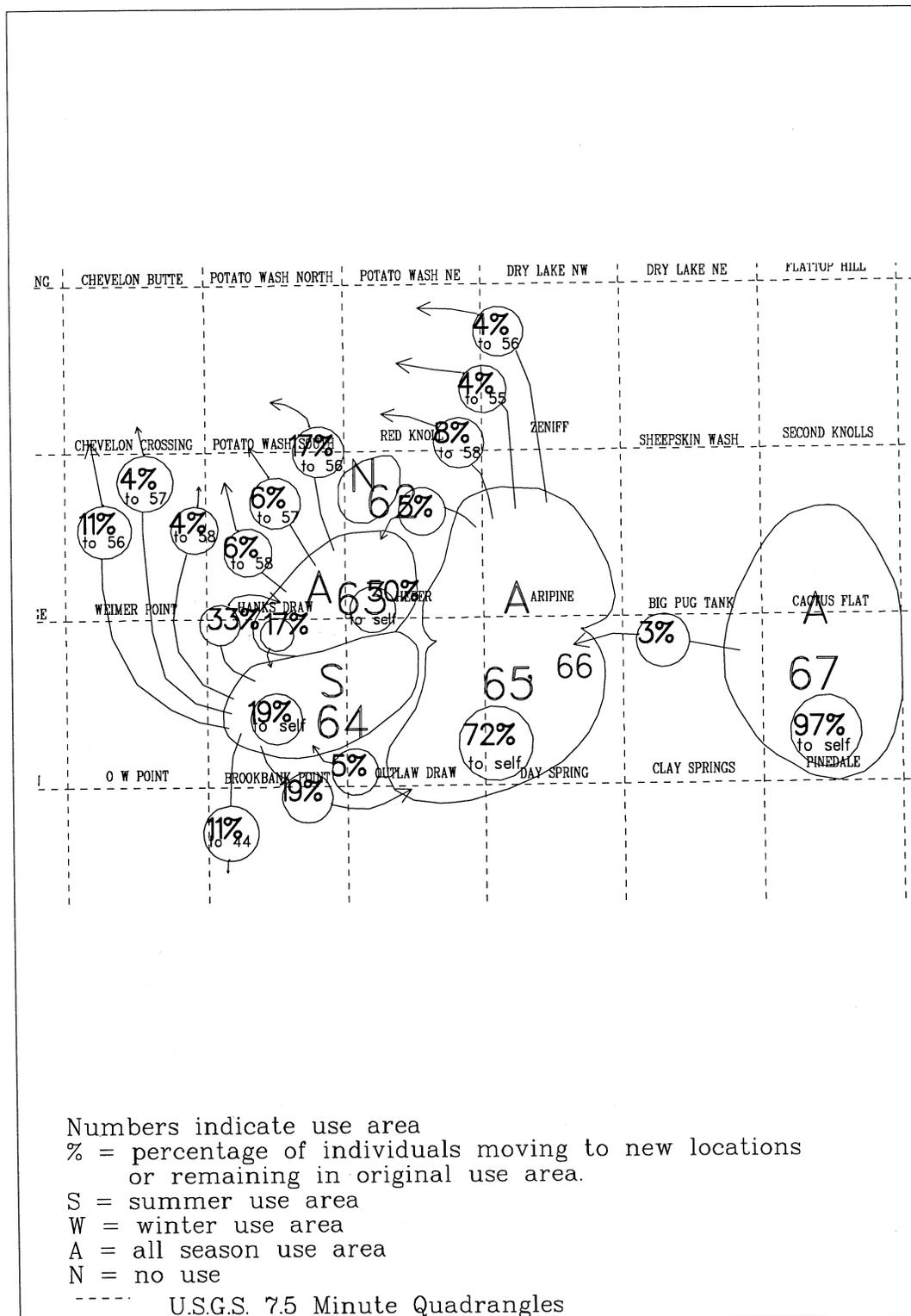
Appendix A34. Fall migration to winter use areas.
 Source Appendices A6, A10.



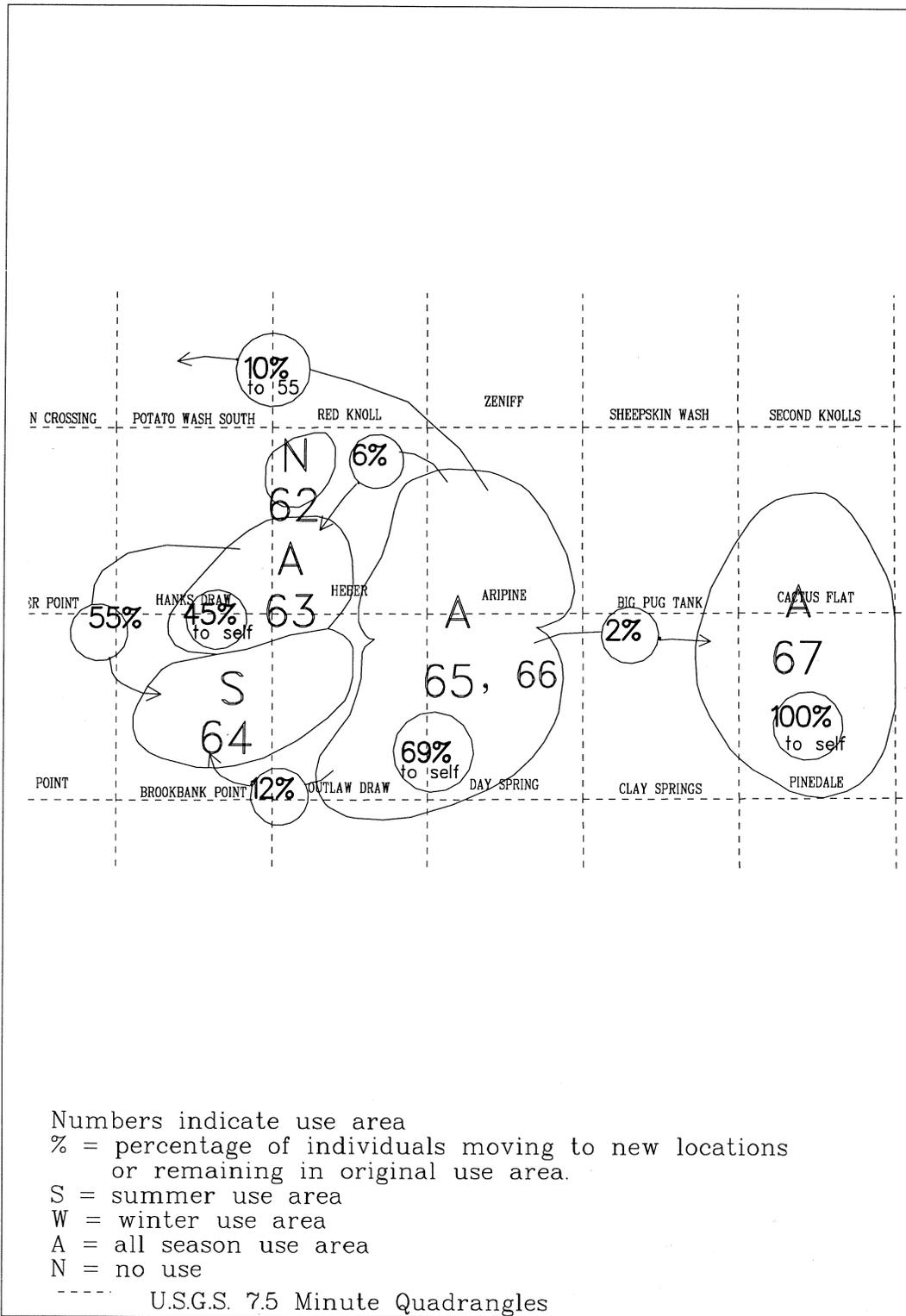
Appendix A35. Spring migration to summer use areas.
 Source Appendices A7, A11.



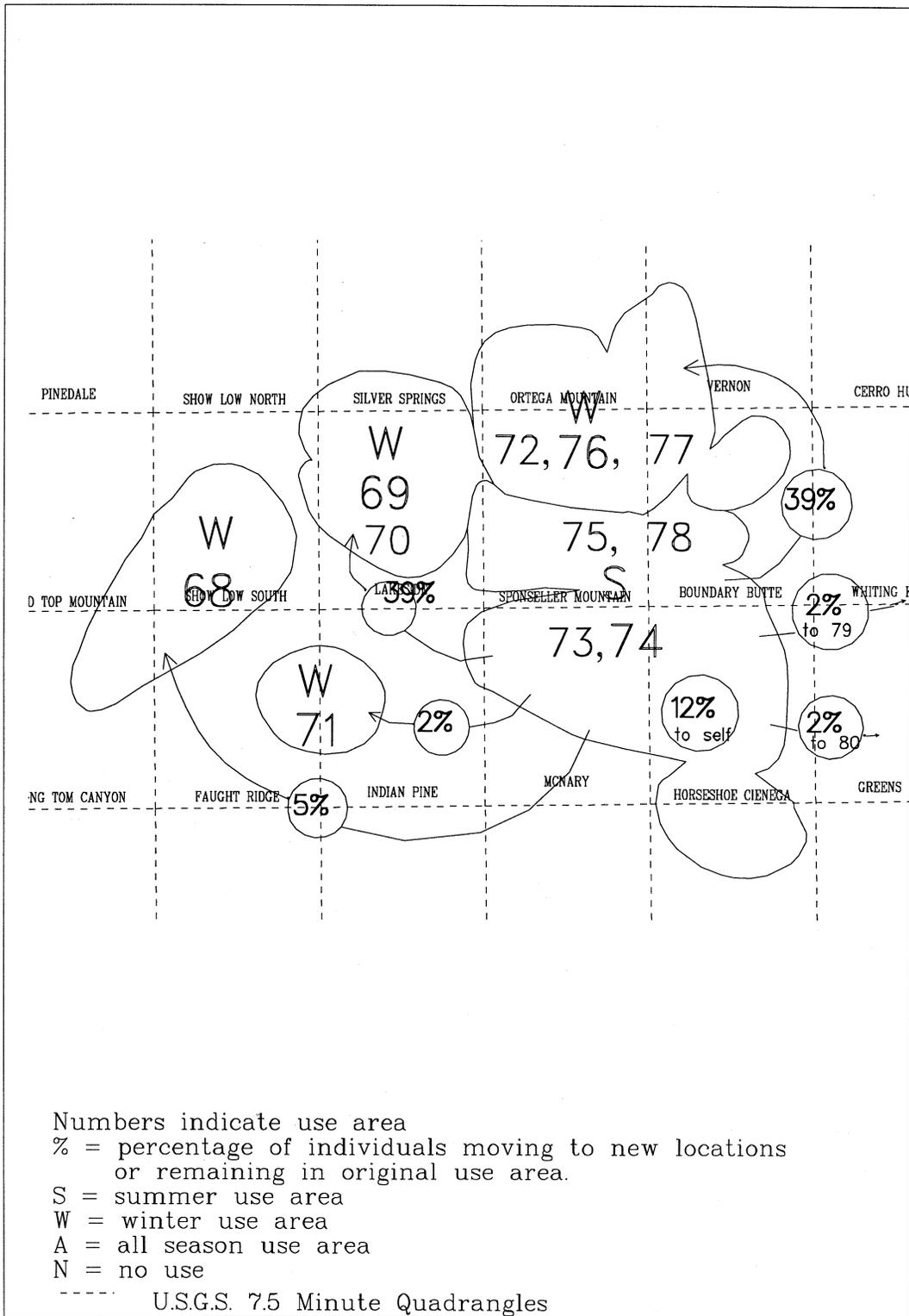
Appendix A36. Fall migration to winter use areas.
Source Appendix A6.



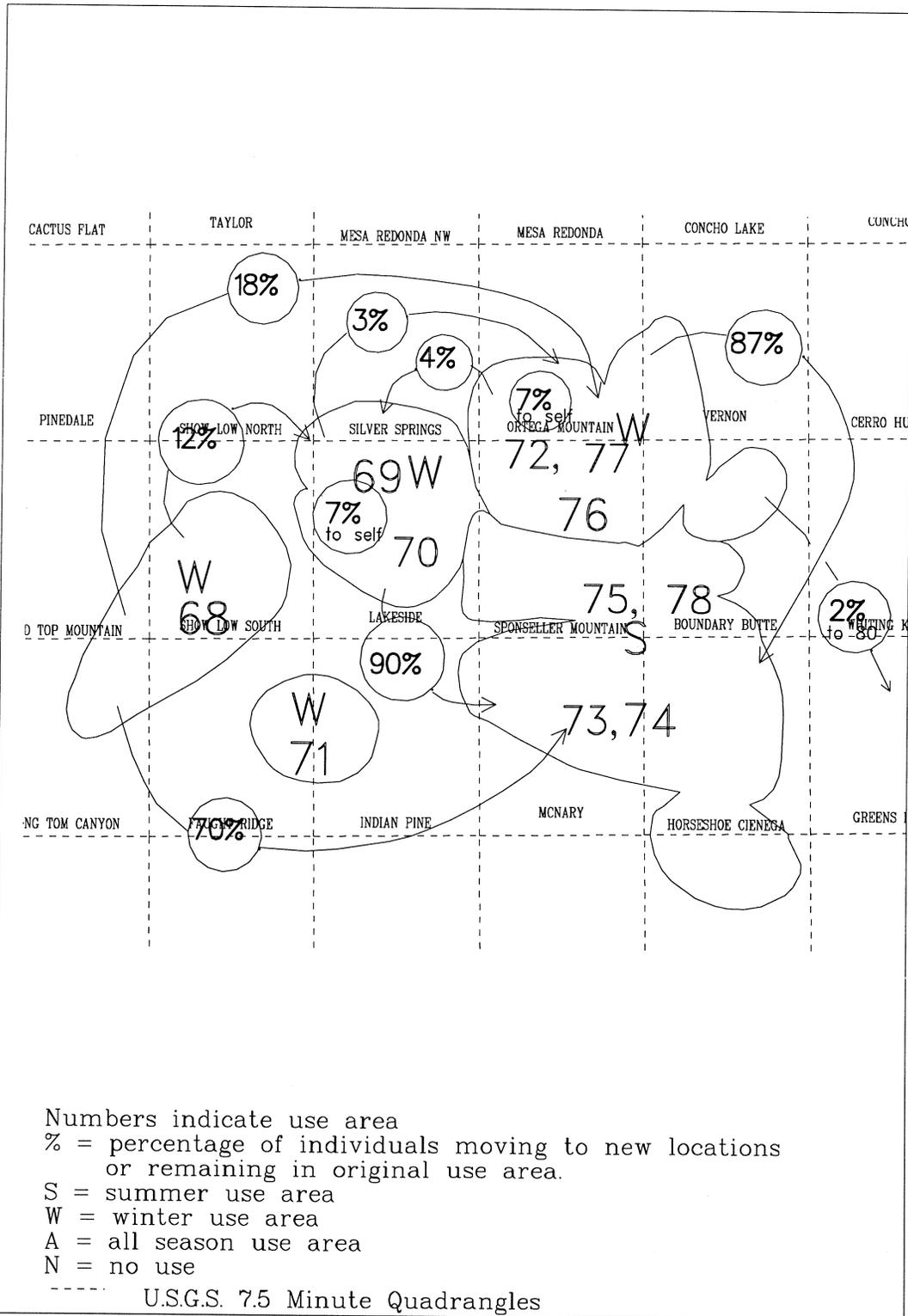
Appendix A38. Fall migration to winter use areas.
 Source Appendices A6, A10.



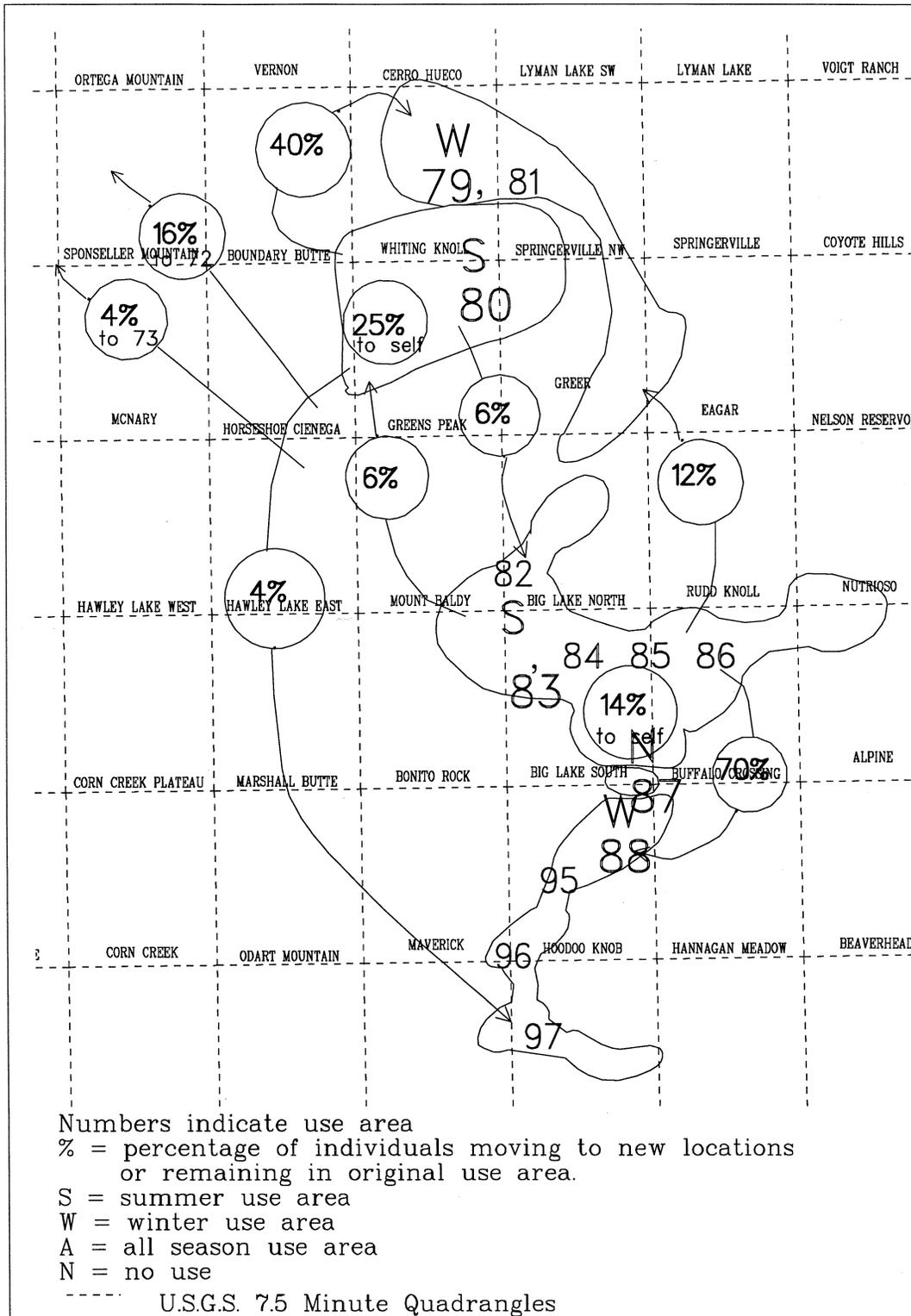
Appendix A39. Spring migration to summer use areas.
 Source Appendix A7.



Appendix A40. Fall migration to winter use areas.
Source Appendix A10.

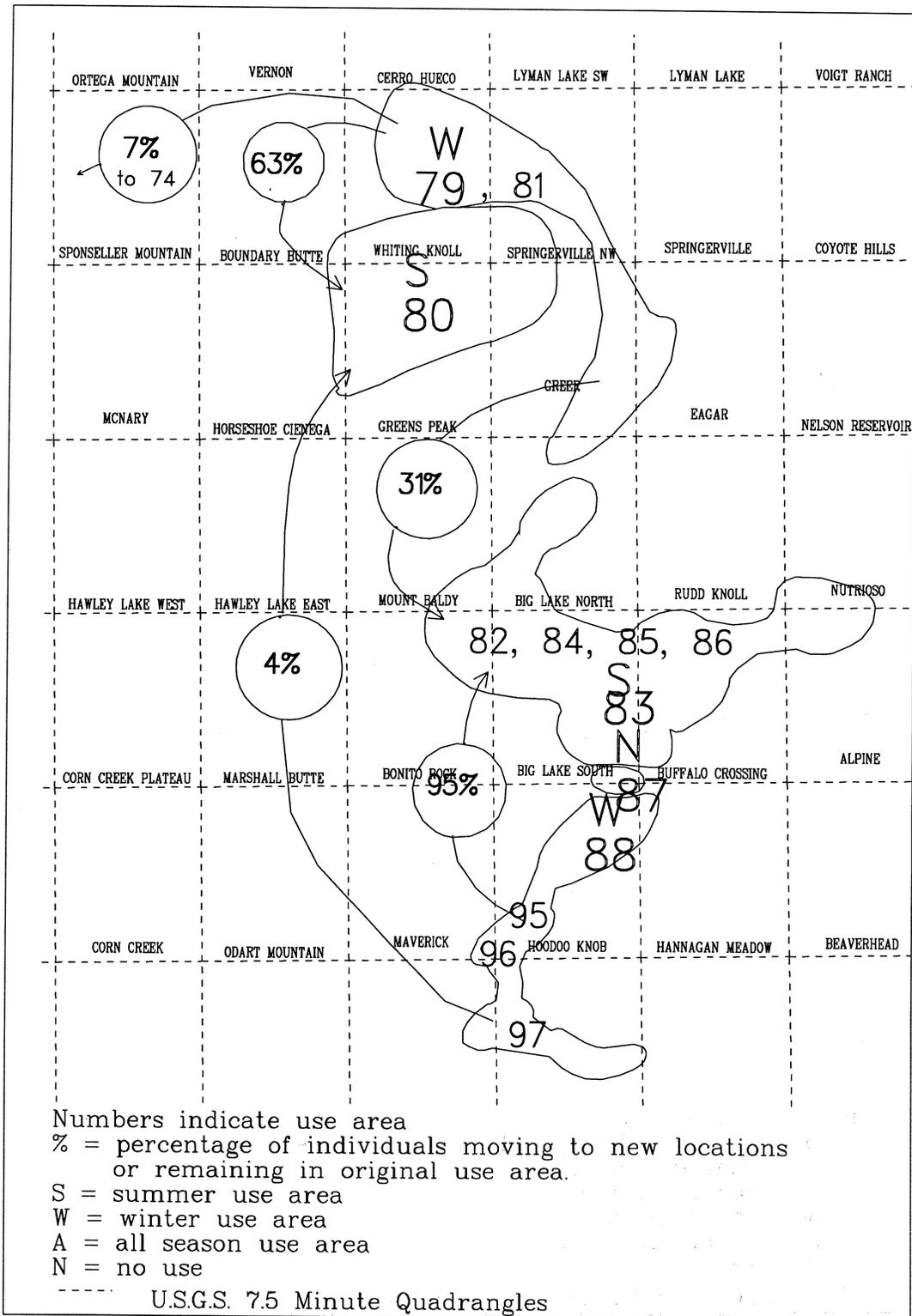


Appendix A41. Spring migration to summer use areas.
 Source Appendix A11.

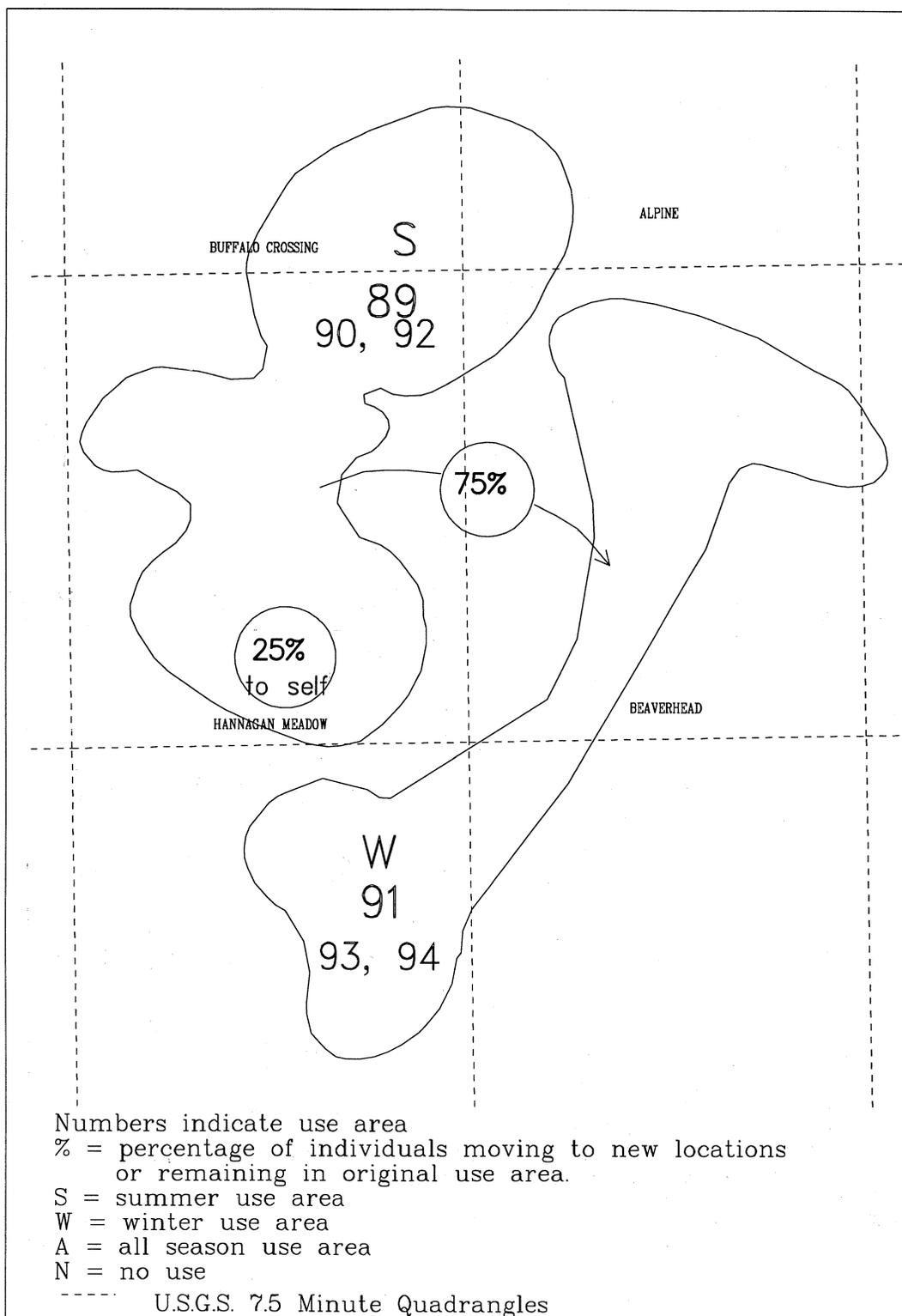


Appendix A42. Fall migration to winter use areas.
 Source Appendix A10.

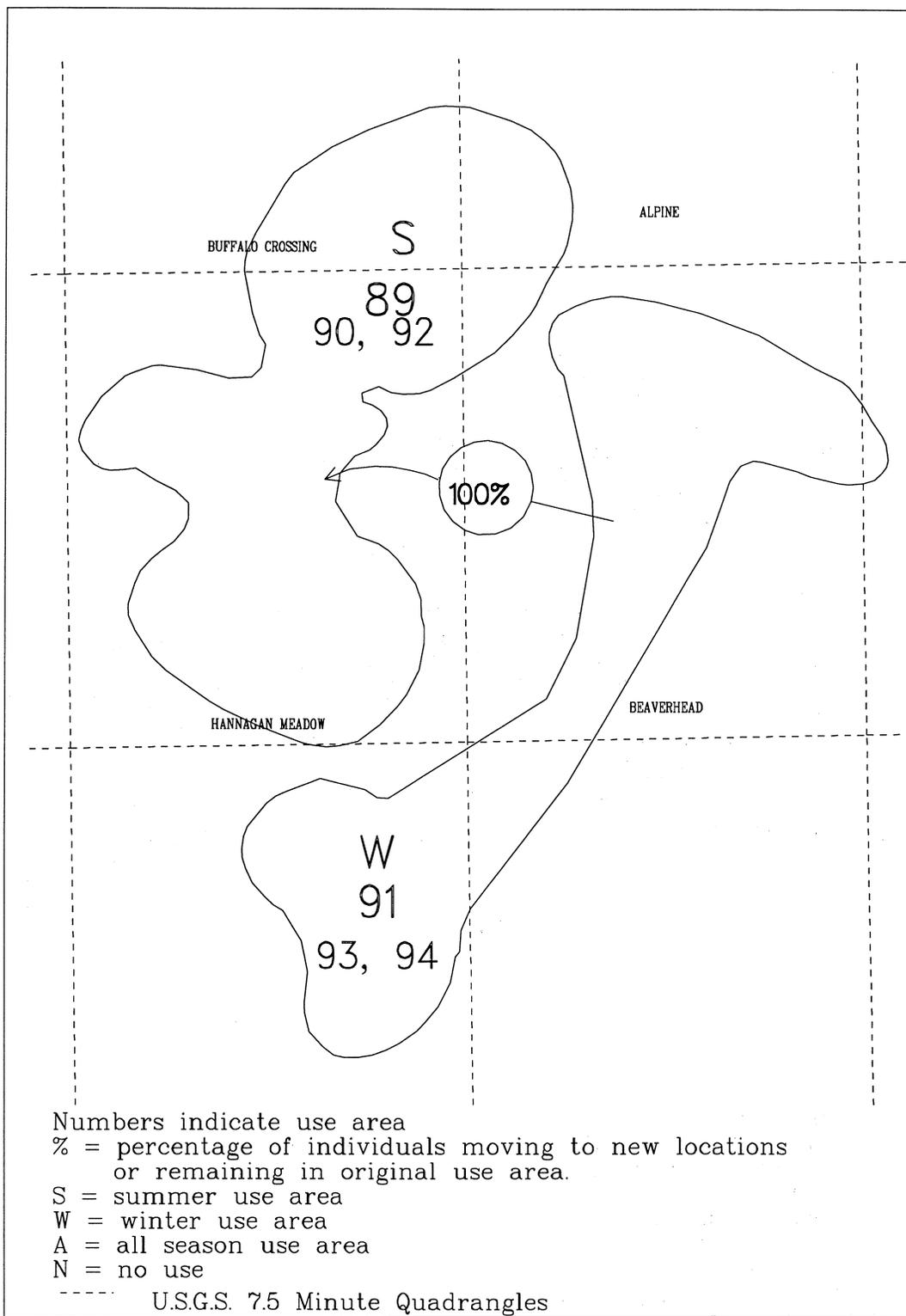
ELK SEASONAL RANGES AND MIGRATIONS



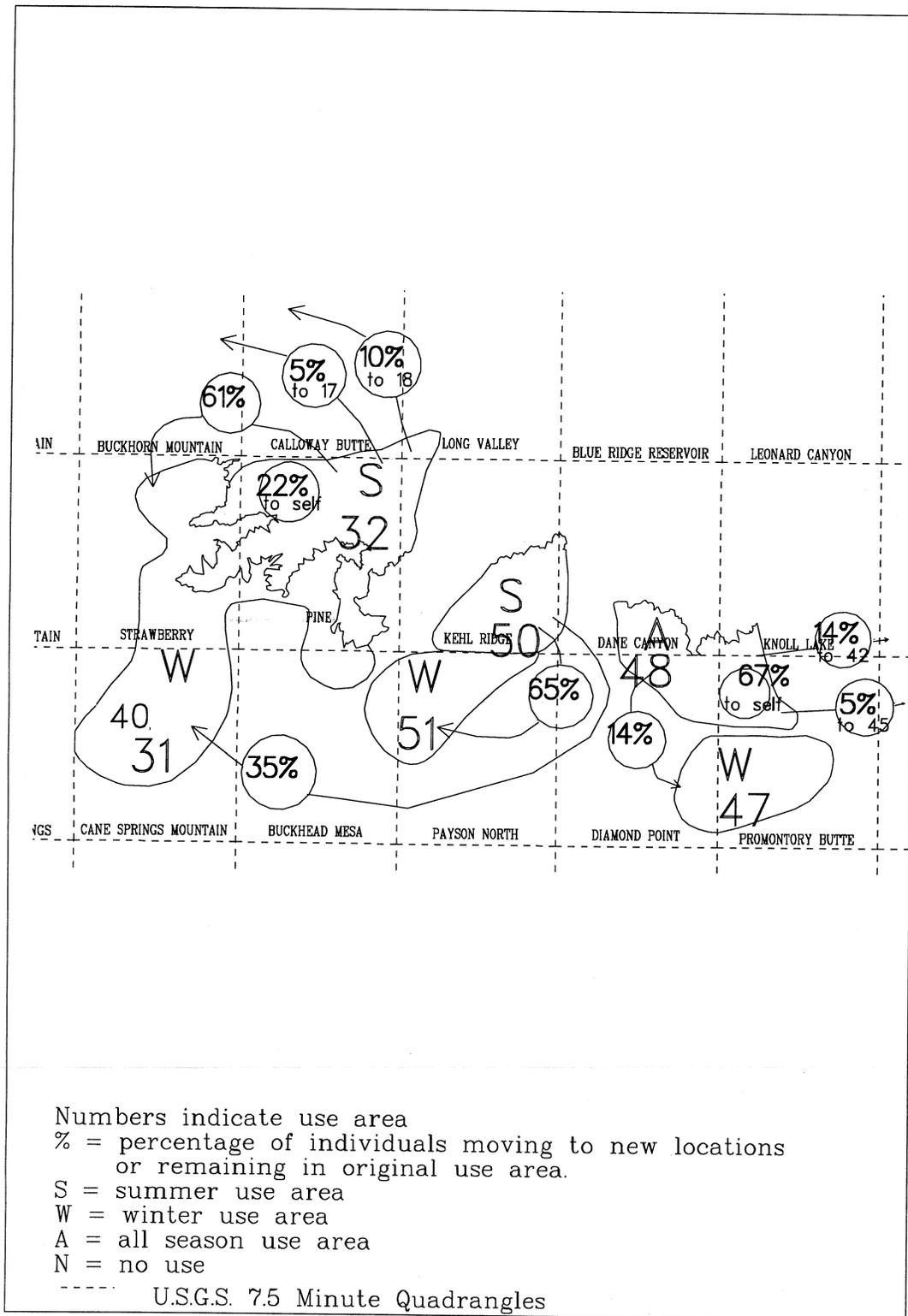
Appendix A43. Spring migration to summer use areas. Source Appendix A11.



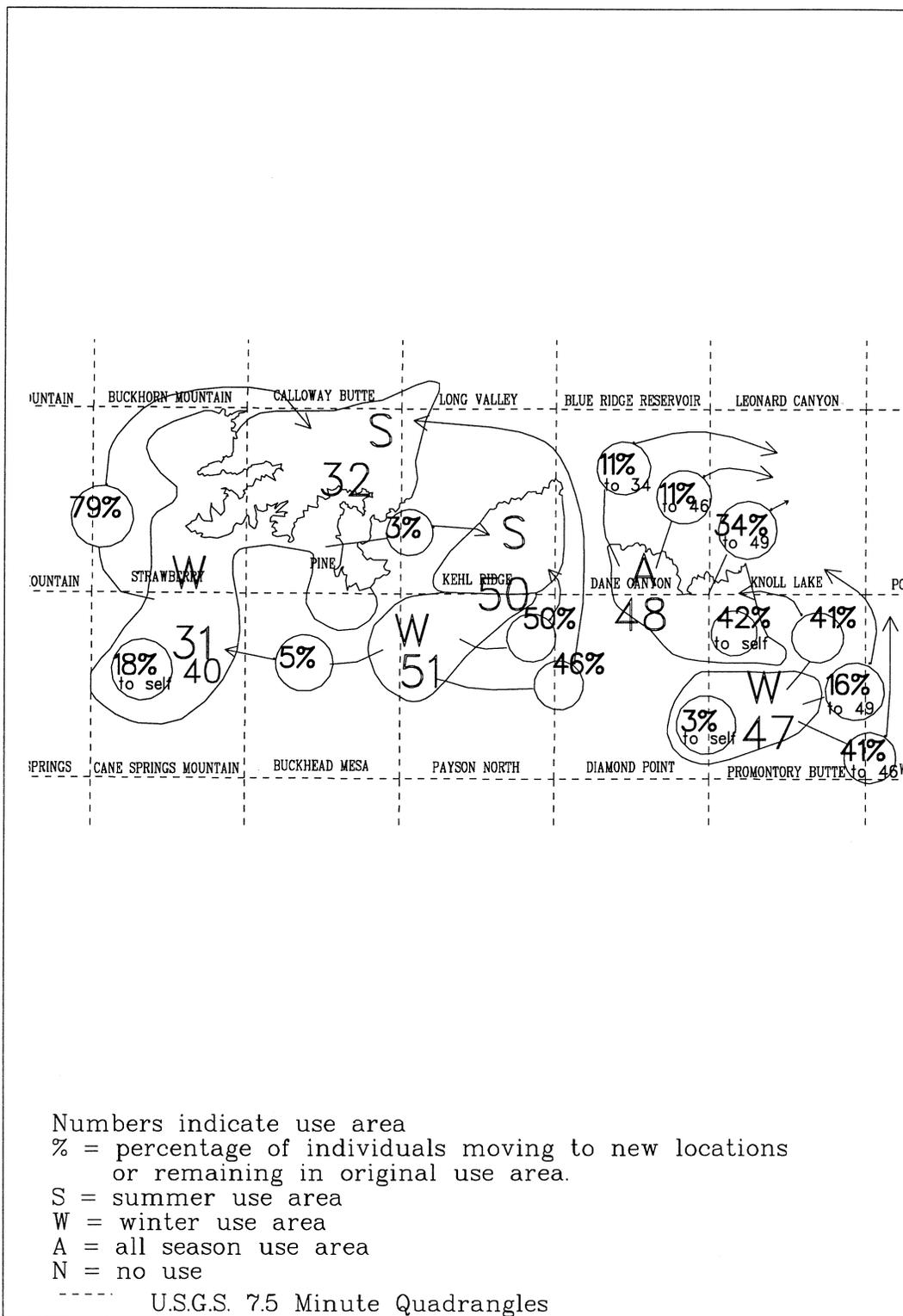
Appendix A44. Fall migration to winter use areas.
 Source Appendix A10.



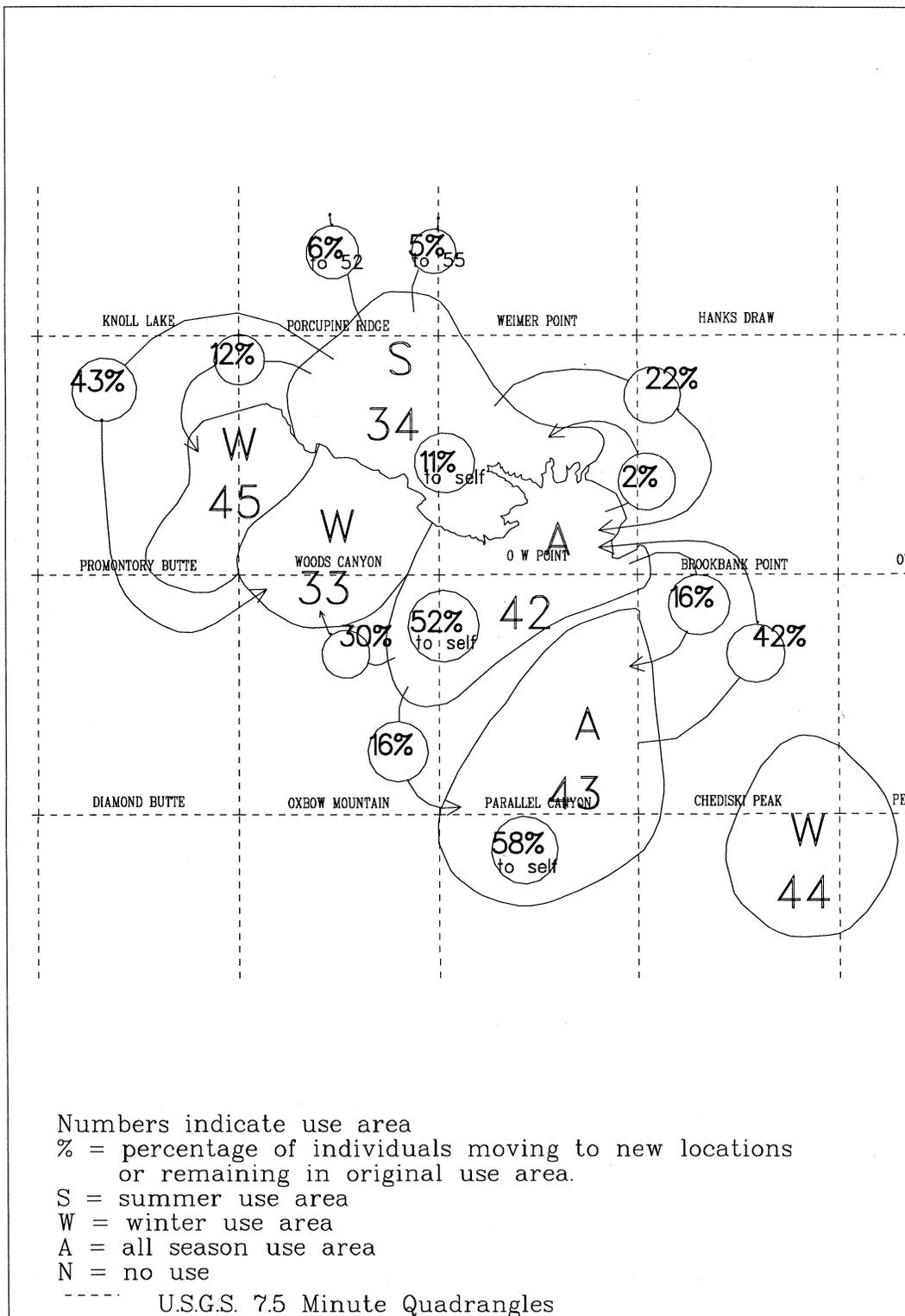
Appendix A45. Spring migration to summer use areas.
 Source Appendix A11.



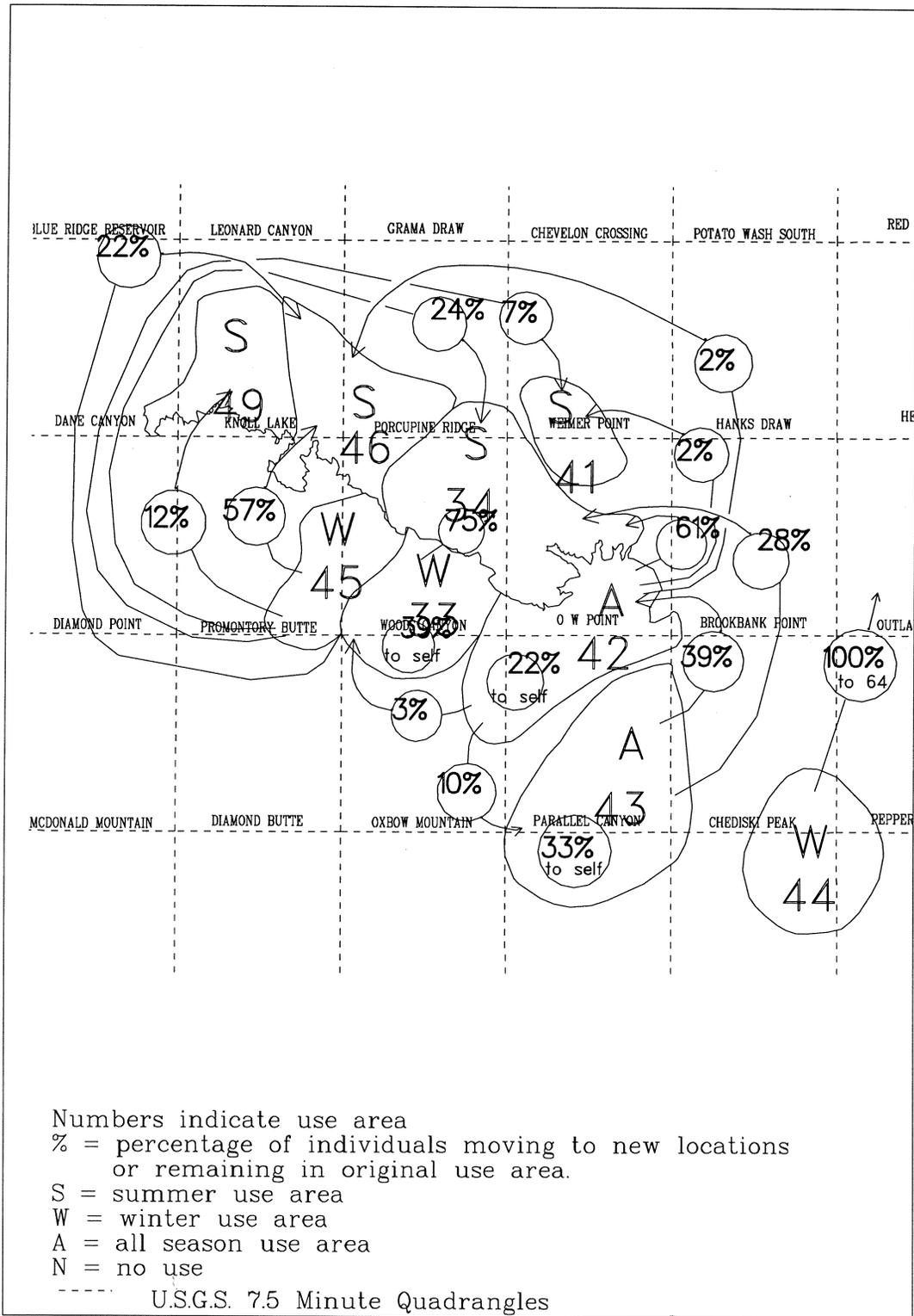
Appendix A46. Fall migration to winter use areas.
Source Appendices A6, A10.



Appendix A47. Spring migration to summer use areas.
 Source Appendices A7, A11.



Appendix A48. Fall migration to winter use areas.
Source Appendix A6.



Appendix A49. Spring migration to summer use areas.
Source Appendices A7, A11.

Appendix B1. Seasonal use area designation for year-round residents below the Mogollon Rim based on $\geq 67\%$ of elk location observations occurring within each use area during winter (January-March) or summer (June-August). Data are from elk captured in Region 6 during summer trapping periods.

Area	Winter		Summer		Designation
	%	(No.)	%	(No.)	
101	0	(0)	100	(5)	Summer
102	50	(3)	50	(3)	All Season
103	100	(12)	0	(0)	Winter
104	11	(2)	89	(16)	Summer
105	78	(7)	22	(2)	Winter
106	0	(0)	100	(4)	Summer
107	36	(10)	64	(18)	All Season
108	100	(5)	0	(0)	Winter
109	10	(1)	90	(9)	Summer
110	52	(11)	48	(10)	All Season
111	100	(9)	0	(0)	Winter
112	0	(0)	0	(0)	None
113	33	(7)	67	(14)	Summer
114	45	(17)	55	(21)	All Season
115	100	(3)	0	(0)	Winter

Appendix B2. Number of telemetered elk comprising each use area's subpopulation. Data are from elk captured in Region 6, below the Mogollon Rim, during summer trapping periods.

Area	Winter	Summer
	January-March	June-August
101	2	2
102	3	3
103	3	3
104	3	3
105	3	3
106	3	3
107	5	5
108	2	2
109	4	4
110	5	5
111	4	4
112	0	0
113	4	4
114	6	6
115	2	2

Appendix B3. Summer use by summer use area populations. Distribution of elk observations among summer (June-August) use areas used by elk that originated from a given summer use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of all summer observations, with the number of observations presented in parentheses.

Summer Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
101	50 (5)	109 40 (4)	106 10 (1)			10
104	89 (16)	105 11 (2)				18
106	24 (4)	109 53 (9)	110 18 (3)	107 6 (1)		17
109	41 (9)	101 23 (5) 107 5 (1)	106 18 (4)	110 14 (3)		22
113	61 (14)	114 39 (9)				23

Appendix B4. Winter use by winter use area populations. Distribution of elk observations among winter (January-March) use areas used by elk that originated from a given winter use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of all winter observations, with the number of observations presented in parentheses.

Winter Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
103	75 (12)	102 19 (3)	109 6 (1)			16
105	78 (7)	104 22 (2)				9
108	42 (5)	107 25 (3)	110 25 (3)	111 8 (1)		12
111	39 (9)	110 35 (8)	108 22 (5)	107 4 (1)		23
115	50 (3)	114 5 (3)				6

Appendix B5. Year-round use by all season use area populations. Distribution of January-March and June-August elk observations among use areas used by elk that originated from a given all season use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of the total January-March and June-August observations, with the number of observations presented in parentheses.

All Season Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
102	21 (6)	103 41 (12) 106 3 (1)	101 17 (5)	109 17 (5)	29
107	47 (28)	110 23 (14) 109 7 (4)	111 13 (8) 106 2 (1)	108 8 (5)	60
110	36 (21)	107 27 (16) 109 9 (5)	111 15 (9) 106 5 (3)	108 9 (5)	59
114	61 (38)	113 34 (21)	115 5 (3)		62

Appendix B6. Winter use by all season use area populations. Distribution of January-March elk observations among use areas used by elk that originated from a given all season use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of all winter (January-March) observations, with the number of observations presented in parentheses.

All Season Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
102	19 (3)	103 75 (12)	109 6 (1)		16
107	33 (10)	111 27 (8)	110 23 (7)	108 17 (5)	30
110	38 (11)	111 31 (9)	108 17 (5)	107 14 (4)	29
114	63 (17)	113 26 (7)	115 11 (3)		27

Appendix B7. Summer use by all season use area populations. Distribution of June-August elk observations among use areas used by elk that originated from a given all season use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of all summer (June-August) observations, with the number of observations presented in parentheses.

All Season Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
102	23 (3)	101 39 (5)	109 31 (4)	106 8 (1)		13
107	60 (18)	110 23 (7)	109 13 (4)	106 3 (1)		30
110	33 (10)	107 40 (12)	109 17 (5)	106 10 (3)		30
114	60 (21)	113 40 (14)				35

Appendix B8. Distribution of year-round elk observations among game management units (GMU) occupied by elk that originated from a given GMU. Data are from elk captured in Region 6, below the Mogollon Rim, during summer trapping periods. Observations are presented as percentages of all observations, with the number of observations presented in parentheses.

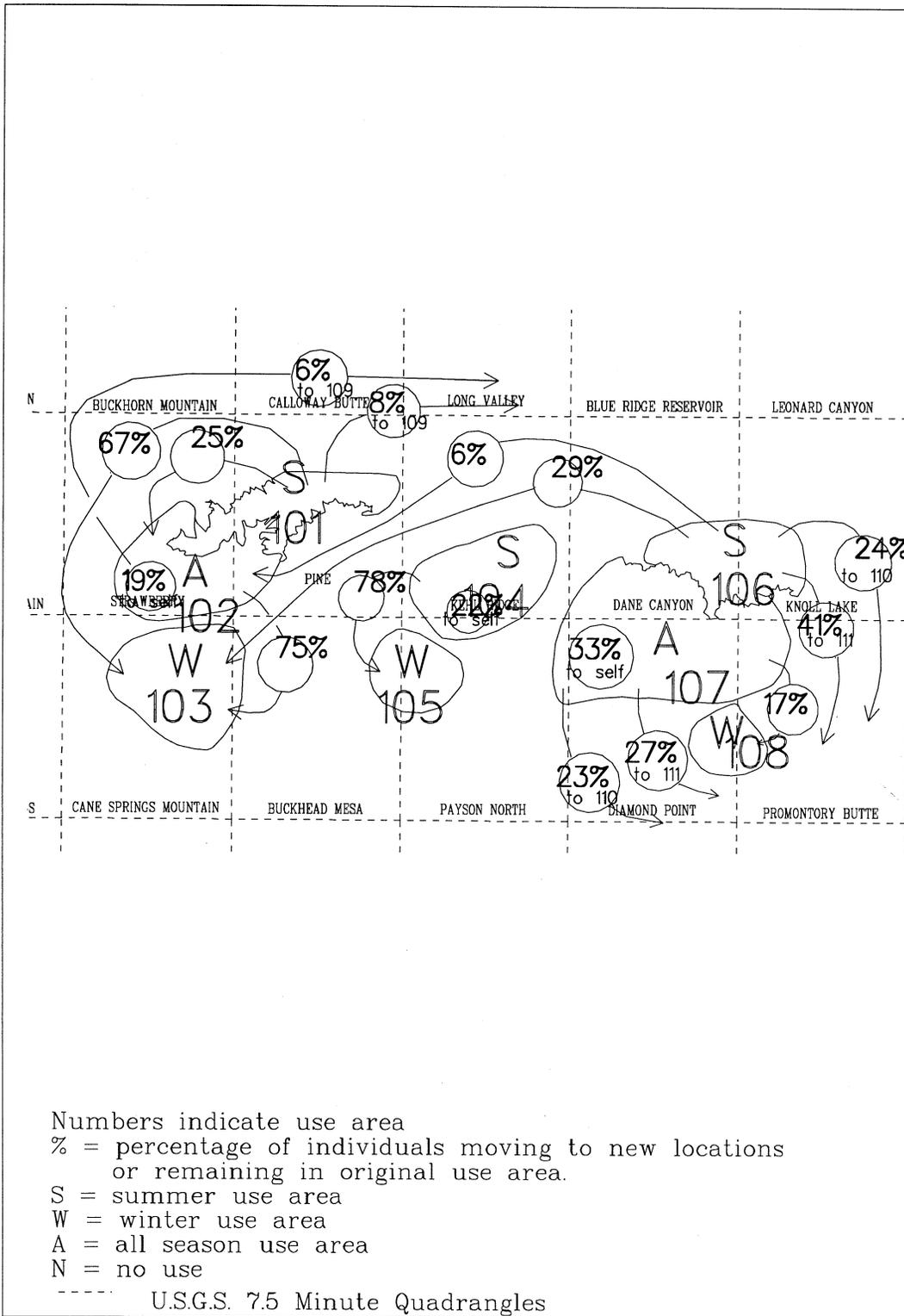
GMU	Self % (No.)	GMU % (No.)	GMU % (No.)	GMU % (No.)	GMU % (No.)	Total No. Locations
22	71 (170)	23 17 (41) 6A 3 (6)	4A 5.4 (13)	5A 4 (9)		239
23	59 (146)	22 20 (48) 3C 1 (2)	25/26 13 (32) 5A 1 (2)	4A 7 (16)		246
6A	13 (6)	22 60 (29)	5A 17 (8)	4A 10 (5)		48
25/26	26 (32)	23 72 (89)	3C 2 (2)			123
5A	10 (10)	22 32 (31) 6A 6 (6)	23 29 (28)	4A 22 (21)		96
4A	22 (21)	22 32 (31) 6A 6 (6)	23 29 (28)	5A 10 (10)		96
3C	4 (2)	23 92 (44)	25/26 4 (2)			48

Appendix B9. Fall Migration. Distribution of elk observations among winter (January-March) use areas used by elk that originated from a given summer (June-August) use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of all winter observations, with the number of observations presented in parentheses.

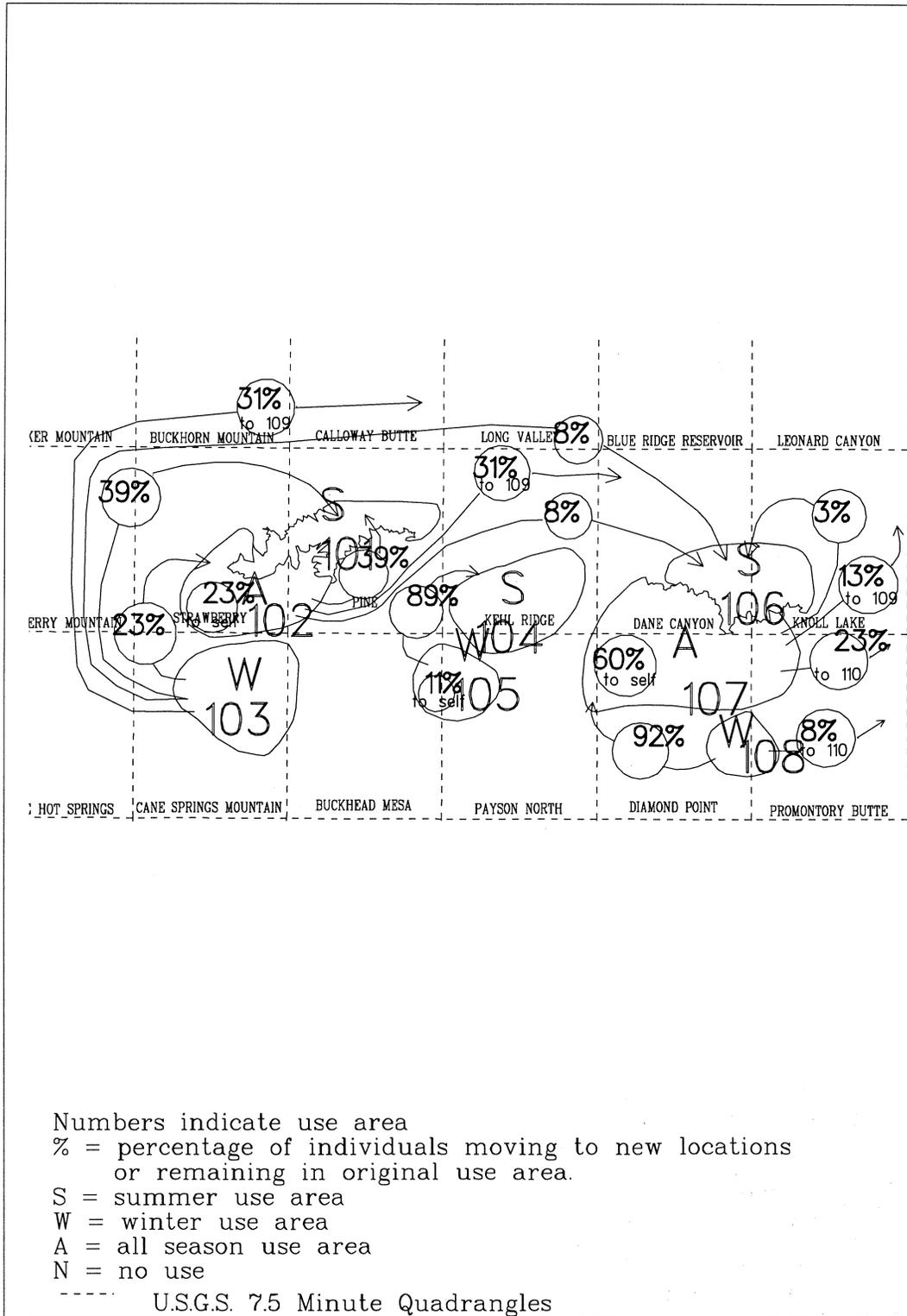
Summer Use Area	Area	% (No.)	Area	% (No.)	Area	% (No.)	Area	% (No.)	Total No. Locations
101	103	67 (8)	102	25 (3)	109	8 (1)			12
104	105	78 (7)	104	22 (2)					9
106	111	41 (7)	103	29 (5)	110	24 (4)	102	6 (1)	17
109	103 109	35 (8) 4 (1)	111	30 (7)	110	17 (4)	102	13 (3)	23
113	114	62 (13)	113	33 (7)	115	5 (1)			21

Appendix B10. Spring Migration. Distribution of elk observations among summer (June-August) use areas used by elk that originated from a given winter (January-March) use area defined by elk that were captured in Region 6 during summer trapping periods. Observations are presented as percentages of all summer observations, with the number of observations presented in parentheses.

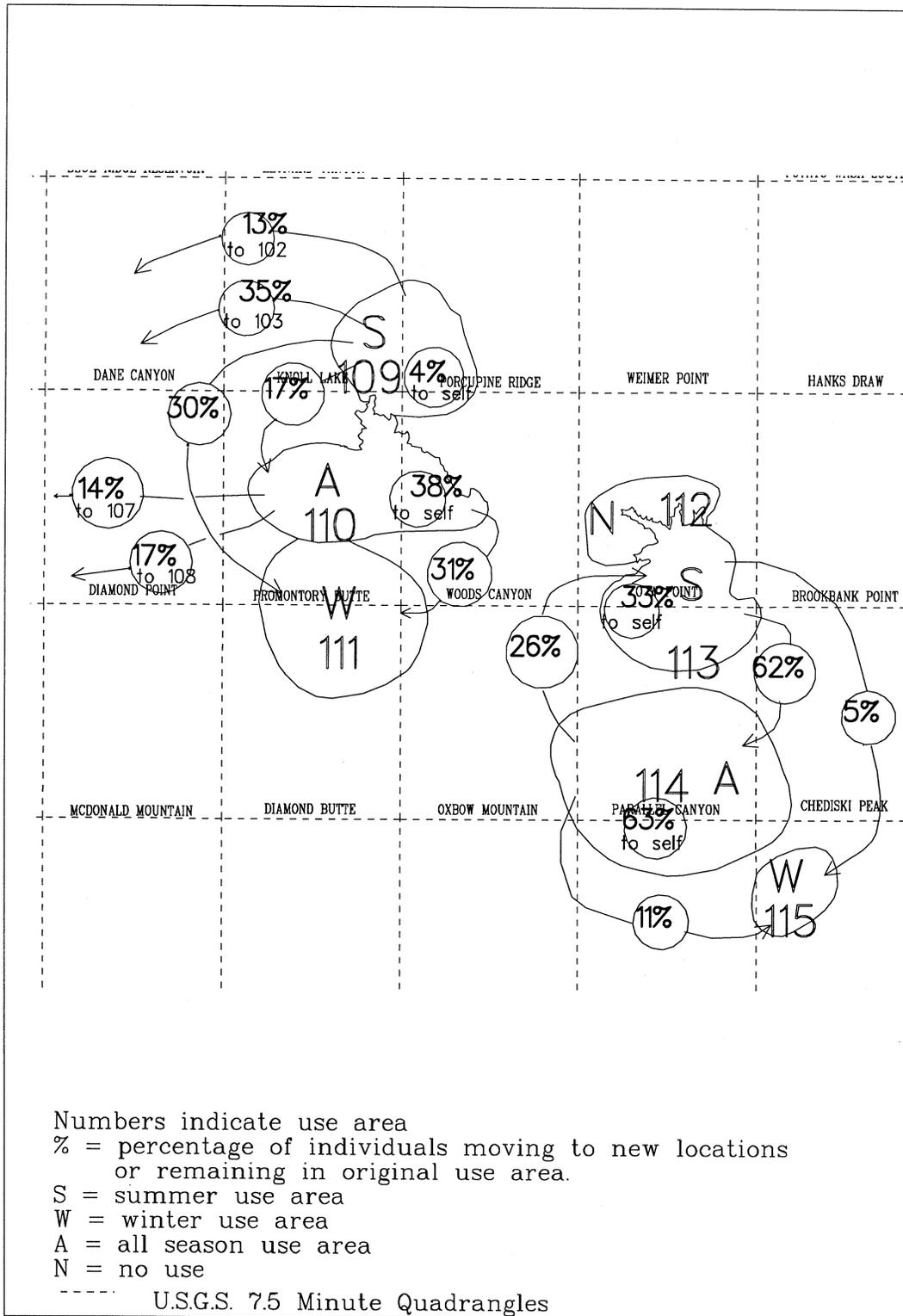
Winter Use Area	Area	% (No.)	Total No. Locations						
103	101	39 (5)	109	31 (4)	102	23 (3)	106	8 (1)	13
105	104	89 (16)	105	11 (2)					18
108	107	92 (11)	110	8 (1)					12
111	110	38 (9)	107	29 (7)	109	21 (5)	106	13 (3)	24
115	114	92 (11)	113	8 (1)					12



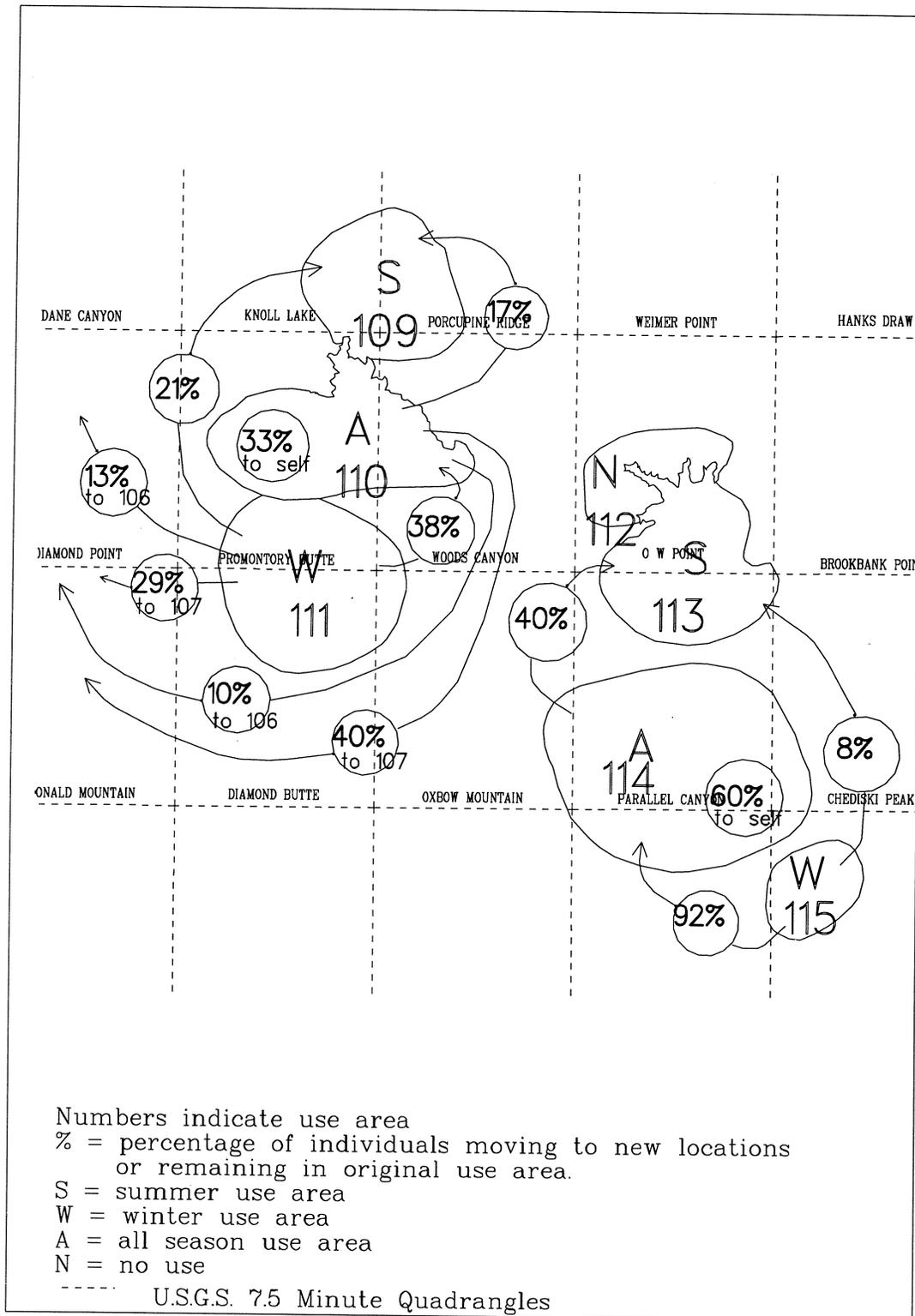
Appendix B11. Fall migration to winter use areas.
Source Appendices B6, B9.



Appendix B12. Spring migration to summer use areas.
Source Appendices B7, B10.



Appendix B13. Fall migration to winter use areas.
 Source Appendices B6, B9.



Appendix B14. Spring migration to summer use areas.
 Source Appendices B7, B10.

Appendix C1. Seasonal use area designation for use areas defined by elk captured on the White Mountain Apache Reservation and radio-tracked by Tribal Game Management personnel. Designation based on $\geq 67\%$ of elk location observations occurring within each use area during winter (January-March) or summer (June-August).

Area	Winter		Summer		Designation
	%	(No.)	%	(No.)	
116	100	(6)	0	(0)	Winter
118	0	(0)	0	(0)	None
131	100	(11)	0	(0)	Winter
132	0	(0)	0	(0)	None
133	100	(8)	0	(0)	Winter
134	0	(0)	100	(1)	Summer
135	100	(7)	0	(0)	Winter
136	0	(0)	0	(0)	None
137	100	(8)	0	(0)	Winter
138	100	(3)	0	(0)	Winter
139	100	(2)	0	(0)	Winter
140	100	(7)	0	(0)	Winter
141	100	(2)	0	(0)	Winter
142	100	(5)	0	(0)	Winter
155	75	(3)	25	(1)	Winter
156	0	(0)	100	(14)	Summer
157	36	(5)	64	(9)	All Season
158	0	(0)	100	(19)	Summer
159	0	(0)	0	(0)	None
160	0	(0)	100	(6)	Summer
161	0	(0)	100	(22)	Summer
162	67	(10)	33	(5)	Winter
163	0	(0)	100	(4)	Summer
164	982	912)	8	(1)	Winter
165	35	915)	65	(28)	All Season
166	29	(2)	71	(5)	Summer
167	100	(6)	0	(0)	Winter
168	25	(1)	75	(3)	Summer
169	50	(2)	50	(2)	All Season
170	0	(0)	0	(0)	None
171	100	(6)	0	(0)	Winter
172	100	(5)	0	(0)	Winter
173	100	(3)	0	(0)	Winter

Appendix C2. Number of telemetered elk comprising each use area's subpopulation. Data are from elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation.

Area	Winter January-March	Summer June-August
116	2	2
118	0	0
131	2	0
132	0	0
133	3	3
134	2	2
135	4	4
136	0	0
137	4	4
138	4	4
139	1	1
140	4	4
141	3	3
142	3	3
155	2	2
156	3	3
157	4	4
158	8	8
159	0	0
160	2	2
161	8	8
162	4	4
163	1	1
164	9	9
165	6	6
166	3	3
167	4	4
168	1	1
169	3	3
170	0	0
171	2	2
172	1	1
173	3	3

Appendix C3. Summer use by summer use area populations of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of elk observations among summer (June-August) use areas used by elk that originated from a given summer use area. Observations are presented as percentages of all summer observations, with the number of observations presented in parentheses.

Summer Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
134	10 (1)	156 50 (5)	163 40 (4)			10
156	93 (14)	155 7 (1)				15
158	54 (19)	161 20 (7)	156 14 (5)	157 11 (4)		35
160	60 (6)	161 40 (4)				10
161	55 (22)	158 20 (8)	160 15 (6)	165 10 (4)		40
163	80 (4)	134 20 (1)				5
166	33 (5)	156 33 (5)	161 33 (5)			15
168	60 (3)	169 40 (2)				5
156 158	76 (38)	161 14 (7)	157 8 (4)	155 2 (1)		50
134 160 161 163 166	73 (58)	156 13 (10)	158 10 (8)	165 5 (4)		80
134 156 158 160 161 163 166	88 (114)	157 3 (4)	165 3 (4)	155 1 (1)		130

Appendix C4. Winter use by winter use area populations of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of elk observations among winter (January-March) use areas used by elk that originated from a given winter use area. Observations are presented as percentages of all winter observations, with the number of observations presented in parentheses.

Winter Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
116	67 (6)	155 33 (3)				9
131	100 (11)					11
133	62 (8)	116 15 (2)	155 15 (2)	140 8 (1)		13
135	35 (97)	140 30 (6) 142 5 (1)	137 20 (4) 173 5 (1)	141 5 (1)		20
137	44 (8)	138 17 (3) 166 11 (2)	173 17 (3)	139 11 (2)		18
138	17 (3)	137 44 (8) 166 11 (2)	137 17 (3)	139 11 (2)		18
139	50 (2)	137 25 (1)	138 25 (1)			4
140	37 (7)	157 21 (4) 141 5 (1)	133 16 (3) 142 5 (1)	135 11 (2) 162 5 (1)		19
141	13 (2)	135 47 (7)	142 33 (5)	140 7 (1)		15
142	33 (5)	140 40 (6)	135 13 (92)	141 13 (2)		15
155	33 (3)	116 67 (6)				9
162	56 (10)	157 28 (5)	164 17 (3)			18
164	28 (12)	165 35 (15) 157 2 (1)	162 21 (9) 167 2 (1)	171 12 (5)		43
167	32 (6)	165 42 (8) 168 5 (1)	169 11 (2) 171 5 (1)	164 5 (1)		19
171	60 (6)	169 20 (2)	167 10 (1)	168 10 (1)		10
172	100 (5)					5
173	21 (3)	137 50 (7)	138 14 (2)	166 14 (2)		14
116, 155	100 (9)					9
131, 133	79 (19)	116 8 (2)	155 8 (2)	140 4 (1)		24
116, 131, 133, 155	98 (41)	140 2 (1)				42
135, 140, 141, 142	81 (56)	137 6 (4) 162 1 (1)	157 6 (4) 173 1 (1)	133 4 (3)		69

Appendix C4. (continued)

Winter Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
137, 138, 139, 170, 173	89 (48)	166 11 (6)			54
171, 167	48 (14)	165 28 (8) 164 3 (1)	169 14 (4)	168 7 (2)	29
162, 164	56 (34)	165 25 (15) 167 2 (1)	157 10 (6)	171 8 (5)	61

Appendix C5. Year-round use by all season use area populations of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of January-March and June-August elk observations among use areas used by elk that originated from a given all season use area. Observations are presented as percentages of the total January-March and June-August observations, with the number of observations presented in parentheses.

All Season Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
157	41 (14)	162 18 (6)	161 15 (5)	133 9 (3)	34
		158 9 (3)	164 6 (2)	140 3 (1)	
165	72 (43)	164 17 (10)	171 8 (5)	161 2 (1)	60
		167 2 (1)			
169	13 (4)	171 20 (6)	172 17 (5)	161 13 (4)	30
		165 13 (4)	168 13 (4)	160 7 (2)	
		167 3 (1)			

Appendix C6. Winter use by all season use area populations of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of January-March elk observations among use areas used by elk that originated from a given all season use area. Observations are presented as percentages of the total January-March observations, with the number of observations presented in parentheses.

All Season Use Area	Self % (No.)	Area % (No.)	Area % (No.)	Area % (No.)	Total No. Locations
157	29 (5)	162 35 (6)	133 18 (3)	164 12 (2)	17
		140 6 (1)			
165	50 (15)	164 30 (9)	171 17 (5)	167 3 (1)	30
169	13 (2)	171 40 (6)	172 33 (5)	167 7 (1)	15
		168 7 (1)			

Appendix C7. Summer use by all season use area populations of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of June-August elk observations among use areas used by elk that originated from a given all season use area. Observations are presented as percentages of the total June-August observations, with the number of observations presented in parentheses.

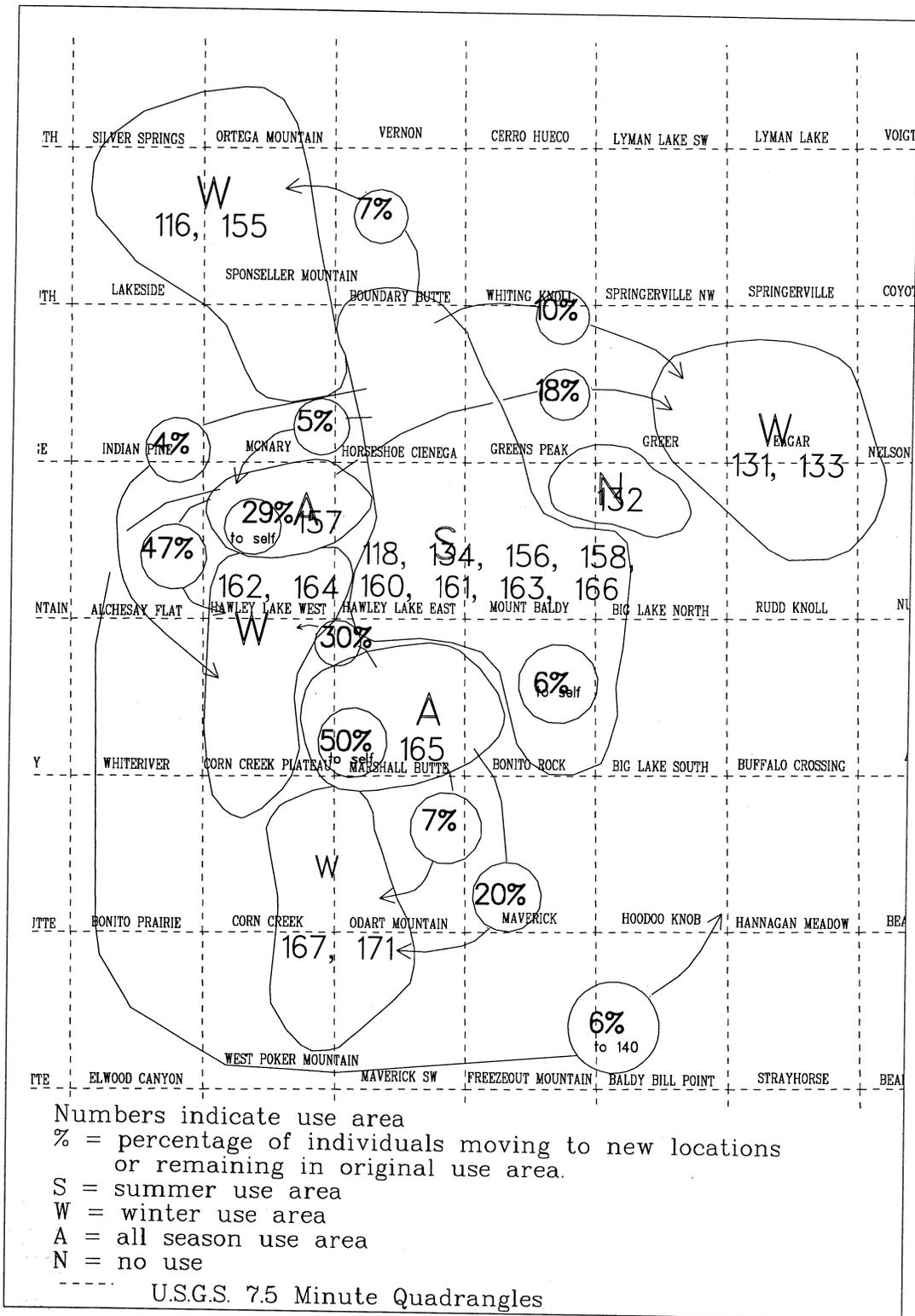
All Season Use Area	Self			Area			Area			Total No. Locations	
	%	(No.)	(No.)	%	(No.)	%	(No.)	%	(No.)		
157	53	(9)	161	29	(5)	158	18	(3)		17	
165	93	(28)	161	3	(1)	164	3	(1)		30	
169	13	(2)	161	27	(4)	165	27	(4)	168	20	(3)
			160	13	(2)						

Appendix C8. Fall migration of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of elk observations among winter (January-March) use areas used by elk that originated from summer (June-August) use areas. Observations are presented as percentages of all winter observations, with the number of observations presented in parentheses.

Summer Use Area	Area			Area			Area			Area			Total No. Locations																		
	%	(No.)	(No.)	%	(No.)	%	(No.)	%	(No.)	%	(No.)																				
118												0																			
134	140	50	(5)	166	20	(2)	137	10	(1)	138	10	(1)	10																		
	173	10	(1)																												
156	116	43	(6)	155	21	(3)	166	14	(2)	137	7	(1)	14																		
	138	7	(1)																												
158	133	21	(8)	135	18	(7)	142	13	(5)	167	11	(4)	38																		
	162	8	(3)											140	5	(2)	141	5	(2)	166	5	(2)									
	137	3	(1)																				138	3	(1)	157	3	(1)	164	3	(1)
	173	3	(1)																												
160	172	50	(5)	137	40	(4)	173	10	(1)				10																		
161	133	13	(5)	137	13	(5)	142	13	(5)	171	13	(5)	39																		
	172	13	(5)											157	10	(4)	135	5	(2)	139	5	(2)									
	141	5	(2)																				138	3	(1)	140	3	(1)	162	3	(1)
	173	3	(1)																												
163	140	100	(5)										5																		
166	137	31	(4)	138	23	(3)	139	15	(2)	166	15	(2)	13																		
	173	15	(2)																												
168	169	40	(2)	167	20	(1)	168	20	(1)	171	20	(1)	5																		

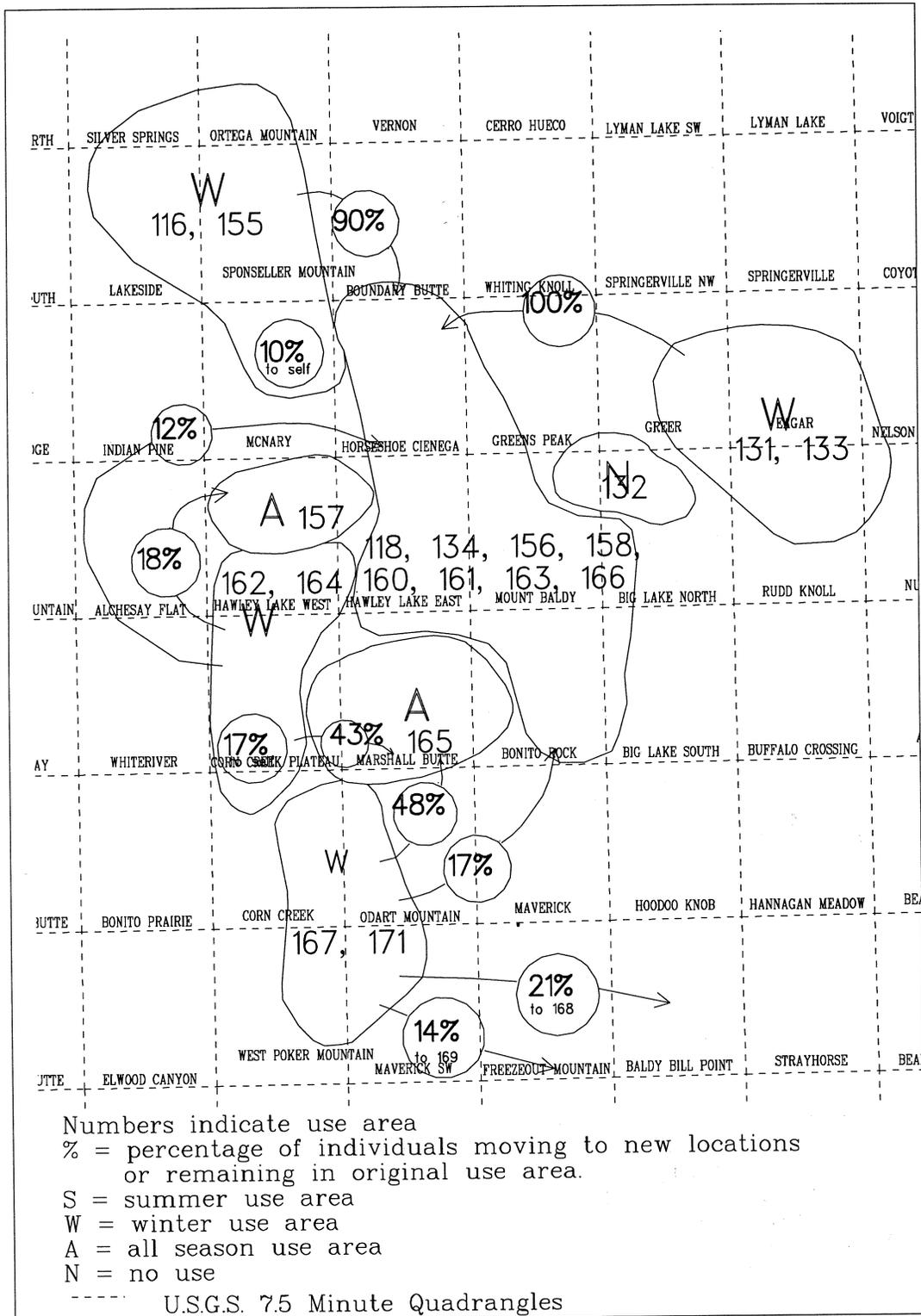
Appendix C9. Spring migration of elk captured and radio-tracked by Tribal Game Management personnel of the White Mountain Apache Reservation. Distribution of elk observations among summer (June-August) use areas used by elk that originated from winter (January-March) use areas. Observations are presented as percentages of all summer observations, with the number of observations presented in parentheses.

Winter Use Area	Area	%	(No.)	Total No. Locations									
116, 155	155	10	(2)	156	90	(18)							20
131, 133	156	42	(5)	158	42	(5)	161	17	(2)				12
116, 131, 133, 155	156	72	(23)	158	16	(5)	161	6	(2)	155	6	(2)	32
135, 140, 141, 142	158	37	(24)	161	34	(22)	163	18	(12)	160	6	(4)	65
	134	5	(3)										
137, 138, 139, 170, 173	161	30	(18)	156	25	(15)	166	25	(15)	160	20	(12)	60
162, 164	165	43	(28)	157	28	(18)	162	15	(10)	161	9	(6)	65
	158	3	(2)	164	2	(1)							
167, 171	165	48	(14)	168	21	(6)	158	14	(4)	169	14	(4)	29
	161	3	(1)										
172	161	60	(3)	160	40	(2)							5
173	156	33	(5)	166	33	(5)	160	27	(4)	161	7	(1)	15



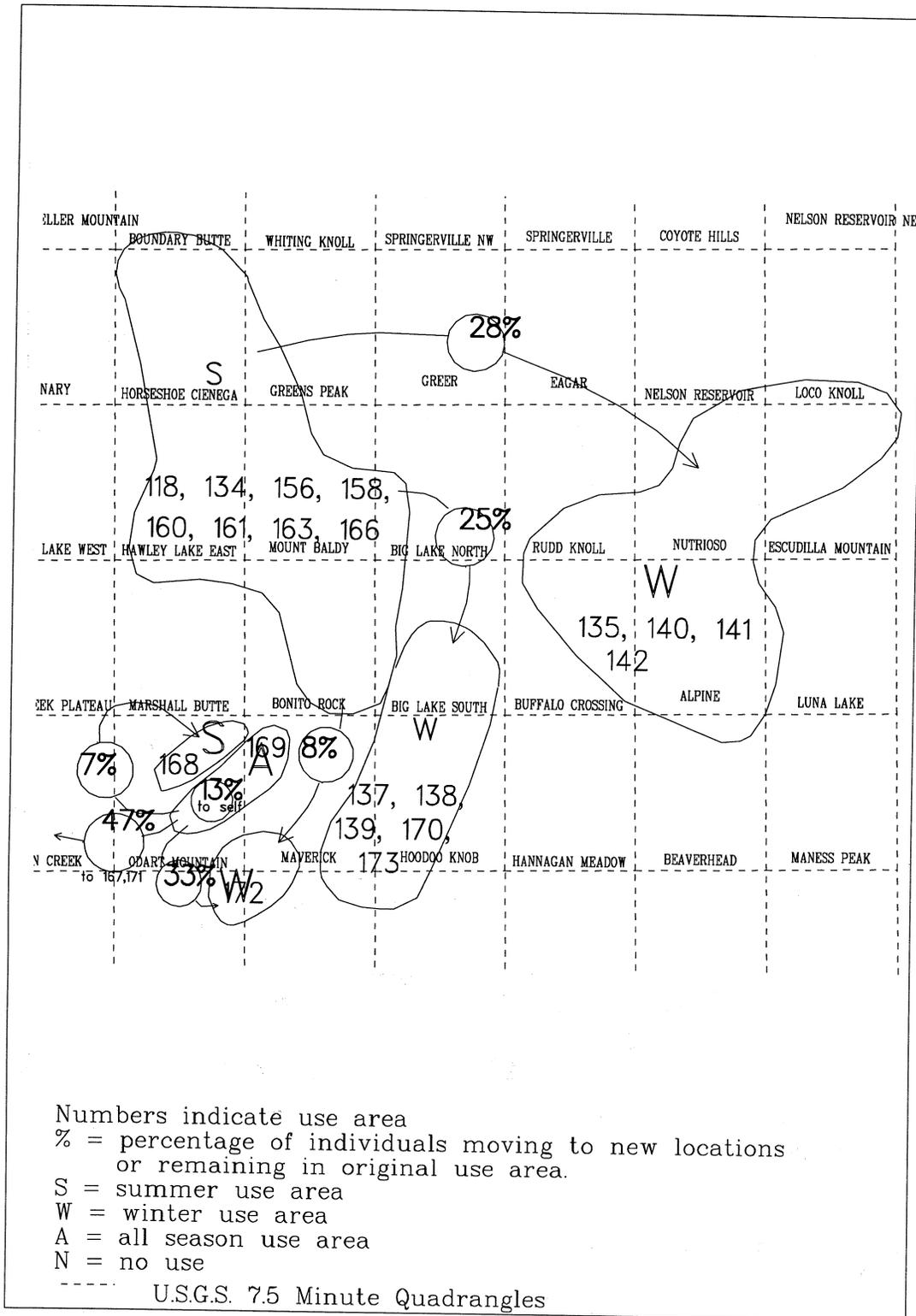
Appendix C10. Fall migration to winter use areas.
 Source Appendices C6, C8.

ELK SEASONAL RANGES AND MIGRATIONS

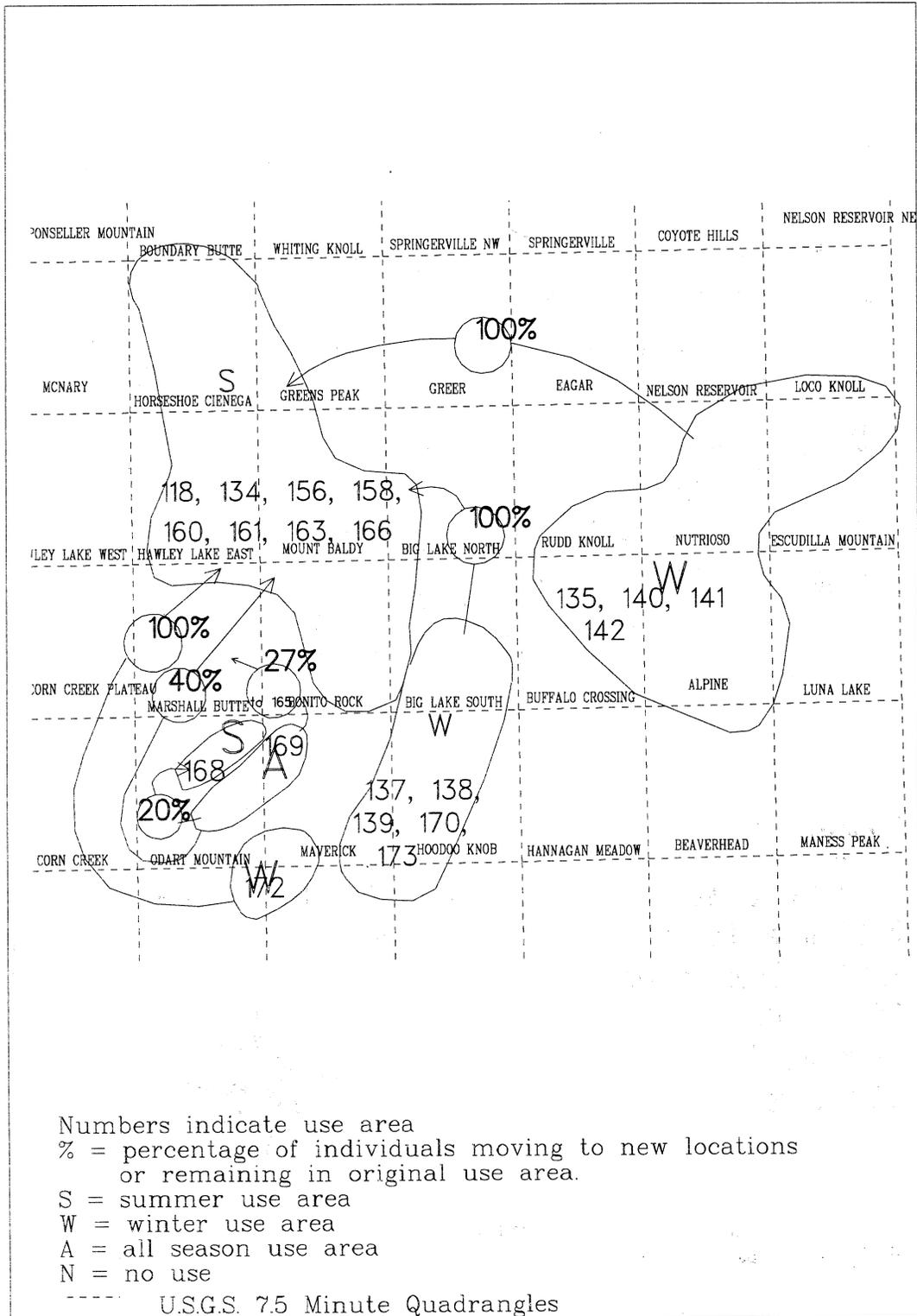


Appendix C11. Spring migration to summer use areas.
Source Appendices C7, C9.

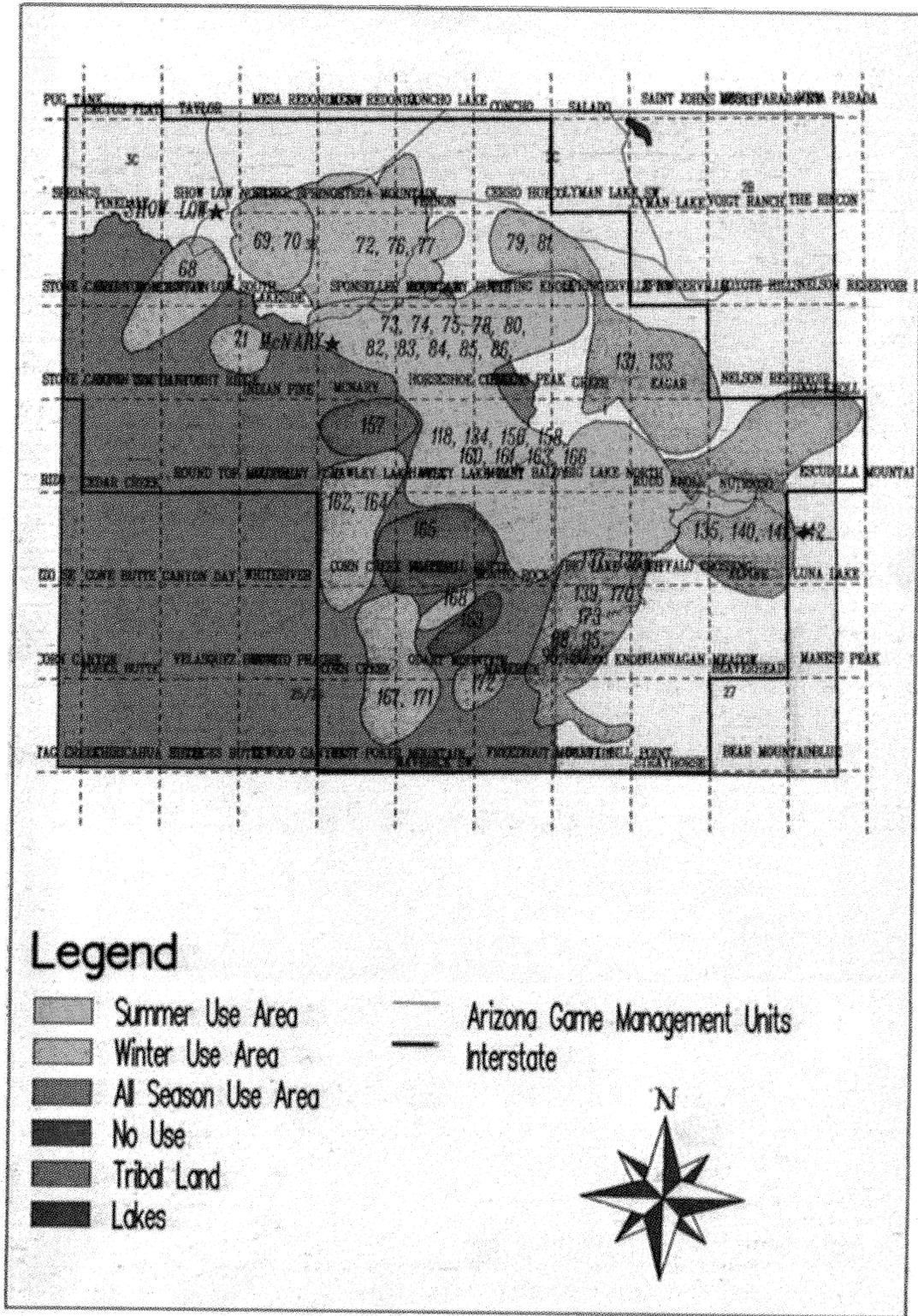
ELK SEASONAL RANGES AND MIGRATIONS



Appendix C12. Fall migration to winter use areas.
 Source Appendices C6, C8.



Appendix C13. Spring migration to summer use areas.
 Source Appendices C7, C9.



Appendix C14. Composite of Use Areas 68-97 from the main data set and Use Areas 116-173 from the White Mountain Apache data set.

NOTES

NOTES

Brown, R. L. 1994. Elk Seasonal Ranges and Migration in Arizona, Arizona Game and Fish Dep. Tech. Rep. 15. 122pp.

Abstract From 1985 to 1994, 360 (357 female, 3 male) elk (*Cervus elaphus nelsoni*) were radio-tracked from aircraft in Arizona at approximately 30-day intervals. Additionally, the White Mountain Apache Tribe provided us with data from 27 telemetered elk captured on their Reservation. Combined, the data from those elk provided home range and migration information on most elk herds within Arizona. Exceptions were populations occupying other Indian Reservations, and small herds at the western and southern periphery of the state's elk range. Mapped locations of radio-marked elk usually formed discrete clusters, the boundaries of which defined seasonal use areas; telemetered elk showed a high degree of fidelity to those areas. Subsequently, we defined individual elk populations that occupied each use area and determined the level of exchange with other areas. The levels of exchange were expressed as percentages. In this manner, migration patterns between use areas were determined and quantified. Elk movement across Game Management Unit boundaries was common. Exchange of individuals between Arizona Game and Fish Department Regions 1 and 2 appeared to be unimportant. However, exchanges between Region 6 and Region 1 and 2 occurred, and have management implications. Time and duration of migration were also documented. The degree of association between use areas was then examined to define herd unit boundaries, and fifteen herd units were identified. The implications of managing on a herd unit basis, and a management unit basis, are discussed.

Key Words: elk, *Cervus elaphus*, Arizona, home ranges, migration, use areas.

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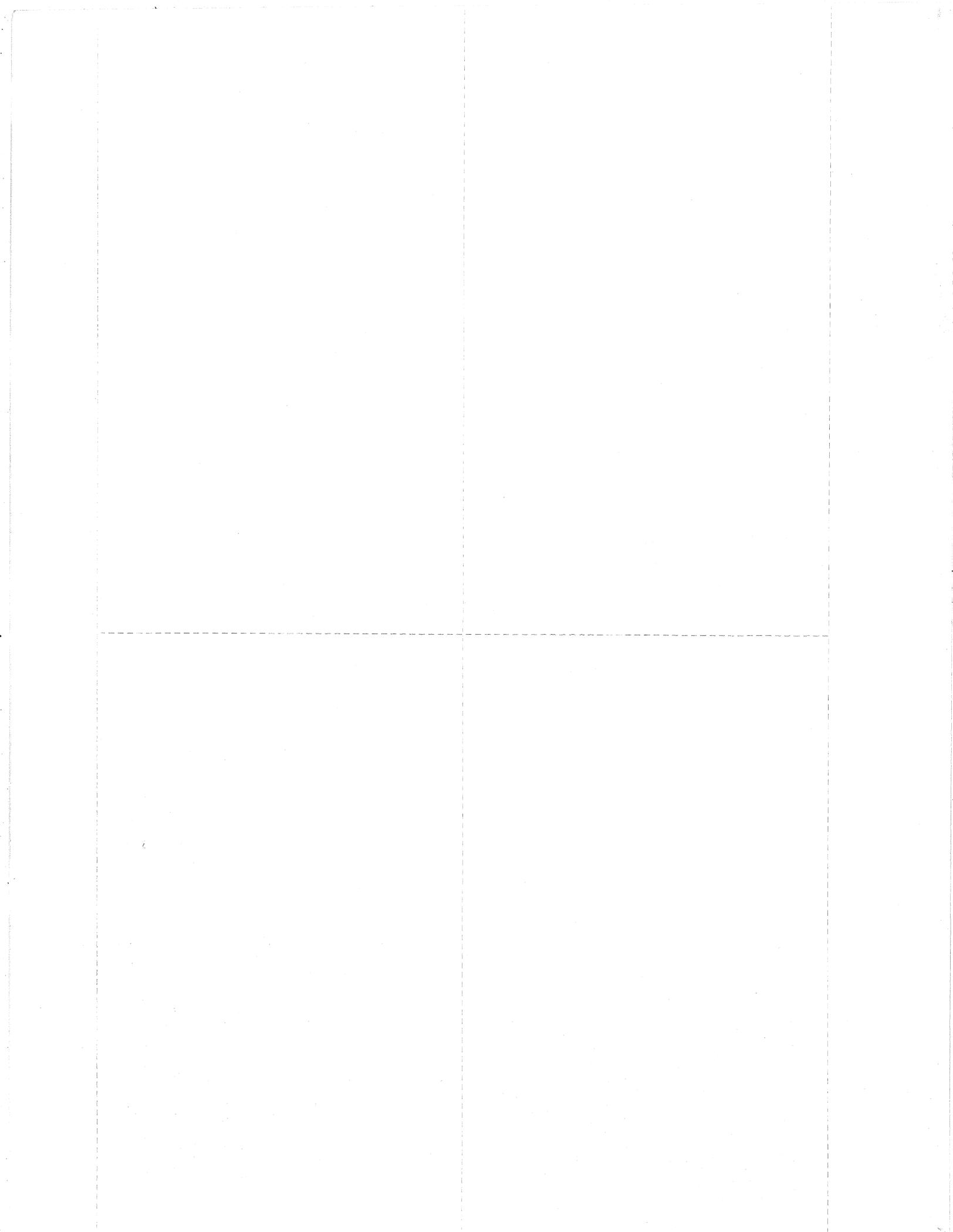
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Wes Keyes (Cover, Pages 9, 32, 67)



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