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RELATIONSHIP OF WEATHER AND OTHER ENVIRONMENTAL VARIABLES TO THE CONDITION OF THE KAIBAB DEER HERD

A Final Report

CLAY Y. McCULLOCH AND
RONALD H. SMITH
September 1991

FEDERAL AID IN WILDLIFE
RESTORATION PROJECT

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Two hunters at Fredonia who enjoyed unrestricted hunting of Kaibab deer about 1900. At that time "a group of men would go together with their team and wagon and bring back 10 or 15 and give to the people for their winter meat." (Unpubl. memoirs of Alfred Brooksby, 1969. 29 pp. Photo courtesy of Brooksby family and Fredonia Centennial Committee).

Relationship of Weather and Other Environmental Variables To the Condition of the Kaibab Deer Herd

Clay Y. McCulloch and Ronald H. Smith

Abstract: Physical vigor and productivity of the Kaibab deer herd tended to fluctuate positively with precipitation and negatively with high deer and livestock numbers during 1953-84. Prolonged ideal moisture conditions were optimal for maximum physical vigor and production of trophy age and younger bucks. The goal of sustained high rates of buck production is well served by moderation of ungulate numbers. Proper management of this deer herd requires maintaining ungulate populations within the capacity of the habitat. Prompt and flexible hunt and livestock management is essential to exploit the fluctuating conditions which weather imposes on deer production and herd size. The most useful management information are annual inventories of yearling buck weight and antler characteristics, and the summer fecal pellet counts considered with local precipitation records. Based on these weather and deer data, forecasts of relative changes in deer herd size would be accurate in most years in the long run, but may not be absolutely reliable for any given year.

INTRODUCTION

This bulletin deals with groups of Rocky Mountain mule deer (*Odocoileus hemionus*) which live on the Kaibab Plateau and adjacent areas as defined below, and are collectively known as the Kaibab deer herd. One purpose of this report is to describe searches for better management information to forecast proper harvest totals for the next hunting season. Improved data collection and analysis techniques led to efforts to learn if other kinds of information might be useful.

Statistical based evaluations were made of historical data from several indicators of well being of the deer population. Deer welfare indices (DWI) were correlated with weather and other natural phenomena which fluctuate from year to year. This method of appraising circumstantial evidence concerned several aspects of the premise that Kaibab deer populations tend to vary inversely with per capita food supply, and that survival rates therefore vary directly with food supply. An additional premise is that the food supply varies with precipitation and inversely with herbivore numbers. Among the hypotheses tested were those that changes in yearling production and deer herd size could be forecast from weather and deer data as early as 6 months before the hunting season.

A second major purpose of this bulletin was simply to present an update of Kaibab deer records. This deer population has fascinated hunters, biologists, naturalists, journalists, and others for most of this century. Rasmussen (1941) summarized existing data to about 1931, and Russo (1964) brought the account to 1961. Several things have happened since then that are of possible interest to Kaibab deer enthusiasts, who may wish to examine relationships not sought or reported here.

METHODS

Data Series

Although data collection for some records needed for correlation tests began as early as 1953, it was not appropriate to compare variables of certain classes for the continuous period of 1953-1984. Instead tests were grouped into several eras because of changes in deer and weather data which became available from time to time. For hypotheses involving weather, periods briefer than 10 years were judged to be too short to include normal recurrences of meteorological events, and the responses of deer to these events. For convenience in making calculations, all data used in correlation tests are in 1 series of tabulations (Tables 1-17).

Most variables compared in cross tabulations of results presented below are for periods ending in 1984 or earlier. The chief exceptions are tests involving animal unit months (AUM) of range forage use, many of which were carried through 1986.

Weather

Precipitation within Kaibab deer habitat (KDH) was recorded seasonally by the Arizona Game and Fish Department (AGFD) beginning in 1971 by means of precipitation storage cans at 9 stations at elevations of 5,650 to 6,500 ft around the base of the Kaibab Plateau (Fig. 1, Table 17). Although they did not directly show precipitation on deer summer range as defined below, these 9 stations provided the best available relative index of precipitation there and of deer habitat in its entirety. For some purposes precipitation records were also grouped as separate means of 3 west side and 3 east side stations only.

Earlier than 1971 there were no precipitation data available from within KDH, except for intermittent records of the National Oceanic and Atmospheric Administration (NOAA) stations at Bright Angel Ranger Station on the north rim of the Grand Canyon, and Jacob Lake, and occasional Forest Service fire season records. For 1953-1970, tests of association with deer variables used precipitation recorded outside of this study area, expressed as the mean of 3 or 4 stations, as they were intermittently available, 20 to 50 miles west of the Kaibab Plateau. They were the NOAA stations at Tuweep, Short Creek, Pipe Springs, Fredonia, and Kanab.

Days of snow cover 1 inch deep or deeper were tallied for sites on open level ground of west side intermediate winter range at 6,500 ft elevation. These data are an index of conditions which tended to encourage deer to concentrate at slightly lower elevations on the west side. Snow data do not indicate conditions for the east side, which sometimes had little or no snow cover when there was much on the west side.

Daily high and low temperatures during winter were recorded by drum-chart thermographs with 31-day clock drives and bi-metallic sensors. They were housed in standard wooden weather instrument shelters. One temperature station was at the Table Rock precipitation station on the west side and the other was on the east side at the Buck Farm precipitation station (Fig. 1, Table 17).

Monthly wind runs during winter were recorded by cup driven anemographs and anemometers at 30 ft above ground on treeless sites. One was at the Table Rock station and the other at Buck Farm station.

Population Estimates

For the period 1972-1986 estimates of deer herd size on summer range were derived from accumulation rates of fecal pellet groups on 3,736 circular plots of 100 ft^2 each. The permanently marked sample plots were cleared of droppings about June 10 and summer accumulations were counted about September 10 of each year. Most plots were in forest areas and were systematically spaced in grids of 24 plots per cluster which occupied an area of 1/8 by 1/2 mile. The exceptions were meadow clusters which were 1/8 by 1 mile and contained grids of 40 plots each.

Clusters had their long axes along roads in randomly selected land sections (1 mi^2). An average of 9 of the 153 clusters were temporarily unusable each year as a result of various disturbances such as timber harvest,

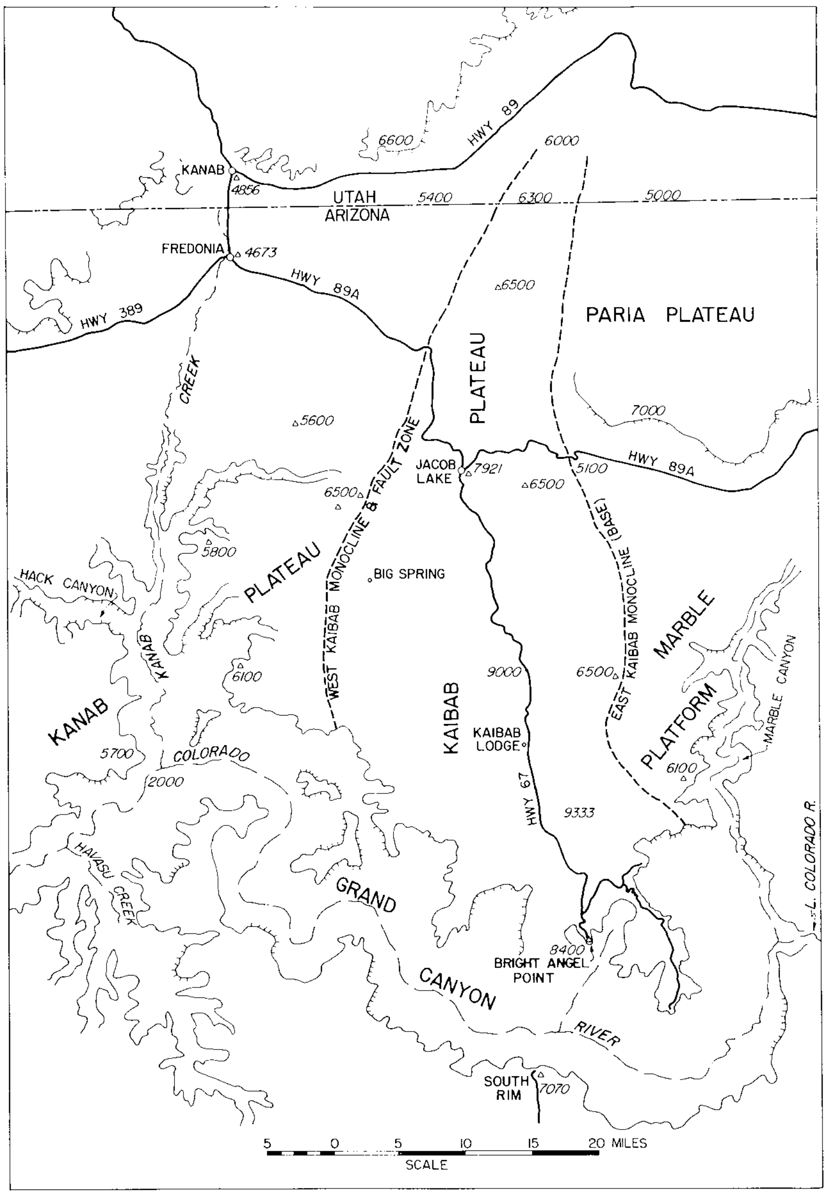


Figure 1
Kaibab Plateau and adjoining areas of Kaibab deer habitat. Triangle symbols show sites of precipitation recording stations.

blowdowns, or fires. Samples were stratified by tree overstory types and administrative jurisdiction of the land (e.g. pine type, National Park, etc.).

Groups of fecal droppings with fewer than 30 pellets were not counted and neither were groups with pellets of apple seed size, which were presumed to be from suckling fawns. During the first 2/3 of the accumulation period fawns were largely on a milk diet and their solid defecations were likely few and small and mostly eaten by their dams (Hirth 1985). Field estimates of fawn:doe ratios in late summer indicated that the fawn population was not completely weaned and foraging with does until 1 to 3 weeks after the end of the pellet accumulation sample period used for deer population estimates (Table 18). The pellet size class rejected from population calculations was smaller than the smallest observed on winter ranges, which are rarely occupied by suckling fawns.

Fecal accumulation rates were used to estimate deer population densities, exclusive of fawns, by assuming a defecation rate of 13 groups per deer per day, and projected according to extent of area of each sampled stratum. For the purpose of the population estimate this was defined as all areas on the Kaibab Plateau above elevation 7,200 ft, a total of 575 mi^2, and was obviously a conservative view of deer summering areas. The definition excludes ca. 30 mi^2 of pine with Gambel oak (*Quercus gambelii*) understory, where accurate pellet counts are not feasible, as well as pinyon-juniper (*Pinus edulis-Juniperus osteosperma*) and other areas where deer are present in summer.

Variance among clusters was calculated for each stratum and the total sample variance was weighted according to area of each type represented. The result made it possible to calculate confidence limits for the pellet accumulation rate. Fecal accumulation rates were also used to estimate summer herd size 1969-1971, but with different sample systems which precluded variance estimates. Estimates have been made of the Kaibab deer herd earlier than 1969 (Rasmussen 1941; Swank 1958; Russo 1964). Because of the differences in methods used to derive these estimates, it would be inappropriate to compare them with deer numbers reported here.

Deer Surveys

Field classification counts (deer surveys) of bucks, does, and fawns were divided into east and west groups for this report. East groups were those deer sighted east of Highway 67 and south of Highway 89A in hunt areas 8-11 (Fig. 2). West groups were those sighted in hunt areas 1-6, including animals seen from the hunt area boundaries which were Highway 67 and Forest Service road 461.

The pre-hunt deer surveys were done almost entirely along roads in summer habitat on the Kaibab Plateau by observers in motor vehicles. In most years, crews were small and effort occurred during the period September 25 - October 31 to permit coverage of major deer concentration areas. In some years most of the pre-hunt survey data were contributed by Forest Service and AGFD crews whose principal duty was some other kind of field work. Replication of survey effort was common on parts of the summer habitat. Pre-hunt surveys earlier than September 25 were excluded from correlation tests because of the bias against fawns noted above (see Population Estimates). Pre-hunt counts in northern hunt areas 7 and 12 (Fig. 2) and on Bureau of Land Management (BLM) land directly north of those 2 areas were too few to be considered separately, as were counts on southern parts of the habitat in Grand Canyon National Park (GCNP), but are tabulated in the category of all areas 1-12. In many years post-hunt deer surveys were not attempted on the east side, or when attempted they yielded too few observations for statistical testing when considered separately from the category of all areas 1-12 (Fig. 2).

As with pre-hunt surveys, post-hunt survey crews were usually too small to observe all parts of the winter habitat simultaneously. Instead, the area was covered on several different days and sometimes with interruptions of days or weeks between efforts. In some years, parts of the winter range were not surveyed at all due to impassable roads, especially in Hunt Area 1 south of Sowats Canyon and on the Gooseneck-Eagle Pass area (Fig. 2). In other years the main winter survey effort was postponed until January because it appeared that many of the deer had delayed their downward movement from the oak and woodland areas into the more open cover of lower elevation zones.

Winter surveys were done mostly in the open savannah cover type of Jumpup Pasture and other western portions of Hunt Area 2 (Fig. 2). The BLM portions of west winter range north of Snake Gulch were usually included in post-hunt deer surveys, but areas below the cliffs within the Grand Canyon and of Kanab Creek Canyon were not. All post-hunt surveys reported here were done by observers who traveled by motor vehicle, horseback, and on foot. Fawn:doe ratios are not reported for cases with fewer than 75 antlerless deer classified for a given time-place category. Even with these minor problems, survey data are a valuable tool in determining sex and age ratios assuming an adequate number of deer are surveyed.

Although deer survey crews were not organized for this purpose, it was possible in some years to compare estimates of fawn:doe ratios by different observers on the same target population. For this the crew reports were segregated into subgroups of 1 to 3 observers who had not traveled with nor reported with another subgroup of the crew.

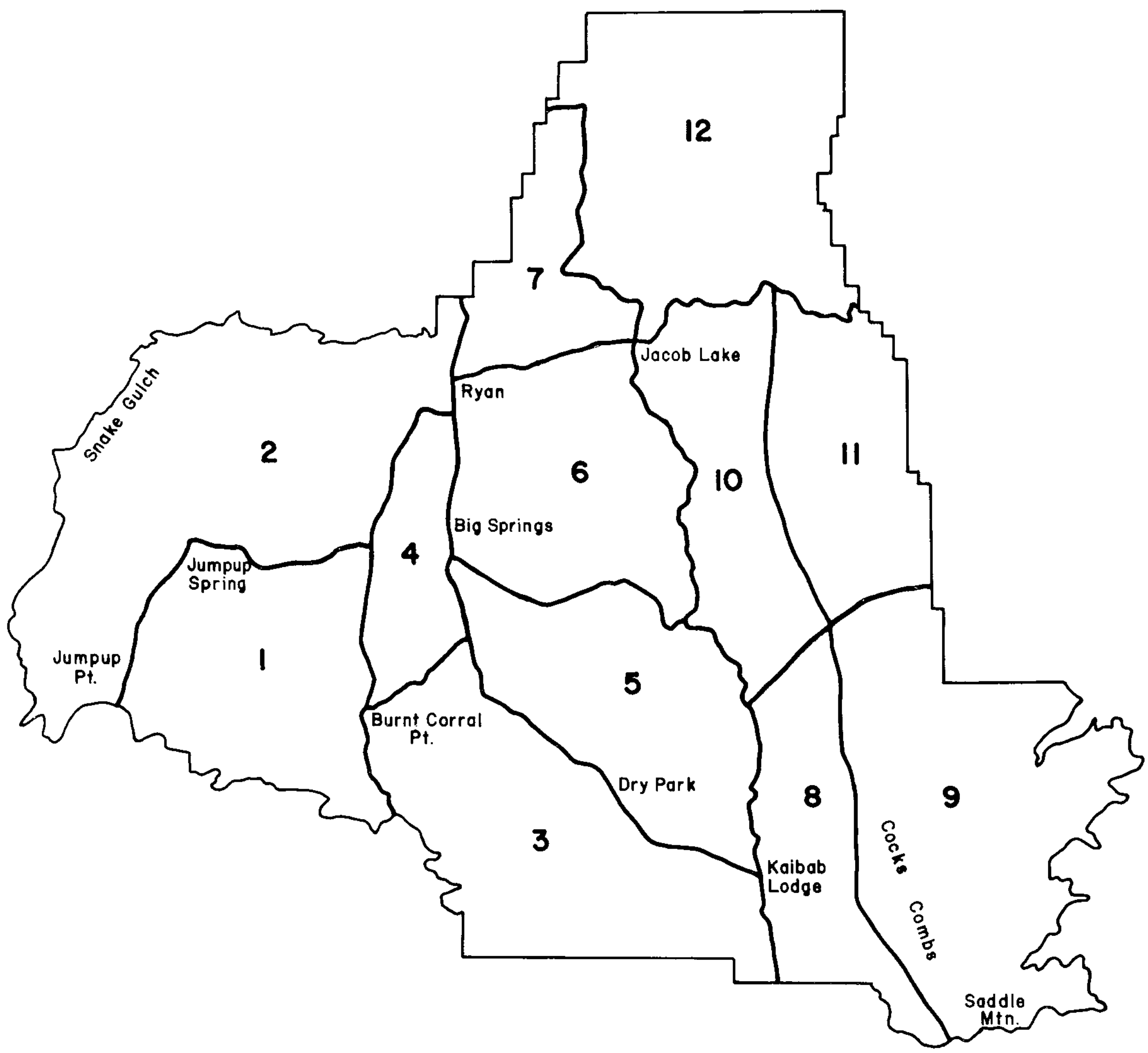


Figure 2
Hunt area subdivisions of Game Management Unit 12-A, Kaibab North Ranger District, Kaibab National Forest.

Physical Characteristics

All successful hunters were required to bring their deer carcasses to checking stations for inspection. About 98% of the hunters did so prior to 1976 as a result of strict check-in and check-out regulations for all hunters successful or otherwise. Thereafter the check-in requirements for hunters were discontinued, and we estimate compliance with the check-out requirement dropped to 80-85% in most years, by comparing mail questionnaire reports of hunter success with check station data.

Weight, antler, and age records of deer harvested by hunters were stratified by areas when possible. West groups were those deer killed in hunt areas 1-6 west of Highway 67, but excluding BLM areas north of Snake Gulch and the north end of the Kaibab Plateau (Fig. 2) East groups were taken in hunt areas 8-11 east of Highway 67. As with the field classification counts, harvest data from northerly hunt areas 7 and 12 were too sparse to be considered separately. GCNP was not hunted and so provided no harvest data. Some original check station records had been discarded by the time this compilation began, therefore many comparisons of east-west deer data prior to 1970 are not possible.

Ages were estimated for all buck carcasses brought to checking stations by tooth eruption patterns, tooth wear patterns, or cementum aging. Fawns and yearlings of both sexes were distinguished from each other and from older deer by tooth eruption patterns. Prior to 1964 most harvested does were not aged and available doe age data through 1963 are limited.

Age ratios of hunter harvested antlerless deer (fawns, yearling does, and older does) were not tabulated nor used here for time-place samples smaller than 50 such deer. The harvested fawn:doe ratios of 1953-1976 and 1985-1986 are interpreted as relative indices, but not as absolute estimates of fawns:doe. The harvested ratio of yearling does to older does, however, is taken here as absolute or nearly so. Presumably few hunters can or wish to distinguish age classes in their selection of does. A similar assumption was made by Robinette et al. (1957).

Before 1971 deer older than yearlings were aged only on the basis of tooth wear. These age classes were not usable for mean and variance comparisons of weights and antlers among years and areas. Beginning in 1971 deer older than yearlings were assigned annual age classes by examinations of cementum layers of incisors (Phelps 1978; Carrel 1980). Some original check station data were discarded prior to this project precluding calculation of yearling buck mean carcass weights for most years prior to 1965, and for weight variances before 1970.

Antler point counts excluded brow tines and points of less than 1 inch. "Cactus bucks" with grossly abnormal antlers were excluded from all antler data summations in this bulletin, but number of points is otherwise presumed to be an index of antler mass (Goss 1983). Antler spread data have been recorded and stored differently at different times and are not used here for any correlation-regression analyses. As explained elsewhere in this bulletin (Data Quality) the mean number of antler points per buck can not be calculated from the data available before 1970. The minimum sample size used for this report was 25 yearling bucks for the calculations of mean weights and antler characteristics. Due to the scarcity of data for bucks age 2, 3, and 4 years we chose to risk calculations with sample sizes as small as 10 bucks.

Recorded carcass weights were "hog dressed" indicating that front and rear body cavities were empty of heart, lungs, liver, and other viscera and with head, hide, and feet included (Schemnitz 1980). Colloquially, and in some Department files, this condition has been referred to as "field dressed," but actually represents hog dressed weight.

Instruments used for weighing at the Jacob Lake checking station were spring balances (1953-1959); wall mount beam balance (1960-65); hydraulic scales (1966-69); steelyard (1970); and platform beam balance (1971-1984). At the second checking station, which was in Houserock Valley, weights were taken by spring balances (1953-1965); wall mount beam balance (1966-1971); and platform beam balance (1972-1978). The Houserock Valley station was closed after 1978. Examples of confidence limits of weight and antler data for yearling and cementum age classes of bucks have been published (Barlow and McCulloch 1984); supplemental data are included here. Crews were not required to weigh carcasses of does and fawns, but this was done occasionally.

Hunt Phenology

Deer hunts within each year were classified phenologically because calendar dates and weather and migrational status of the deer affect certain aspects of hunt success and age composition of the buck harvest (Barlow and McCulloch 1982). Late hunts were those which had a substantial portion of the harvest on winter range below and outside of the forested habitat, when there was persistent snow cover on summer range during opening weekend. This was usually about November 15-20. Early hunts opened between October 10-November 14 and most of the harvest then occurred above the winter ranges. Scattered hunts occurred when most of the deer were in movement from timber areas to winter ranges. This third category is ignored for purposes of the correlation analyses attempted here; data were arbitrarily summed with what seemed the more appropriate of 1 of the other 2 hunt classes, early or late. In all hunts opening weekend typically finds 2/3 or more of the permitted hunters in the field and most of the deer harvest occurs during that part of the hunting season.

Diet

There have been several attempts to describe the Kaibab deer diet and most of those reports were borrowed and used here. Early observers tabulated the pooled results of rumen samples from different kinds of feeding areas or different seasons, or both (E. R. Hall 1925 unpubl. ms.; Wright and Arrington 1950). Their data were later stratified by time and site and retabulated along with reports of some later collections of rumen samples from winter habitat (McCulloch 1978). All have been condensed for the present bulletin.

More recently, analyses of deer fecal composition were done and are initially reported here. The laboratory work was contracted to Colorado State University and Texas Tech University which used techniques similar to those described by Hansen and Clark (1977). Winter deer habitat samples were from 50 pellet groups on each of several arbitrarily selected sites collected in late winter and early spring, 1977-1981. Age of fecal specimens ranged uncertainly up to 5 months. Lab examinations and reports were separate for each site for each year.

The collections of winter fecal samples were done along meandering routes in areas that ranged from 1/4 to 1-1/4 mi in diameter, depending on abundance of deer droppings in a particular part of the winter habitat. No pellets were taken from groups closer than 30 ft to each other.

Summer fecal samples were the current summer deposits on the permanent plots described above for the deer population estimates. Age of the summer specimens was therefore 3 months or less. For each of 5 summers, 1977-1980 and 1983, fecal samples were grouped by habitat types within which the sample size ranged from 10 to 51 per habitat type. For each site each year, and for both seasons, the lab analyses used a blend of all defecations, with each defecation represented by 1 pellet in the mixture. Each composite sample was examined at the rate of 100 microscope fields per site, except for the 1977 winter samples. For that period the inspections were at the rate of 20 fields per individual sample, 1 of which was taken from each of the 50 samples which represented a particular site.

Subjective rankings of annual abundance were attempted for mushrooms and acorns. These were cursory appraisals during field work that was being done for some other purpose. Years of irruptions of tent caterpillars (*Malacosoma* spp.) were determined by direct observation (1969-1984), and from Forest Service reports for earlier years.

Cliffrose (*Cowania mexicana*) twig use was estimated by actual measurements of linear amounts on tagged plants before and after each season of deer occupation of winter habitat (1953-1968). This is an index of absolute amounts of the browse removed by animals rather than the relative frequency of cropped twigs estimated by methods used in 1984 and later.

Ungulate Indices

Range forage use is expressed in terms of animal unit months (AUM), which is the theoretical amount consumed by 1 cow in 1 month, representing about 600 to 975 lbs of forage air dry weight (Stoddart and Smith 1943). For some years prior to 1962, the available grazing records listed only cattle numbers rather than AUM; a conversion factor of 1.32 AUM was then applied for half of the year for each head permitted. This was to adjust the estimate for the forage consumed by calves, which were not included in the grazing fees but were present on the range until they were sold in autumn. Deer use was calculated at 5 deer-months per AUM. A further and minor refinement was the factor of 1.2 to convert horse and mule numbers to AUM. The livestock use data presented here includes the herd of 100-200 buffalo which occupied part of the east winter deer habitat, with buffalo reckoned at 1 AUM per head per month. The estimate of the summer deer herd without fawns (POP) was considered as an index of deer biomass on summer range, assuming that use of forage by 1 deer for 5 months represented 1 AUM. That index (POP) further represented roughly the deer biomass including fawns on winter range during the winter immediately preceding the pellet count.

The livestock grazing records were provided by offices of the KNF in Fredonia and by BLM in St. George. They also provided records of vegetation changes such as logging and eradication of pinyon-juniper woodland.

Dates

Unless otherwise noted data represent the precipitation or grazing season or other event ending in the calendar year indicated. For example, "post-hunt survey 1962" refers to the hunt of November 1962, even though some deer classification counts may have been done in January 1963; and "winter 1983" refers to the winter ending March 31, 1983.

Wildlife habitat discussed here is described in all laws and contracts and administrative documents, and is physically measured in British-American units. The instruments used to describe the deer and other phenomena were also of that system. To avoid the awkwardness of bilingual communication with conversion to metric units, the observations are presented in their less cosmopolitan but original terms of miles, pounds, inches, etc. Plant names are according to McDougall (1973).

HABITAT DESCRIPTION

Topography

Landforms diversify the climate and vegetation and outline seasonal distribution of the Kaibab deer population. In this report "Kaibab Plateau" refers to that uplift as defined by Powell (1875) and later by other geologists (Huntoon 1974; Baars 1983). The deer inhabit not only the Kaibab Plateau but a larger adjoining area (Fig. 1, 3). The total encompassed could be as great as 2,031 mi^2 or as little as 1,086 mi^2, depending on arbitrary delineation of territory occupied by deer in winter (Russo 1964). The conservative view would exclude expanses of treeless terrain below the Kaibab Plateau and inner portions of the Grand Canyon where winter populations in most years have appeared to be sparser than 1 deer per mi^2.

Seasonal Ranges

The great majority of the deer within this defined area are seasonally migratory (Table 19). They spend the summer, which is the fawn birth and nursing season, and most of autumn above elevation 7,000 ft on the southern 3/4 of the Kaibab Plateau. In most years there have been substantial numbers of deer above that level as early as May 15 and as late as November 15. Evidence of downward movement off the Plateau has been noted as early as September and as late as January for a few deer. The upward spring migration is generally more abrupt, usually in May or late April, although deer have appeared on the forested Plateau as early as February. During the period 1978-1983 groups of radio collared deer generally remained on summer range from June 4 to October 28 (Haywood et al. 1987).

The greatest wintering area lies west of and below the Kaibab Plateau on a portion of

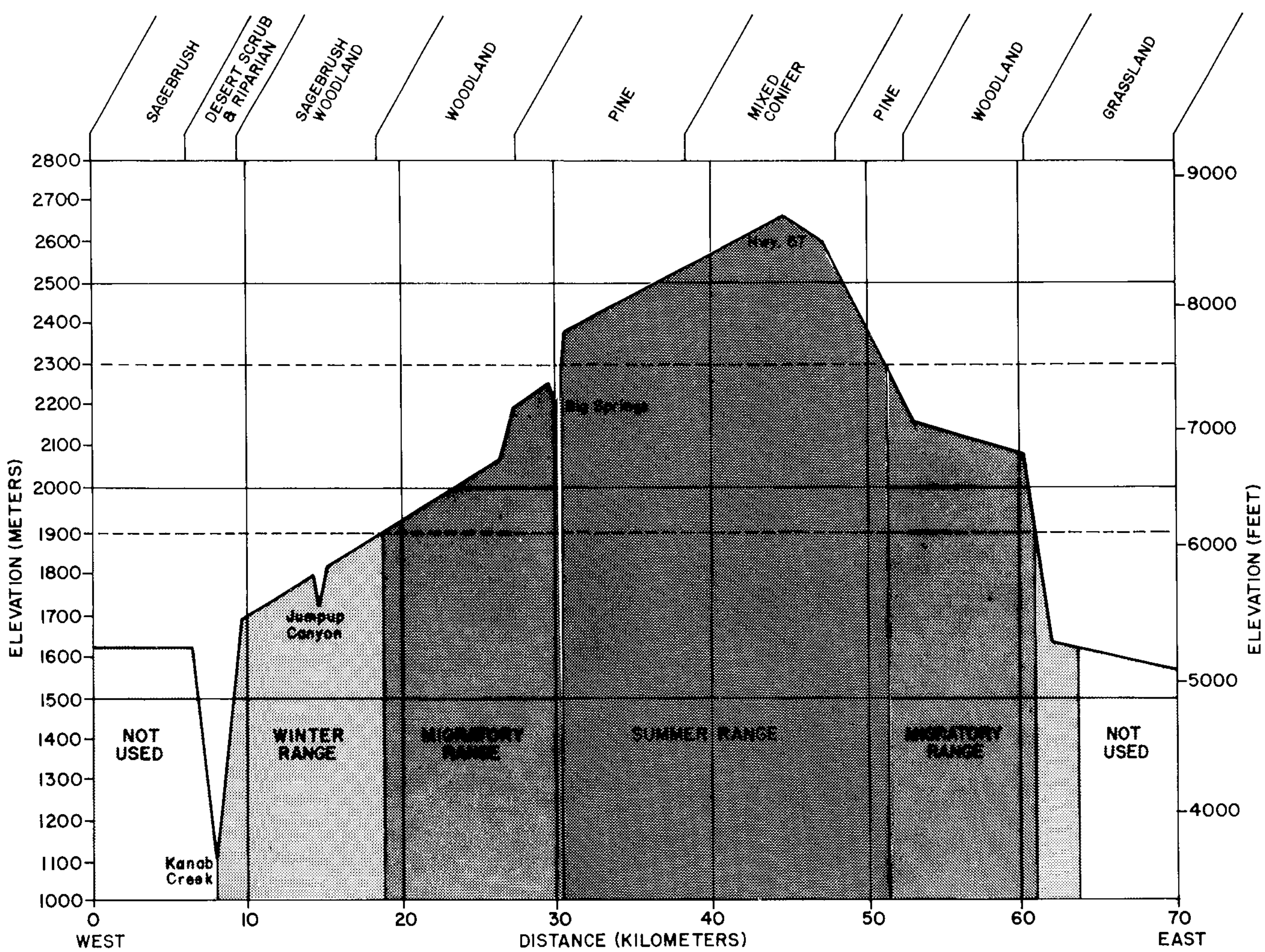


Figure 3
Biotic communities on west-east vertical profile through Kaibab deer habitat at Big Springs.

early as September and as late as January for a few deer. The upward spring migration is generally more abrupt, usually in May or late April, although deer have appeared on the forested Plateau as early as February. During the period 1978-1983 groups of radio collared deer generally remained on summer range from June 4 to October 28 (Haywood et al. 1987).

The greatest wintering area lies west of and below the Kaibab Plateau on a portion of the Kanab Plateau east of Kanab Creek (Fig. 1, 3, 4). The area within the cliff rimmed canyon of Kanab Creek is also part of that west winter range. However, the overall density of deer within Kanab Creek Canyon is much less than on the extensive area above and east of the cliffs. Some deer which use the area within Kanab Creek Canyon seem to be brief visitors rather than winter-long inhabitants. Tracks along the major trails through the cliffs indicate sometimes rapid, nonstop travels by deer between the streambed and areas above the cliffs. A few deer appear to winter on the Kanab Plateau west of Kanab Creek.

The other main winter range of deer which migrate from the Kaibab Plateau is on the lower slopes of the East Kaibab Monocline and a portion of the Marble Platform near Marble Canyon (Fig. 1, 3). Part of the main summer herd winters at the southern edge of the Kaibab Plateau in a narrow zone along the cliffs of the Grand Canyon. That guessed fraction of the herd is small (Table 19). Some descend into the Grand Canyon.

A small fraction, perhaps 5% of the animals in the outlined KDH elevations were below 6,000 ft during summer. These deer are likely a mixture of late upward migrants to summer range, early downward migrants, summer wanderers between the seasonal ranges, and some yearlong residents of those lower elevations. A doe with a spotted fawn was reported on Gooseneck Point at 6,000 ft on August 5, and another doe and fawn were reported on June 7 in Kanab Creek Canyon at 3,200 ft. Possibly they migrated to the Kaibab Plateau after fawns became large enough to travel. Haywood et al. (1987) reported upward migration of a doe with fawns that was delayed until July 25.

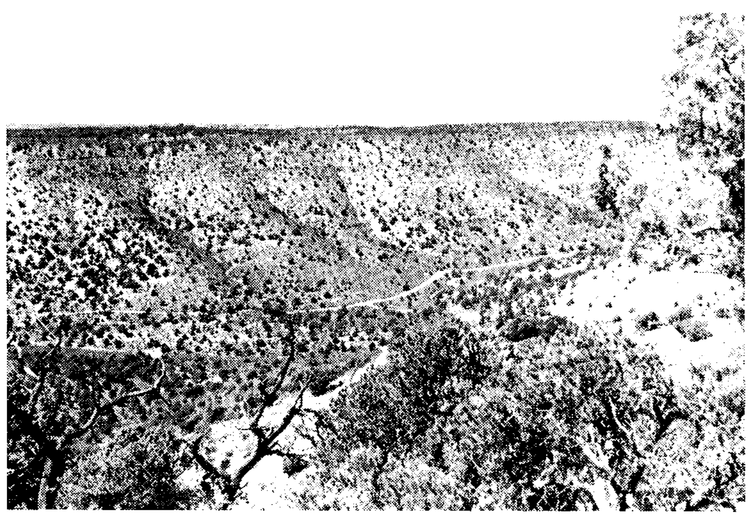


Figure 4
Winter concentration zone of deer has steep, south-facing slopes intersperesed with gentler slopes between the canyons which dissect the Kanab Plateau west of Kaibab Plateau. View at Jumpup Canyon elev. 5,700 - 6,000 ft.

Climate

The highest elevations of KDH receive about 3 times as much precipitation as the lowest. There are other obvious differences in seasonal and annual distribution of moisture within the habitat. They reflect various exposures of terrain to the 3 major sources of atmospheric moisture in this region. No 1 station adequately represents precipitation for the entire KDH (Table 20).

Most of the moisture in the KDH is delivered by the prevailing westerly winds (Sellers and Hill 1974), which are the principal source of cool season moisture, October-May. Evidence of a rain shadow appears in precipitation records at stations leeward from the summit of the Kaibab Plateau. At Houserock Trick Tank, for example, there was 38% less annual precipitation than at Table Rock Enclosure at the same elevation on the west side (1971-1984). Vegetation reflects this. The more xeric plant communities extend to higher elevations on the east Kaibab Monocline than on the terrain west of the Plateau. This vegetation condition is pronounced along the northern part of the Monocline, north of Tater Canyon, and less so south of there.

Westerlies also deliver some summer moisture, but much comes from southerly and easterly sources (Sellers and Hill 1974). One is humid air from the Caribbean-Atlantic region, from which develop frequent but brief and highly localized convective storms, typically in late afternoons (Fig. 5). The other summer source is great, anticyclonic tropical storms, remnants of which move into this area and produce widespread rainfall which persists for a day or 2 with each storm.

Precipitation on adjoining areas may be a useful, but not exact indicator of moisture deposited in deer habitat (Fig. 6-8). For example, records at Kanab sometimes indicated that summers were dry when they were not dry in the KDH, as indicated at Bright Angel (on Grand Canyon North Rim), Jacob Lake, and AGFD stations (Tables 7-13). Conversely, records for Grand Canyon South Rim failed to correlate with records for summers which did have unusually light precipitation on areas north of the Grand Canyon, as in 1921, 1925, 1947, 1965, 1974, and 1981.

The Kanab and South Rim stations, near but off the opposite ends of the Kaibab Plateau, showed less seasonal disparity in their winter than in their summer records. However, there were October-May dry periods which appeared more extreme at the South Rim than at Kanab, as in 1943, 1947, and 1951 (Fig. 8). Palmer Drought Severity Indices (PDSI) have indicated monthly as well as seasonal disparities between the regions which bracketed the deer habitat (Karl and Knight 1985). Strict interpretation of those

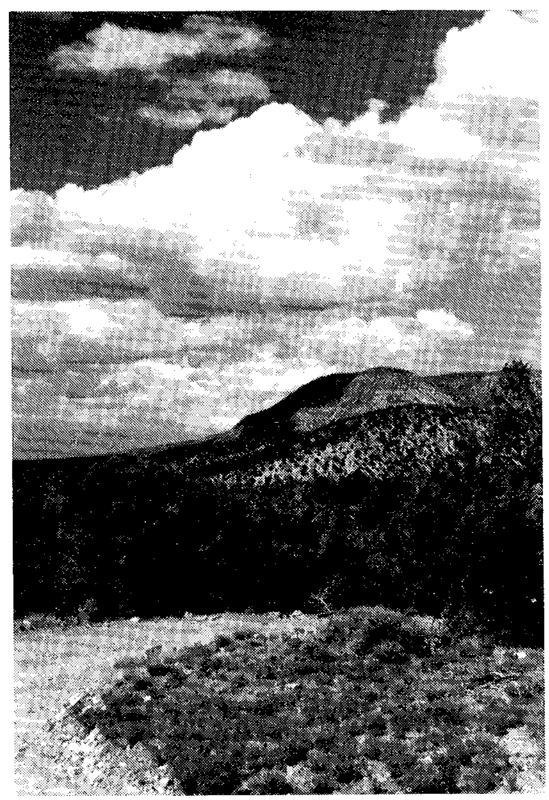


Figure 5
Sources of summer moisture developing above northern portion or the Kaibab Plateau, Buck Ridge Point.

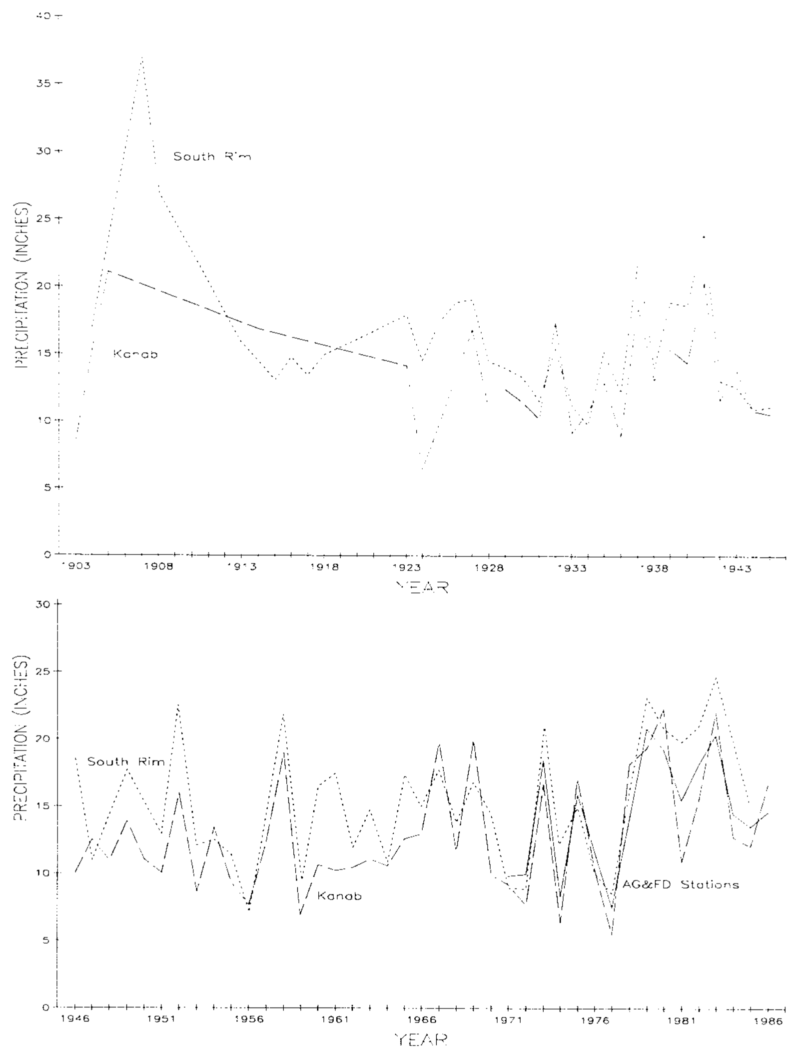


Figure 6
Water year (Oct - Sep) precipitation history at stations near and on Kaibab deer habitat.

indices to KDH was not recommended by those authors (Karl and Knight 1985). Extended wet periods near KDH seemed to occur less frequently than extended dry periods (Table 21).

Localized areas are typically most affected by drought within the KDH as well as on the adjoining region, especially in summer. For example, in 1984 there was a difference of 7.98 inches (123%) in rainfall at north and south parts of the deer summer habitat at Jacob Lake and Bright Angel stations (Tables 11, 12). Winter precipitation also was sometimes localized, as in the case of Sowats Point and Buck Farm weather stations where a difference of 7.56 inches (77%) occurred during October-May 1978. These precipitation patterns have apparent effects on the deer population and implications for hunt management, as discussed later in this report. Although drought, as it restricts forage growth, is a direct index of 1 source of stress for deer, there is another precipitation factor which is sometimes a direct and sometimes an inverse index of stress potential. That variable is snowfall at the elevations of deer winter range. In some years much of the winter precipitation in that zone is deposited almost entirely as snow, which is later useful for deer as it enhances forage growth the following year, but is immediately stressful as it covers food and makes it unavailable during the current winter. Winters of unusually deep, persistent, extensive snow cover below 6,500 ft have been noted during seasons ending in 1932, 1937, 1948, 1949, 1957,

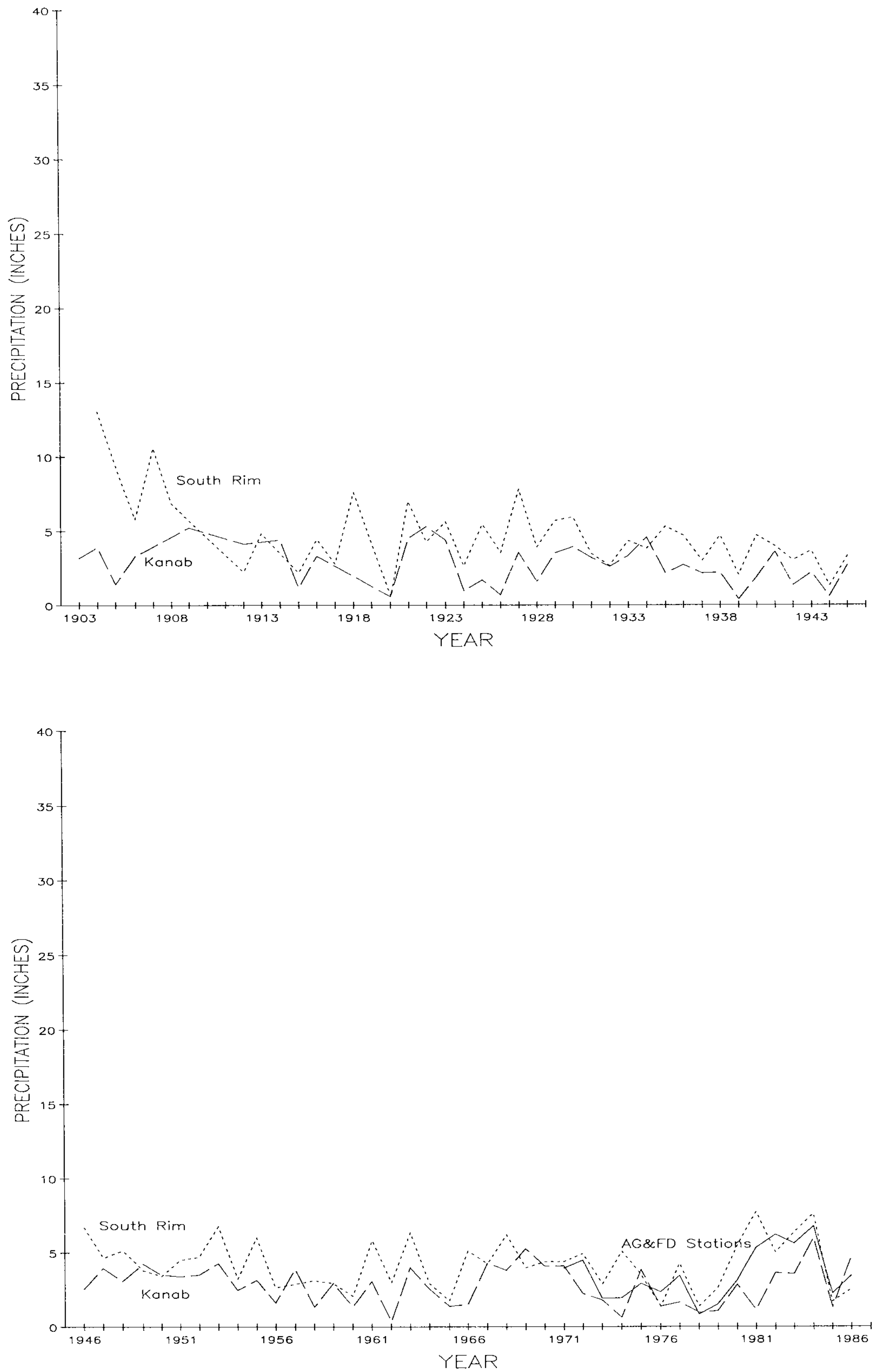
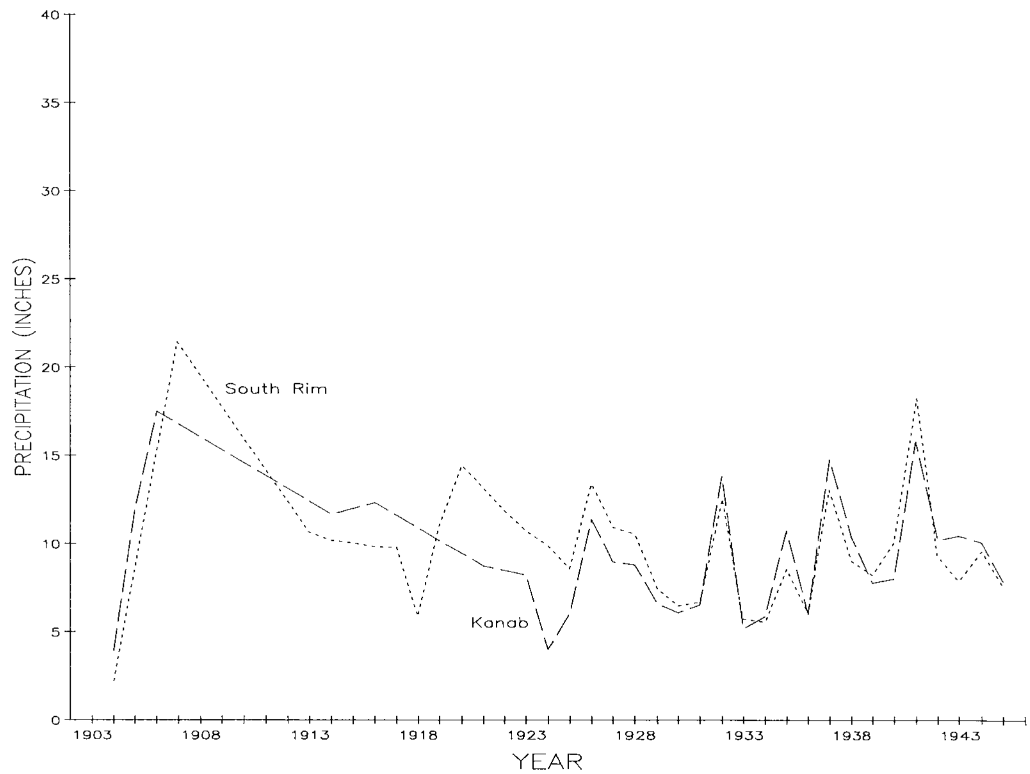


Figure 7
Summer (Jun - Aug) precipitation history at stations near and on Kaibab deer habitat.



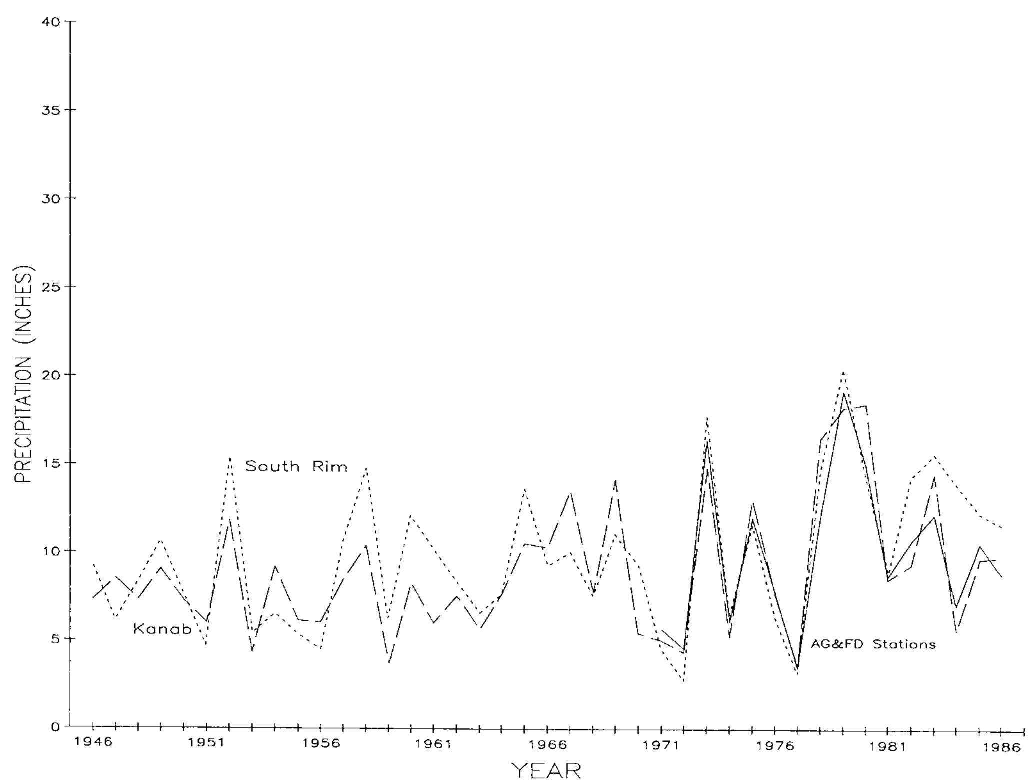


Figure 8

Cool season (October-May) precipitation history at stations near and on Kaibab deer habitat.

1961, 1962, 1973, 1975, and 1979. The recent period of 1980-1987 has been an unusual time of successive, mild, open winters for Kaibab deer.

When snow covers the deer food on the Kaibab Plateau there is obvious cause for migration from summer range. Rasmussen (1941) appropriately described the downward migration as abrupt and total for the deer population if persistent snow cover came early, but protracted and scattered if heavy snowfall delayed until late in the season. Haywood et al. (1987) studied the migration behavior of radio collared deer and found that early high elevation snowfall resulted in full migration.

Snow seems to be the chief factor which limits deer use within winter habitat. A complex of conditions of depth, firmness, duration, and extent of snow cover tend to separate different concentration areas of deer in winter (Fig. 3). There is a tendency for deer to avoid extensive areas which have the kind of snow cover which impairs the mobility they need for foraging, socializing, and avoiding predators. The preference for lower rather than upper parts of the winter range prevails among many deer even in open winters with little snow cover on the upper parts. This habit seems to be consistent since it was reported in the 1920s (Mann 1941; Rasmussen 1941).

The lowest mean daily temperatures recorded near the west and east bases of the Kaibab Plateau occurred during the December-January seasons of 1973 and 1979. Those were also the 2 snowiest winters of the period of available temperature records (Table 6). However, the lowest single daily temperature was -23 F recorded on January 3, 1971, during an unusually snow-free winter on west winter range at 6,100 ft.

Seasonal wind runs (miles/winter) differed as much as 80% among years at a given station (Table 6). It was not unusual for anemographs to record high wind runs in opposite directions on the same day at the 2 stations east and west of the Kaibab Plateau.

Vegetation

The forested region on the Kaibab Plateau is summer and fall habitat of the migratory members of the deer population whose topographic distribution was defined previously (Figs. 1, 3). The elevation zone of mixed conifer (*Pinus-Picea-Abies-Pseudotsuga*) and aspen (*Populus tremuloides*) trees, about 8,300 to 9,200 ft, supports greater deer densities than the pine type below it at 7,000 to 8,300 ft. Small areas of forest, generally less than 5 acres, dominated by mature aspen had greater rates of deer pellet accumulation than any other tree overstory type during June-September (McCulloch and Smith 1982).

A savannah of pinyon and juniper trees and sagebrush (*Artemisia tridentata* and *A.* spp.) (Fig. 3) has winter concentrations of deer from late November through March of most years. West of the Kaibab Plateau this type occurs from about 5,400 to 6,200 ft above and east of the cliffs which form the eastern rim of Kanab Creek Canyon. In years of high deer numbers, as in 1961-1963, densities equivalent to winter-long use of more than 150 deer/mi^2 occurred on parts of this savannah type (McCulloch 1963).

Above the savannah and below the forest area is an extensive woodland of pinyon-juniper (Fig. 3). This intermediate portion of the winter range receives 26% more precipitation and typically has lighter deer use than the more open sagebrush-tree type below. It also is typically a portion of the avoided snow zone mentioned above. Since 1954 about 1/4 of the native woodland area on the west side deer habitat has been cleared to improve grazing for cattle (Table 22).

Vegetation types of the east side winter range are arranged in the same vertical order as on the west. However, the savannah type is narrow along the north half of the East

Kaibab Monocline, and broad in the south as the Marble Platform rises gradually from grassland and sagebrush into a woodland zone (Fig. 3).

The forested summer range is more extensive than the savannahs where most deer winter. However, the summer range is smaller than the total of all areas occupied by deer at some time during winter. As noted above, the extent of winter deer habitat can vary greatly according to the observer's arbitrary delineation of the lower, outer boundaries. The relative size of and critical need for summer and winter habitat has been a topic of perennial debate in the process of management decisions on where and how to improve habitat.

A narrow zone of Gambel oak, (Brown et al. 1979) not shown on the diagram (Fig. 3), occurs within the lower pine forest and upper pinyon-juniper woodland areas. Many deer remain in the oak zone in late fall and feed on fallen acorns until snow covers the ground, as late as January in some years. Within the oak zone are extensive stands of another deciduous shrub, New Mexican locust (*Robinia neomexicana*).

Inner portions of the Grand Canyon contain warm desertscrub habitat (Warren et al. 1982). It extends northward up the canyon of Kanab Creek and merges there with cold desertscrub (Warren et al. 1982). Another vegetation component of KDH is the subalpine meadow (Brown et al. 1979), surrounded by mixed conifer forest. Those large meadows, including the ones traversed by Highway 67, supported less than 1 percent of the deer population as estimated by fecal accumulation rates in 1984. Some of those meadows are nevertheless famous for tourist viewing of deer concentrations, namely De Motte Park and Pleasant Valley.

Political Partitions

Administrative jurisdiction of the land (Table 19) does not conform with ecological units such as deer habitat. The 3 federal agencies managing the area, are the United States Forest Service (USFS), National Park Service (NPS), and BLM. Each has different policies which affect grazing, logging, and other causes of vegetation change. NPS land is closed to hunting, while the others are not. AGFD partitions the remainder of deer habitat outside the National Park into 2 Game Management Units, 12A which is administered by KNF portion, and 12B which is administered by BLM.

Logging of the virgin forest and artificial seeding, primarily with grasses, has altered most of the deer habitat in the period of 1946-1986, on the KNF portion of the Kaibab Plateau (Table 22). In contrast, the GCNP portion remains old growth forest. It is virgin in the sense that it is unlogged, but it is artificially changed by the suppression of natural wildfires from 1906 to 1979. Since 1980 prescribed burning in the GCNP has slightly reduced the acreage of the unnaturally dense understory of young trees that developed during the era of fire suppression. Further contrast results from vegetation differences that may have occurred with closure to grazing on the GCNP portion of the deer habitat beginning about 1920. Grazing on the KNF and BLM part of the habitat has been continuous since the 1870s.

FOOD

Variety

Evidence has provided an outline of the diets which influences the numbers and physical development of individuals of this deer herd (Fig. 9). Deer are mixed feeders, taking many different kinds of plants. Consumption of each particular food by this large group of deer has shown major changes from season to season, year to year, and from 1 part of the habitat to another (Tables 23-25). Diet composition fluctuates with the relative availability of the different foods, depending on weather

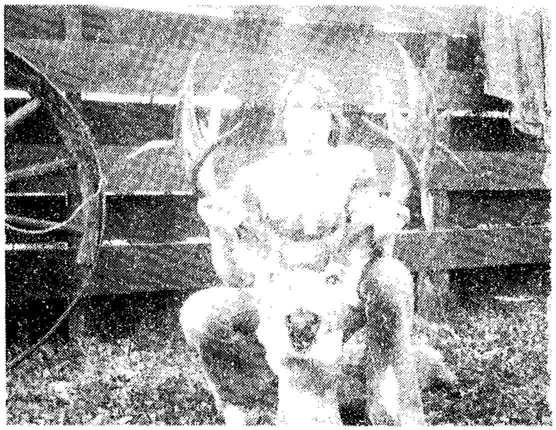


Figure 9
During years of abundant food supply bucks can develop trophy qualities at an early age. This one had dressed carcass weight of 208 lbs, antler points 9L x 8R, spread 34 inches, and was larger than average for its age of 3-1/2 years. Taken November 3, 1981 by S. R. Pratt in Hunt Area 7 near Big Saddle. (Photo Courtesy of R. O. Pratt).

and plant growing conditions, and the changing numbers of deer and other animals which eat the plants.

Winter

Small-leaved evergreen shrubs, chiefly sagebrush, provided much of the diet during most winters when food habits studies were attempted (Table 23). Native bunchgrasses appeared in rumens and in some fecal samples in large amounts. The grasses (primarily muttongrass, *Poa fendleriana*) identified in winter deer feces were cool season perennials which are green in winter (Fig. 10). The sampling technique did not distinguish species within the genus. Perhaps there were more *Poa* spp. in the diets than the samples indicated because the fecal technique has tended to underestimate amounts of that genus in deer diets (Gill et al. 1983). Warm season grasses such as *Bouteloua* spp. are not green in winter and were virtually absent from fecal samples, although they are commonly available to deer on winter range sites.

Figure 10
Mutton grass is a favorite winter food of cattle as well as deer. Fresh tracks indicated that this plant was cropped by cattle in Ranger Pass pasture (elev. 6,00 ft., March 1986); similar use of the grass was common in Horse Springs study exclosure and other areas occupied by deer

Deer distribution is further evidence of deer preference if not physiological need for a mixed diet. Despite the apparent importance of sagebrush as winter food, deer seldom concentrated on areas where it was abundant if there was a lack of other foods such as cliffrose or cool season perennial grasses.

Although it is 1 of the main winter foods taken by deer, cliffrose does not seem to be especially nutritious. During winter dormancy of the shrubs the evergreen leaves of sagebrush and cliffrose on Kaibab deer winter range had about the same crude protein content of 9% to 10% (McCulloch 1967). The content of cliffrose twigs was only 6%. Since deer normally eat fibrous and less digestible twig material as a consequence of consuming the leaves of cliffrose, the mean protein content is likely to be lower for total ingested cliffrose than for ingested sagebrush browse. Sagebrush is normally eaten with minimal intake of stem material. Nutrient content other than crude protein in cliffrose leaves is not known for this area.

Sagebrush may provide more nutritious food for deer during the latter part of winter for another reason. Spring growth increases the nutritive content, especially that of protein and phosphorus, in shrubby foods of deer (Swank 1958). Winter dormancy of sagebrush tends to end in March; sometimes in February, a month or so before growth starts on cliffrose at the same site, so sagebrush may be the higher quality food at that time. There are some forms of sagebrush which deer may distinguish as better forage than others, but are not readily distinguished on any basis by range technicians and botanists.

Phenological changes in nutrient content of winter forage plants are among likely stimuli for the upward migration of deer from their winter habitat in April and May. The movement typically coincides with maturation of muttongrass at elevation zones occupied by deer in winter. The early growth stage of muttongrass, available to deer before the spring migration, is important as judged not only by the diet estimates (Table 23), but by the common occurrence of grass clumps cropped in late winter. The grass at that time has high contents of crude protein and phosphorus (Morgart et al. 1986). These are essential for deer growth and antler development (French et al. 1956; Magruder et al. 1957; Goss 1983), but the nutrient values in muttongrass decline as it reaches the flowering and seed stage (anthesis) about April and May of most years. The new growth of cliffrose, which does not begin until about that time, is not a sufficient attraction to hold deer on the winter habitat despite the normal springtime increase in nutritive content (protein and phosphorus) which is typical of shrub species in general (Swank 1958).

Summer Diets

The 2 main reported components of the Kaibab summer deer diet have been leaves of aspen (Fig. 11) and, in aggregate, a dozen or more species of herbaceous plants characteristic of the forest understory (Fig. 12, 13; Table 24). This generalization is based on estimates of rumen contents in the 1920s and 1940s (McCulloch 1978), and on feeding minutes studies in the 1960s (Hungerford 1970). These reports agree with subjective impressions of cropped plants observed in the field at sites where deer sign was more prevalent than livestock tracks and droppings. Pellet accumulation rates showed a significant affinity of deer for sites where aspen browse was available, and rates increased with the abundance of aspen foliage (Fig. 14) (McCulloch and Smith 1982). However, this study of association did not include other kinds of food available on those sites. The places with 15-year histories of consistently high pellet counts characteristically had a pattern of food and cover distribution that was presumably preferred by deer. There were typically several distinct tree age stands and other forms of vegetation closely mixed as small patches of each type within an area 100 to 150 yards in diameter.

Figure 11
High-lining of small aspen trees has been a widespread condition only during eras of high deer numbers. KNF 8,100 ft., June 1987.

The fecal analysis studies during 1977-1983 (Table 25) surprisingly failed to show aspen as an important item in the summer diet of deer as indicated by samples collected from several hundred square miles of forest habitat in 5 different summers. This scarcity of aspen in the samples may have been due to the fact that digestion destroys most of the identifying features of aspen leaves, as demonstrated in the laboratory (Brigid Holland, pers. comm.). Apparent content of aspen was


(a)
(b)

Figure 12
These and many other species of herbaceous plants are important foods of deer on summer range.

as great as 52% in 1 series of fecal samples (Hansen and Lucich 1978) which were collected in 1977 separately from the other 1977 summer samples reported here (Table 25). It was later judged that some unknown item may have been mistaken for aspen in that unique series (T. Foppe, pers. comm.).

Native legumes such as lupine (*Lupinus* spp.), lotus (*Lotus* spp.) and milkvetch (*Astragalus* spp.), and other forbs such as wild-buckwheat (*Eriogonum* spp.) and penstemon (*Penstemon* spp.) were prominent among herbaceous foods in summer deer diets (Tables 24, 25). The feeding minutes study reported more grasses than did the rumen and fecal techniques, and indicated that the diet can change abruptly at different times during the summer (Hungerford 1970).

Rumen and fecal samples collected in large montane meadows more than 200 yards wide, such as De Motte Park, contained high percentages of plants typical of forest rather than meadow vegetation (Hansen and Lucich 1978; McCulloch 1978). Small, narrow meadows in the bottoms of ravines within the forest appear

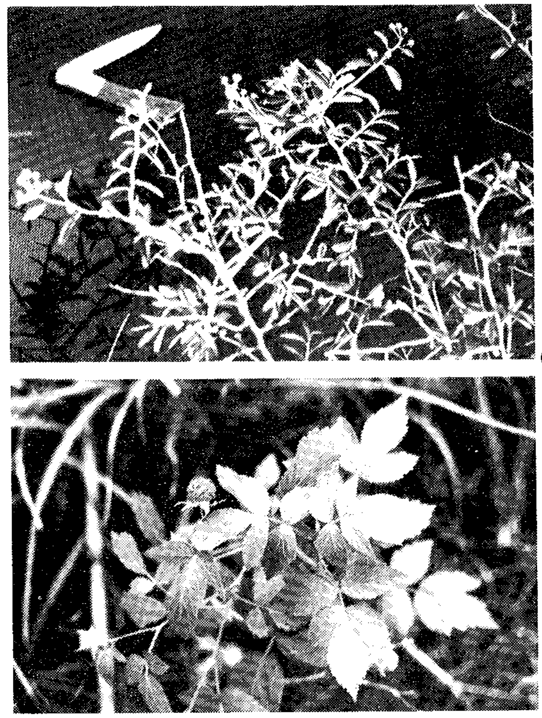

(a)
(b)

Figure 13
Shrubby browse species contribute with herbaceous plants and aspen foliage to feed deer in summer. (a) Fendler ceanothus; (b) raspberry.

to be important food sources, as are the edges but not the main portions of the large meadows. The latter, as sampled at Dry Park, Pleasant Valley, etc., were lightly used by deer as compared with forested areas according to the fecal accumulation rates on the different areas during 1969-1986.

Figure 14
Sites dominated by mature aspen overstory contain abundant varieties of deer foods and cover and had greater rates of deer pellet accumulation than any other type of tree stand in summer.

Mushrooms are readily consumed by mule deer when available even though rumen and fecal analyses have not shown this (E. R. Hall unpubl. ms.; Rasmussen 1941; Hungerford 1970). Most rumen samples seem to have been collected in seasons of mushroom scarcity, and the fecal analysis technique cannot detect mushrooms (R. M. Hansen, pers. comm.).

In autumn, before their downward migration from the forest, deer are often seen eating fallen aspen leaves. As frost withers the lupine, other forbs, and mushrooms, deer feed frequently on the green basal foliage of perennial grasses, and on the evergreen leaves of the forb-like Oregon-grape (*Berberis repens*). Acorns are important food for deer when they congregate in the shrub oak zone in the lower pine and upper pinyon-juniper types. As with mushrooms, the acorn crop can vary greatly from year to year. There has been less objective effort to define deer diets in autumn than in other seasons (McCulloch 1978).

Competitors

Competition between deer and livestock for food has been an issue of long standing contention. Deer and cattle eat many of the same species of plants. This is apparent from casual observations of freshly cropped plants on sites where only 1 or the other kind of herbivore was recently present as evidenced by tracks and droppings, and by direct observations of feeding animals. Examinations of stomach contents further confirmed that there is some dietary overlap, but large differences in the percentages of the jointly used plants which made up the diets of the 2 kinds of sampled animals (Wright and Arrington 1950).

Attempts to evaluate the degree of competition via diet composition studies failed partly because of the difficulty of describing the varied diets of large populations of animals under the fluctuating conditions of feeding areas and seasons. In addition, diet studies alone could not address the question of how much of each kind of food remained available in a critical season for deer after cattle had eaten part of the supply.

With low to moderate rates of stocking of cattle and deer during 1972-1979 (Tables 1-15; Fig. 15), there was no detectable evidence that competition for food or other needs allowed cattle to preempt portions of the summer deer habitat (McCulloch and Smith 1982). In Utah, however, cattle did tend to exclude deer from some sites (Julander 1966). It is likely that livestock had the same kind of effect on Kaibab deer distribution on summer range prior to 1972, during periods of excessive ungulate numbers, but this could not be tested.

Pasture Improvement

There have been many efforts to improve the food supply or relieve deer-livestock competition by removing trees and planting forage species, mostly exotic grasses, on summer and winter ranges. The benefits of such treatments for livestock seem obvious. Grass production usually increased, but benefits for deer are difficult to demonstrate.

It is clear that deer numbers and indices of physical condition have failed to stabilize at high levels despite these investments in pasturage. Instead the deer indices have continued to fluctuate following the clearing of tens of thousands of acres of pinyon-juniper woodland (Fig. 16) on winter habitat since 1954 (Tables 1-3, 22), and the conversion of most of the virgin forest to various states of logged timber on summer habitat since about 1946. If timber harvests and associated practices have benefitted deer this is not readily apparent as an effect on deer population densities.

During a period of 15 years, deer density on summer habitat types in fawning seasons were not consistently greater on the National Forest than on the unlogged, ungrazed, and presumably unimproved old growth forest of

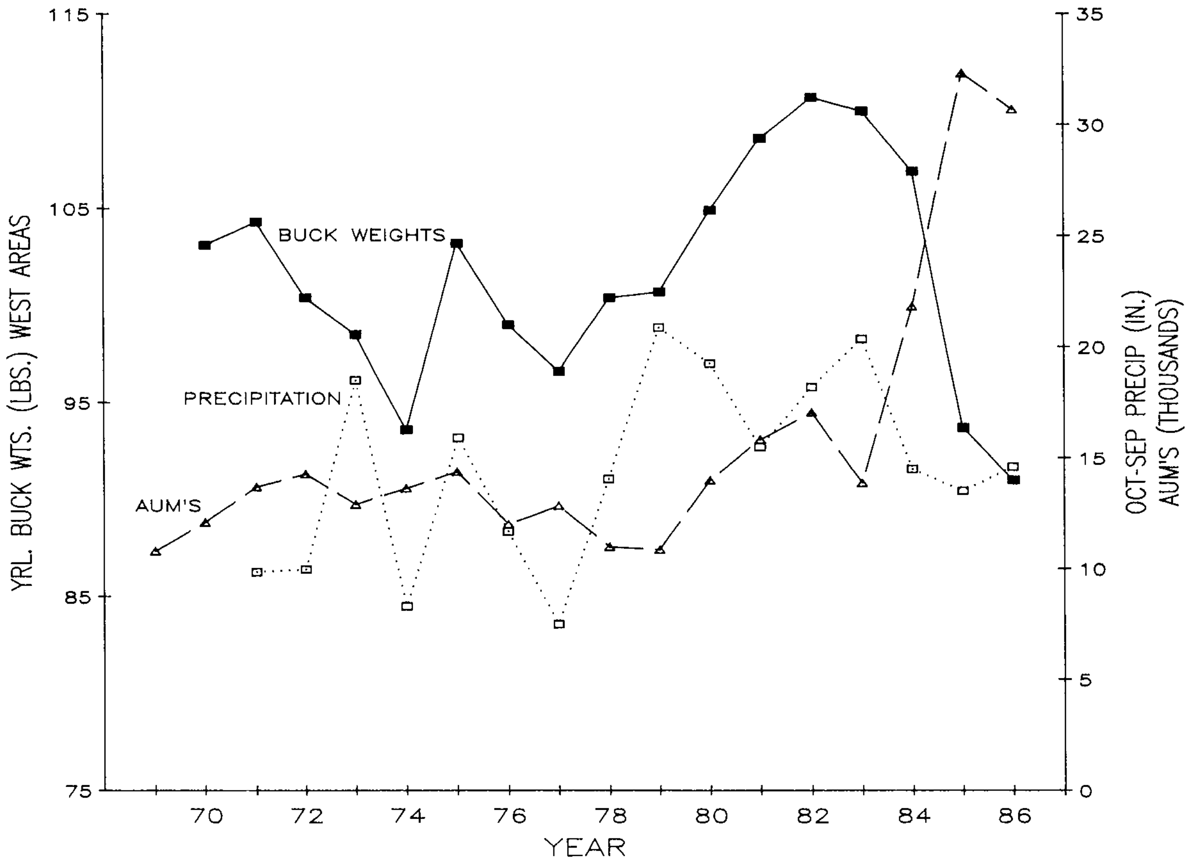


Figure 15
Fluctuations of west yearling buck weights (Areas 1-6) with index of total ungulate biomass (AUM) on summer range and annual (Oct - Sep) precipitation at 9 AGF stations.

the National Park (Table 26; Fig. 17, 18). Particularly while deer numbers were high, that is after 1979, this technique of comparison failed to show significant differences between KNF and GCNP in any year in the pine overstory type. A statistically significant difference between the 2 jurisdictions appeared only once in 15 years in the mixed conifer type. While these vegetation changes on KNF may not have directly improved conditions for deer, it is possible that capacity for livestock was increased without seriously heightening competition for food with deer.

Weights and Antlers.

Data from hunter checking stations provide evidence of annual changes in the amount of food available per deer. Yearling buck records are the most important for this purpose because yearlings are faster growing

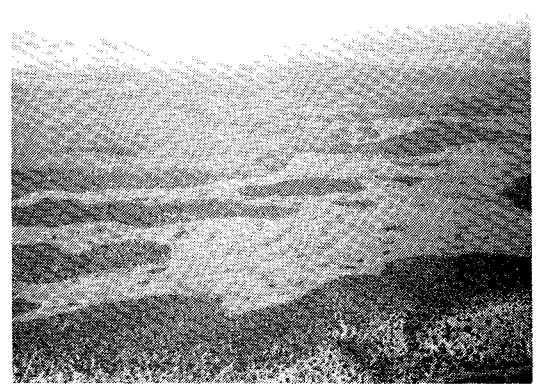


Figure 16
Aerial view of pinyon-juniper woodland cleared to increase grass for cattle. Heavy gray areas (distant) had trees bulldozed 1956. Light gray areas (nearer) had trees chained 1983. Dark specks within tree eradication areas are trees left to provide deer cover. Natural savannah occurs on south-facing slopes of ravine (foreground). Sowats Pasture elev. 6,200 - 6,700 ft.

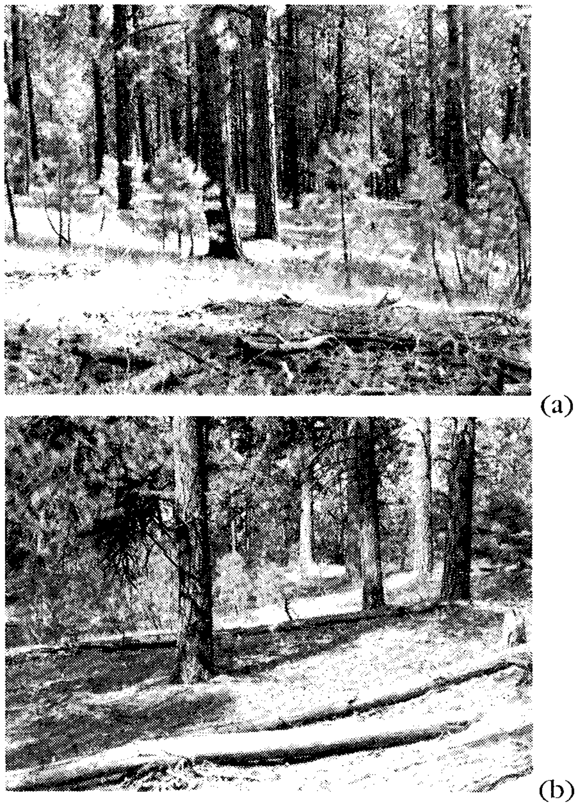


Figure 17
Virgin pine forest sites like these were persistently used by deer during fawning seasons. Openings and 5 age classes of trees occur in small patches closely mixed within a 2-acre circle (diameter 100 yards). GCNP Tiyo Point elev. 8,000 ft.

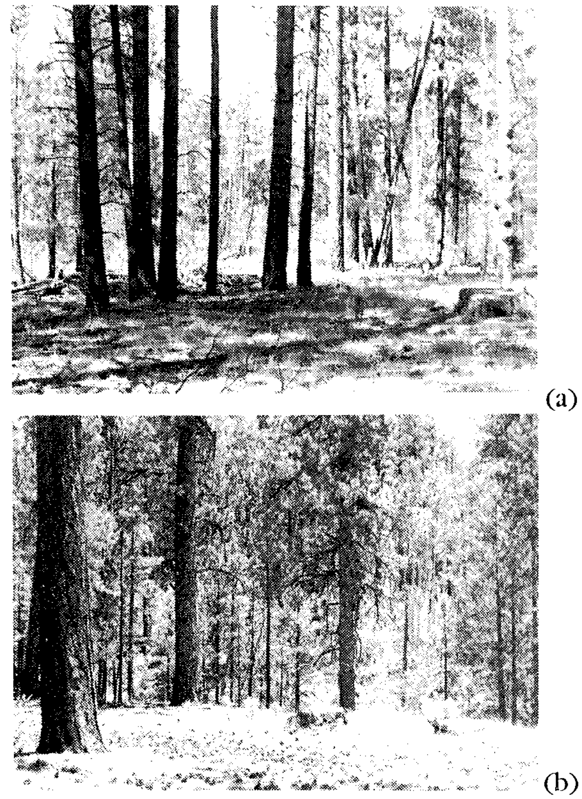


Figure 18
Lightly logged pine timber sites like these were consistently used by deer during fawning seasons, KNF, Moquitch Point, 8,100 ft.

and their weights are more likely to reflect fluctuations in the level of nutrition than weights of any other age group. During their 17-month life span up to time of harvest by hunters, a group of yearling bucks from 1 hunt area showed a mean gain of 162 lbs. (Table 27), allowing that hog dressed weight was 73.4% of live weight (Robinette et al. 1977). Several individual yearling bucks in that group had estimated live weights of 200 to 208 lbs.

The harvest of yearling bucks provides samples that are larger and more likely to represent all parts of this habitat than any other age group. Large samples are desirable because of the great variance among individuals of any age class. For example, hog dressed carcass weights have ranged from 60 to 153 lbs among yearling bucks, and their antler point counts, from 1 to 9 per individual (Fig. 19).

Carcass and antler development of bucks older than yearlings also reflect changes in the plane of nutrition, but due to the slower growth rates of older animals their average annual differences are not as easy to observe with the techniques used at checking stations. The older classes also afford smaller samples in the harvest by hunters.

Averages for Kaibab bucks show continued weight gain and increase in antler size to age 6-1/2 years, and these characteristics do not decline until after 8-1/2 years (Tables 3, 28). Many observers have reported that carcass and antler growth among male deer (*Odocoileus* spp.) may continue through age 4 to 6 years (Hunter 1947; Mohler et al. 1951; Robb 1951; Brohn and Robb 1955; Krefting et al. 1955; Severinghaus 1955; Lang 1957; Taber and Dasmann 1958; Cowan and Long

1962; Klein 1964; Roseberry and Klimstra 1975; Robinette et al. 1977; Mackie et al. 1978; Barlow and McCulloch 1982). Does also show continued growth through age 6-1/2 years (Table 29).

Despite the consistency of average weight and antler development increasing with age, there are wide (87%) variations among individual older bucks just as there are large (155%) differences among individual yearling bucks. Within the cementum age class of 6-1/2 years carcass weights ranged from 142 to 265 lbs. hog dressed. There was a difference of 6 years in the ages of the largest buck taken in different years (Table 30).

There can be significant mean differences in weights and antlers of the same age class from different parts of the Kaibab in the same year. For several years, yearling bucks on east side areas 8-11 were on the average lighter than those taken west of Highway 67 in areas 1-6 (Fig. 2). Within the eastern group, Area 10 (Telephone Hill, Big Ridge) often yielded heavy yearlings when other east side areas produced smaller ones. Within western hunt areas, yearlings from Area 6 (Fracas Lake vicinity) weigh less than those of Area 3 (Big Saddle) (Table 27).

As ranked by weight and antler spread, the biggest buck each year was produced more frequently in Area 10 than in any of the other 11 areas (Fig. 2); west Area 3 ranked second by these criteria (Table 30). Both places are typically early hunt areas with deer generally absent during late hunts by the time the summer range has a persistent snow cover. West side Area 1 was second to Area 10 in a comparison based on biggest buck per square mile of huntable territory; this excluded the virtually unhunted regions of shortgrass plains in Area 9 and the low elevation sandrocks zone of Kanab Creek Canyon in areas 1 and 2. East side areas 8 and 11 (Dog Lake, Saddle Mountain, Seegmiller Point) were especially poor sources of the biggest

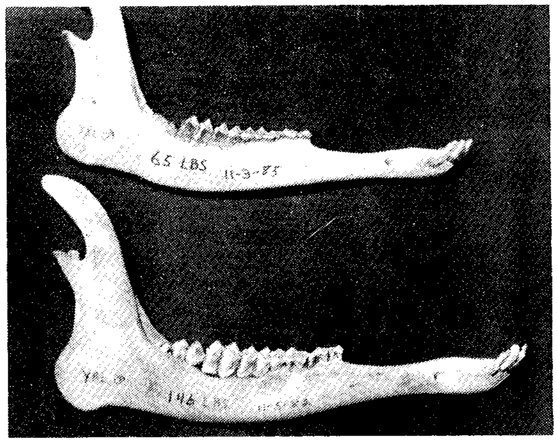


Figure 19
Dressed weights of some yearling bucks were more than twice the weights of others, as in the case of the "forkies" from which these jaws were taken. Presence of the deciduous tricuspid (third premolar at star) distinguished yearlings from deer aged 2-1/2 years and older.

buck each year; so were west side Area 5 and north end areas 7 and 12.

On a different basis for comparing trophy buck sources, the western subdivisions were superior to east side hunt areas. Carcasses of bucks that were young, but in the trophy age class at 4-1/2 years, were significantly heavier ($P \leq 0.05$) on late hunt Area 2 (Slide, Jumpup) than on late hunt Area 9 (South Canyon, Buck Farm) during the drought era of 1971-1978. During those same years the carcasses of the same age class were heavier ($P \leq 0.05$) on early hunt Area 3 than on early hunt Area 10. Mean antler point counts were also greater on early hunt Area 3 than on Area 10.

Carcass weights ought to be more comprehensive than antler points as an index of food supply. Growth of skeletal, muscle, fat, and other tissues can respond more directly than growth of antlers to changes in food availability in some seasons of the year. Elongation of antler main beams was 88% to 94% complete by the end of July on 2 experimental bucks in Colorado (Banks et al. 1968; Anderson 1981). Thus antler growth of the current year should be minimumly affected by late summer growth of mushrooms; response of forage plants to summer rains which usually begin in July; by acorn crops which mature in the fall; or by depletion of food sources on summer range by deer and livestock up to the time of the hunting season when weight and antler data are collected. However, up until this time, antler growth can be more sensitive to nutrient availability. If there was an appreciable increase in number of antler points in late summer after elongation of main beams, this was not indicated in the literature (Banks et al. 1968).

Large antlers go with large bodies and this applies within each as well as among the several age classes. At cementum age 4-1/2 years for example, individual buck carcass weights were positively correlated with antler points of the same animal ($P \leq 0.01$, $N = 272$, $r = 0.239$). Forage supplies that are not adequate for maximum growth rates of yearlings would also be insufficient for the greatest rates of trophy buck production.

RESULTS

Collateral Deer Data

Foreknowledge of likely change in deer numbers or the recruitment rate is welcome in the art of planning the harvest of deer next year. Aside from predicting whether or not there will likely be more or fewer deer to hunt, the estimates of deer welfare indices are useful simply to affirm each other. All estimates of deer herd conditions are subject to statistical and other kinds of errors. As discussed below (Data Quality), it is preferable not to base management decisions on a single kind of data. Plans can be made with more assurance if the different indices agree than if they don't.

Terms.

In the interest of economy, the following abbreviations are used to indicate the variables under discussion:

HFD1	harvested fawns:does at least 1 year old
HFD2	harvested fawns:does at least 2 years old
HYD2	harvested yearling does:does at least 2 years old
HYB2	harvested yearling bucks:bucks at least 2 years old
YMP	mean antler points of yearling bucks
Y3PT	percentage of yearling bucks in harvest having 3 points on at least 1 side
YCW	mean carcass weight of yearling bucks
BCW2, 3, 4	mean carcass weight of 2, 3, 4 year bucks
BMP2, 3, 4	mean points of 2, 3, 4 year bucks
POP	estimated summer population of adults
OFD	fawns:does pre-hunt survey (Oct)
DFD	fawns:does post-hunt survey (Dec)
SSAD	success rate of any-deer permittees
Y2P	Oct to Sep precipitation for prior 24 months
YSP	Jun - Aug plus Oct to Sep precipitation for prior 16 months
Y3P	Oct to Sep precipitation for prior 36 months
HFMF	male:female ratio in harvested fawns
SSBO	success rate, buck only hunts
BHDBO	bucks per hunter day, buck only hunts
HPAD	authorized hunter permit numbers

Several kinds of data collected at hunter checking stations did forecast population fluctuations (Table 31). Changes in harvested fawn:doe ratios (HFD1, HFD2) were positively related to annual changes in the recruitment index expressed as the harvested ratio of yearling does to older does (HYD2) of the period, 1953-1976. So were antler growth indices (YMP, Y3PT) of 1953-1968. Carcass weights (YCW, BCW2), as well as antler growth trends (Y3PT, YMP, BMP2), tended to be predictive of herd size (POP) of the following summer, 1970-1984. Indices of antler growth (YMP, Y3PT) were positively related to indices of fawn and yearling survival (HFD1, HFD2, HYD2) derived from the same year's hunt data. The 2 harvested fawn:doe ratios (HFD1, HFD2) were mutually confirming (Table 31).

During the 1953-1976 era of any-deer hunting, when weight and pellet count data were not available for most years, the only usable index (Y3PT) of physical vigor correlated with productivity as represented by age ratios of harvested antlerless deer (HFD1, HFD2, HYD2) (Table 31). Later, when several kinds of weight and antler data were available, but harvested age ratios of antlerless deer were generally not, the physical condition indices (YCW, BCW2, BCW3, YMP, Y3PT) usually forecasted changes next year in the index of herd size (POP) (Table 31). When weight and antler growth increased, herd growth tended to follow but only up to a point. The correlation occurred during the period of low to moderate deer densities, 1970-84. Physical condition indices began to decline after 1984 as total ungulate numbers, primarily deer, became much higher (Fig. 15).

Weight and antler data were useful to judge the likelihood of error in the estimate of herd size (POP). For example, the high indices of weight and antler growth in 1982 indicated that a nutrition induced decline of herd size was not to be expected in the next year, 1983. The 1983 deviation downward from the preceding population trends of 1979-1982 was contradicted by the weight data of 1983. Later data from the pellet group counts in 1984, 1985, and 1986 further confirmed the judgment that the 1983 herd estimate had been low (Fig. 20).

Pre- and post-hunt deer surveys of fawn:doe ratios were neither forecasters nor current year validators of changes in the other kinds of deer welfare indices, namely; weights and antler growth, harvested indices of fawn production and yearling recruitment, and herd size (Table 31). The pre- and post-hunt fawn:doe ratios did correlate with each other, however.

Deer survey data (OFD, DFD) notably disagreed with check station data during a historic period which ended with greater than usual interest in this deer herd. That was

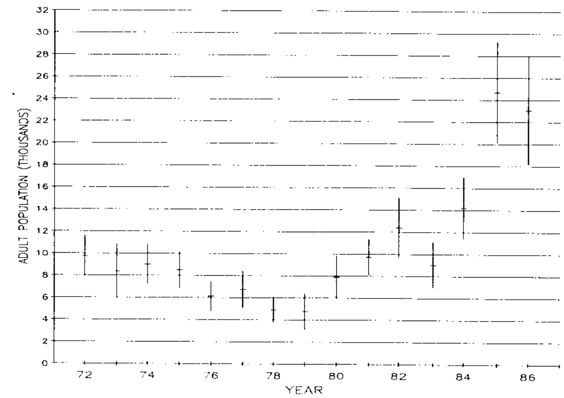


Figure 20
Deer Numbers (POP) on Summer range, ± 95 %CI.

after the any-deer hunt success dropped abruptly in 1967 (Table 5). For 3 years preceding that hunt, the checking station records had indicated declines in the plane of nutrition, as reflected in antlers (Table 2) (YSPT, Y3PT), as well as declines in juvenile survival indices (HFD1, HFD2, HYD2) (Table 1). At the same time the post-hunt estimates of fawn:doe ratios estimated from deer surveys appeared to be increasing or steady at a high level (Fig. 21).

Decision Bases

Correlation tests (Table 32) indicated that post-hunt survey data (DFD) were 1 of 3 kinds of data that dominated management decisions for many years prior to 1968.

The harvested fawn:doe ratio was not accepted as a likely forecaster of change in deer production. HPAD did not correlate with the harvested ratio of fawns to does of breeding age (HFD2) during the hunt of the year immediately preceding the decision (Tables 1, 14, 32), although that fawn:doe ratio did appear to be a relative index of yearling production next year; that is, the 2 ratios (HFD2, HYD2) correlated (Table 31). The harvested fawn:doe ratio (HFD2) also correlated ($P \leq 0.05$, $N = 6$, $r = 0.880$) with the pellet count index (POP) of changes in herd size next year during the brief period when this data comparison was possible, 1971 to 1976 (Table 1).

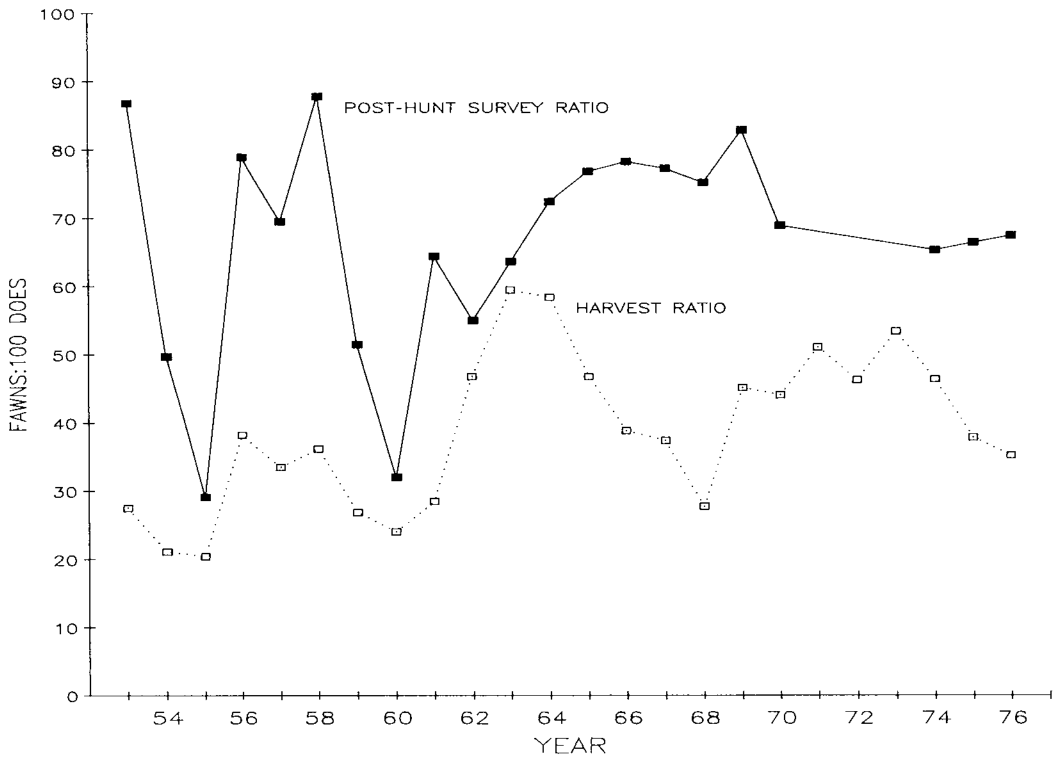


Figure 21
Annual trends of 2 relative indexes of fawn production, 1953-1976. Fawns per doe age 1½ yrs. and older, pooled data from all areas of Kaibab deer habitat.

Until about 1968, 1 of the favored decision bases was the post-hunt ratio of field classified fawns to does of any age including yearling does (non-breeders) (Table 1). As would be expected that kind of fawn:doe ratio (DFD) did correlate with permit numbers (HPAD) decided for the next hunt year (Tables 14, 32).

Hunter Success Rates

Until its unusual decline in 1967, hunt success had been 1 of the other main bases for deer management decisions. As with deer surveys, success rates of any-deer hunters (SSAD) also failed either to coincide with or to anticipate change in the other relative indices of herd recruitment (Table 32). From 1953 to 1967 hunt success (SSAD), expressed as total deer harvest divided by the number of any-deer hunters afield, did not correlate with the harvested fawn:doe ratios (HFD1, HFD2) of the current year; nor with the next year ratio of yearling does per older does harvested (HYD2). Any-deer hunt success may nevertheless be capable of reflecting extreme change in deer numbers. The ratio seemed to serve the purpose in 1967 but it is generally the goal of management to avoid that kind of change. Consequently, hunt success appears to be a poor predictor of smaller changes in herd size to which the yearly allocation of permits must be sensitive.

Any-deer hunt success (SSAD) of course correlated with the number of permits (HPAD) authorized next year (Tables 4, 14, 32); because the 2 are dependent. Success of the last hunting season influences the administrative decision on permits for the next season, and permit numbers are in turn intended to influence hunt success. Despite its limitations as an index of biological phenomena, hunt success is an important consideration for the management of this deer herd; hunters traditionally expect high success.

It is difficult to try to interpret buck hunter success as an index of deer abundance, because abrupt changes occur during the hunting season in the relative vulnerabilities of young and old bucks as a result of weather and migration (Barlow and McCulloch 1984). Despite these complications the 2 expressions of buck-only hunter success (SSBO, BHDBO) did correlate with changes in estimated herd size (POP) (Tables 32).

Precipitation on KDH.

Multiple water year cumulative precipitation within the deer habitat (Table 7, 8, 9) appeared to foretell changes in estimates of herd size (POP) (Table 1). That index of fluctuation in deer numbers correlated with accumulations of precipitation (Y2P, Y3P) which began as early as 3 years prior to the population estimate (Table 33). Herd size also correlated with the June-August summer precipitation of the current year, but not with precipitation of the October-May cool season immediately preceding the summer herd estimate.

The effect of prolonged, multi-year wet periods and also of wet summers separately would favor growth of summer deer foods. This in turn would enhance survival of breeding does, for which summer more than winter is a season of stress and mortality (McCulloch and Brown 1986). Considered by itself the effect of cool season precipitation on deer numbers would be more complicated, depending on whether the moisture arrived early or late in the October-May period and thus affected plant growth more on winter than on summer habitat; or in the form of rain or snow at the winter range elevations. Variations in the form and dates of cool season precipitation would tend to affect different age classes differently. Winter tends to be more stressful and to have food requirements more critical for yearlings and post-weanling (second semester) fawns than for older does (McCulloch and Brown 1986).

Fluctuations of precipitation (Tables 7, 8, 9) appear to be related to the annual changes in indices of certain deer physical condition factors (Tables 2, 3, 33) that they preceded. During the 1971-1984 period for which there were on-site precipitation data available, yearling buck carcass weights were positively correlated with summer precipitation, of the cool season (WP), and the water year, and with cumulative precipitation of extended periods (YSP, Y2P, Y3P) beginning 2 and 3 years before the deer weights were observed. Carcass weights of 2 and 3-year old bucks (BCW2, BCW3) also correlated with several classes of precipitation (Table 33). There were 2 indices of antler growth, namely point frequency and mean points (Y3PT, YMP, BMP2, BMP3), which correlated with winter season and longer accumulations of precipitation (YP, YSP, Y2P, Y3P) (Table 33). These correlations seem to have plausible explanations, but the observed correlation of antler development (Y3PT, YMP, BMP2) with current summer precipitation does not. As noted above antlers were not expected to be a comprehensive index of summer food supply, and at least 1 theory fails to explain the unexpected relationship with June-August precipitation. Wet summers did not tend to follow immediately after wet winters ($P \leq 0.05$), which might be expected to favor antler growth through the effects of plant growth responding to winter moisture on winter, spring, and early summer deer habitats. It is known that antler growth in early summer draws upon calcium in the body during late winter and early spring (Taft et al. 1956 cited in Banks et al. 1968), when Kaibab deer were feeding on winter range.

Precipitation off KDH.

Off-site weather records of the adjacent region may not be good indicators of associations of precipitation with indices of either deer productivity or physical condition (Table 34). None of the periodic classes of precipitation (Table 10) correlated with field observed pre- or post-hunt fawn:doe ratios (OFD, DFD), of the 1953-1969 era (Tables 1-4). There were also no correlations with hunter harvested ratios of fawns to does of all ages (HFD1), of fawns to does aged 2 years and older (HFD2), and of yearling does to older does (HYD2) from 1953 to 1976, when any-deer hunting ended and eliminated the source of those data (Table 34). Yearling buck weight and antler development indices (YCW, Y3PT) likewise did not correlate with off-site precipitation during 1953-1969. The period of precipitation records available within KDH, 1971-76, was too brief to test for correlations with hunter harvested ratios of antlerless deer.

Other Climatic Factors.

It was not possible to test the hypothesis that severe, snowy winters would adversely affect deer welfare during periods of high deer and/or livestock numbers. The 3 severe, snowy winters of the study period 1969-1984 occurred only when total use of winter range by ungulates was low to moderate, at about 11,000 to 13,000 AUM (Fig. 22). With these animal numbers, there were no correlations of DWI with persistence of snow cover on upper elevations of the west winter habitat for which snow records were available.

Winter temperatures expressed as mean daily low (Table 6) did not correlate with any DWI following in the same calendar year in which the winter ended. There was a seemingly spurious correlation of east side winter temperatures with the summer herd index (POP) observed on summer range a year and half later.

Winter wind runs of both east and west side stations, 1971-1981, correlated ($P \leq 0.05$) with summer herd size (POP), but not with other DWI. Winter wind was an index of winter drought, correlating negatively ($P \leq 0.05$) with precipitation of November-March.

Ungulate Populations

Attempts to consider livestock numbers apart from deer numbers indicated relationships with deer welfare indices that were sometimes adverse for deer and sometimes not, depending on the era observed. During the 34-year period of 1953-1986 the characteristics of physical vigor and productivity of the deer population tended to vary inversely with livestock use of the deer habitat. Fluctuations of livestock grazing permits (AUK) on KNF correlated negatively with the then-available index of antler growth (Y3PT), and with post-hunt ratios of fawns per doe (DFD) as field classified (Table 35).

Livestock use (AUK) on KNF also correlated negatively with hunter harvested indices of deer productivity (HFD1, HFD2, HYD2) from 1953 up to the end of any-deer hunting in 1976, when those kinds of deer data were no longer available for comparison. For the deer physical condition indices (Y3PT, YMP, YCW), however, there were no correlations with livestock use by itself during the shorter periods of 1953-1969 and 1970-1986 (Table 35). As explained above, the extended period of 1953-1986 was divided into the shorter ones to test additional kinds of antler and weight data which became available after 1969.

When fluctuations of deer numbers were compared with those of livestock during 1969-1986 the relationships appeared inconsistent. The correlation was positive in the test of the deer herd index (POP) with livestock use (AUK) of summer range, but negative with livestock use of winter range (Table 35). Because present knowledge of diets and forage availabilities is not adequate to segregate the effects of the 2 large herbivores on the deer food supply, it seemed more appropriate to compare deer welfare indices with the combined biomass of deer and livestock.

The index of total ungulate use (AUM) of the deer habitat correlated negatively with deer physical condition during 1970-1986 (Table 36). The coefficient was significant for 1 index (YMP) and weakly so ($P \leq 0.10$) for the other 2 (Y3PT, YCW). According to the basic premise of the Introduction, these negative correlations are likely to become more significant after 1986 unless ungulate numbers are reduced below the levels of 1984-1986 (Fig. 22).

There is presumably some level at which deer and cattle numbers tend to have a greater effect than drought in reducing the per capita food supply, and on the consequences of that food reduction such as depressed indices of physical condition of deer. Hierarchical cluster analysis suggested that deer-cattle density was the more influential of the 2 factors when the decline of mean weights (YCW) continued below 97.6 lbs; or when the mean antler index went below 4.177 points (Tables 37, 38). The cluster averages of the deer physical condition indicators were at those levels for the 5 observed drought triennial (Y3P) when the cattle allocation (AUK) was accounting for 44% of the "low" (14,000) AUMs on summer range; and while the cluster average for the deer herd index (POP) was also "low" at 7,024 head.

When precipitation increased to normal amounts while AUMs remained "low" the YCW rose to 102.0 lbs for a cluster average. With precipitation normal and AUMs "very high" (30,000) the YCW average for that cluster of years fell to 92.4 lbs as deer accounted for 76% of the AUMs in the summer deer habitat. These generalizations by clusters of years are marred by the data of 1 particular year (1972) when YCW remained well above 97.6 lbs and YMP well above 4.177 points (Table 2) despite the drought in 1972 and the "moderate" level of 14,277 AUMs.

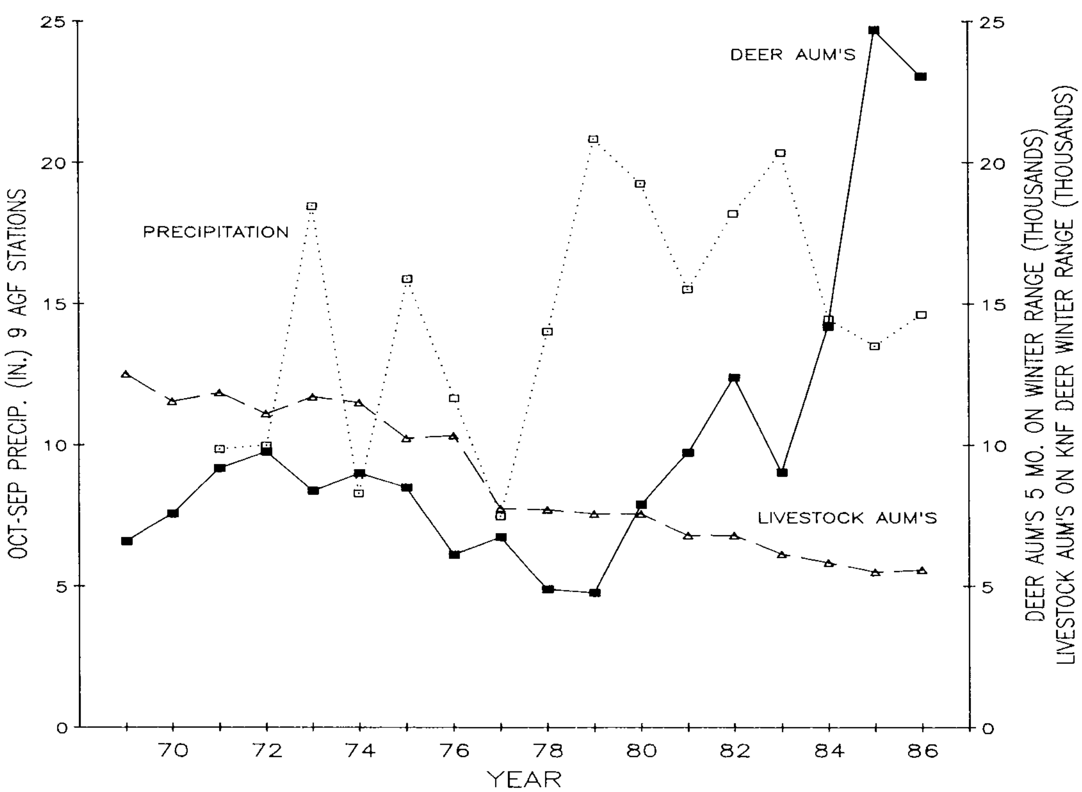


Figure 22
Fluctuations of deer (POP) with cattle (AUK) biomass indexes and annual (Oct - Sep) precipitation at 9 AGF stations.

Other KDH Variables.

There were 3 habitat variables which were given only relative abundance rankings. These correlated in different ways with deer welfare indices (Table 39). The relationship of the mushroom abundance index with those of deer welfare were to be expected, since mushrooms are presumably an index of summer precipitation which should affect weights if not antlers. The association of June-August rainfall with deer variables was discussed above. Despite the scarcity of objective evidence in the food habits data (Tables 23-25), it seems safe to conclude that mushrooms are an important summer deer food; and when mushrooms are abundant, so are the other summer foods that respond to summer precipitation.

Inadequacies of the acorn data is a likely explanation of the failure to show any positive correlation, and of the 1 negative correlation of acorn abundance with deer welfare indices (Table 39). Years of widespread failure and bumper crops of acorns are easily apparent to casual field reconnaissance, but there were probably intermediate stages of acorn abundance which were not distinguished by this method but which were important to deer.

Tent caterpillar data seems almost a discrete variable and it may not have been appropriate to treat them as a ranked variable (Table 39). There were only 2 irruptions of the insects in a period of 32 years, 1953-1984, with each outbreak lasting for 2 or 3 consecutive summers (Table 15, Fig. 23). The years between irruption were periods of virtually no visible presence of tent caterpillars. The positive correlation with deer productivity indices (HFD2, HYD2) is probably a spurious one (Table 39). It seems unlikely that widespread destruction of the aspen foliage by insects during the first half of a summer would actually favor fawn and yearling survival. The negative correlations of tent caterpillars with weights and antlers (YCW, Y3PT) is more reasonable. However, this association represented only 1 event in 15 years.

(a)

(b)

Figure 23
Defoliation by tent caterpillars temporarily eliminated browse for deer and created wintery appearance of aspen in summer of 1977. Kaibab Plateau elev. 9,200 ft.

Neither fawn sex ratios nor the relative abundance of deer accessible to hunters, as indexed by hunt success, seemed uniquely associated with fluctuations of the environmental variables tested. During 1953-1976 the annual changes in sex ratios among fawns harvested by hunters (HFMF) (Table 1) did not correlate with precipitation recorded outside of deer habitat (Table 10); nor with livestock use (AUK) (Table 15); nor with abundance indices of the special foods, mushrooms and acorns (MSHR, ACRN) (Table 16). These same environmental (non-deer) variables failed to correlate with the percentages of any-deer hunters who succeeded in taking a deer (SSAD) (Table 4), and with the number of days spent hunting by the any-deer permittees who succeeded in taking a buck (BHDAD) (Table 4).

Inches of Cliffrose.

Estimates of cliffrose twig use (CTU) by deer and cattle were 1 of the major bases for the annual decisions on numbers of any-deer hunter permits to be authorized, 1953-1968. As expected, this management practice is reflected in the correlation of cliffrose use with hunter permits for the next season, 8 months hence (Table 40).

Despite the apparent importance of cliffrose in the diet, cliffrose use was not an index of any annual changes in the deer welfare indices (YCW, HFD2, etc.) of the same calendar year; that is, of the season immediately following the winter of cliffrose use. Instead, the indicators of well being of the deer herd tended to decline with a delay of 1-1/2 to 2-1/2 years after winters of heavy consumption of cliffrose, and vice versa (Table 40). The correlations seem to represent a complex relationship between amount of cliffrose use and the deer welfare indices. A direct nutritional relationship should have shown some correlations at 7-10 months rather than 20 and 32 months after the twigs were eaten.

QUALITY OF DATA

There are alternate hypotheses to explain events in the history of the Kaibab deer herd. Variation in data collection methods over the last 3 decades make some interpretations difficult. Some of the most intriguing data sets are the estimates of deer numbers. Methods of estimating herd size in the early 1900s (Goldman and Locke 1923) are not known, but in the 1920s simple extrapolations were made from counts of deer sighted on a prescribed portion of the winter range (D. I. Rasmussen, pers. comm.). In the 1950s and 1960s deer numbers were calculated from changes in pre- and post-hunt ratios of field surveyed deer and from the known composition of the harvest by hunters (Swank 1958; Russo 1964). Errors were possible because of the difficulty of observing and classifying representative samples of herd composition, and the unknown numbers of deer killed but not reported by hunters. The more recent way of estimating herd size is described in Methods.

It is possible that unsampled areas may bias the deer population estimate which is projected from the fecal pellet accumulation rate. The summer habitat has a few contiguous areas of several square miles none of which contain any of the 153 transects (clusters of permanent plots) described in Methods. These blocks of unsampled habitat total 10% to 15% of the area delineated for the projection. They are partly the result of compromises with the intended random design. If there are year to year shifts of deer into or out of these unsampled areas there could be false fluctuations in the herd index. Temporary disturbance of sample transects by timber harvest, forest fires, or timber blowdown, and the consequent loss of data could also contribute. This is 1 of several hypothetical explanations for the anomalous dip in 1983 in the population growth curve of the period of 1979-1985 (Fig. 18). Intuitive assessment suggests that use of the pellet count technique usually tends to underestimate herd size.

Clustering of Characteristics

Observed deer population attributes such as fawn:doe ratios, population density, and physical condition tend to be clustered, not homogeneously distributed in time and space. Groups of deer that are different from other groups occupy different areas, and appear to merge and separate from time to time in response to weather, migration, reproduction, and other stimuli. There is evidence of spatial clustering and shifting from year to year in isogram maps of fecal accumulation rates on summer range, and in weight and antler data of deer harvested by hunters.

Antlerless Classifications

Sex and age classes of deer are not uniformly visible to observers. Small errors in field classification counts may have resulted from daily changes of deer activity which occurred during prolonged survey periods; and from movement to, or from, areas of dense cover. Delays in completing surveys has an unmeasured effect on herd composition estimates. High grading is typical of Kaibab deer surveys. Most counts occur where and when large numbers of deer can be observed, even though the readily visible groups may not represent composition of the whole herd.

Another possible cause of error was the misclassification of does and fawns. The distinction is best made by a combination of criteria, namely relative size, and therefore the juxtaposition of individuals, differences of body and head conformation, and the pelage. Yet in many viewing situations it is not possible to employ all criteria. Variations of light, shadow, sight obstacles, angle of view, and brevity of observation can cause erroneous judgment. Observer experience may also affect fawn and doe classification.

Deer surveys were treated here with the assumption that observed deer groups typically contained some additional animals that were not visible and were therefore unclassified. Variance and other analyses were done with no pretense of eliminating bias by deleting groups which had unclassified deer actually reported by observers. On west winter range 13% of the fawn-doe groups of 1970-84 were in this category. To discard them from calculations would have seemed an unjustifiable extravagance, considering the limited survey data available in some years. In the long run, the decision to include groups which had some observed but unclassified animals exaggerated the estimated ratio by 0.0005 fawn:doe.

Small yearlings are likely to cause erroneous field classification of does as fawns, and thus cause over-estimates of the fawn:doe ratio. An extreme example of this may have occurred in 1956 when 99% of the yearling buck carcasses were in weight classes 10% to 27% lighter than the mean of 110 lbs which was observed in 1982-1983. The pre-hunt survey of 1956 had estimated an unusually high ratio of 117 fawns per 100 does; the post-hunt estimate was also above average (Table 1), although it is unlikely that high fawn survival actually occurred when forage supplies were as poor as indicated by the physical condition of the deer. It was a drought year in this region (Fig. 6-8). The antlerless age ratios in the hunter harvest in fact did show unusually low fawn survival in 1956 (Table 1). Food and physical condition of deer were apparently so poor that even the application of 1080 poison to control coyotes in 1956 failed to raise these antlerless indices to normal levels (McCulloch 1986).

Buck Counts

Buck:doe ratios from deer surveys were erratic from year to year (Fig. 24), and seemed not suitable for tests of correlations with any other variables. In addition to the disadvantages of great variance there was a possible survey bias. Over a period of several years the field classified ratio of bucks per doe at pre-hunt (October) surveys was about half that of the ratio estimated by change in the harvested age ratios (Barlow and McCulloch 1984). Although there were fewer years of post-hunt survey records available for this

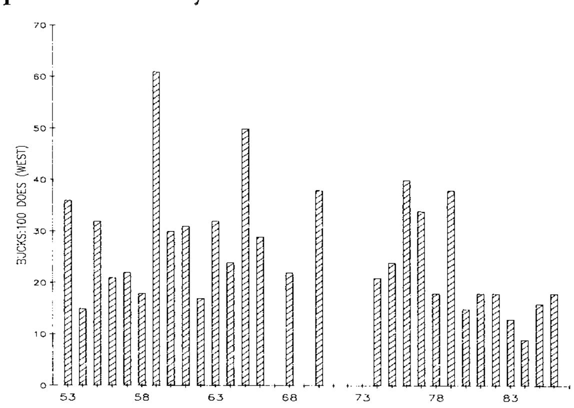


Figure 24
Buck:doe ratios estimated at post-hunt classification counts on west winter deer habitat, 1953-86.

kind of comparison of techniques, it appeared that post-hunt (December-January) data also tended to underestimate buck:doe ratios.

Helicopter Surveys

Deer survey data collected from helicopters were rejected for use in this report. From 1967 to 1974 post-hunt surveys of deer were made in several years by helicopter as well as by ground crews, and in 3 of those years, 1971-1973, the surveys were done by helicopter only. There were several apparent disadvantages to sampling deer sex and age composition from helicopters. For one thing, much replication of observed individuals was possible and likely due to the chaos of milling groups of as many as 50 deer disturbed by the aircraft. There was a tendency for mature bucks, in contrast to does and fawns, to remain motionless and unobserved in dense cover. When ground and helicopter surveys were made on the same areas at the same time, the helicopter data showed 20% fewer bucks per doe. Stringent procedures should be devised to reduce or eliminate the disadvantages of classification counts from helicopters. An additional problem with these early helicopter surveys was that small piston-engine aircraft were used. These aircraft were underpowered and lacked maneuverability. Current use of turbine-powered helicopters have proven far more efficient as a survey tool.

Weights and Antlers

Year to year comparisons of buck weight data are affected by dates of the hunting seasons, either early or late. Buck weights normally decline with the beginning of rut in autumn, but this seemed a negligible bias for the purposes of this report. The means of yearling carcasses decreased only 1% from the early to late hunting seasons in those years when data were available to compare the 2 seasons.

Beginning in 1977 skinned carcasses of deer were accepted for weight records if the complete but separate hide could be included. If any feet were missing an estimate of 1 pound was added for each missing foot. In fact, weights of yearling buck feet ranged from 1 to 1-1/4 lbs each, depending on the individual animal and the hunter's technique of removing the foot. An unassessable bias was the hunter practice of trimming fat from the carcass. About 3/4 of the carcasses were checked out within 1 to 3 days after the kill, so moisture loss presumably had a minimal effect on mean weights (Robinette et al. 1977). For samples larger than 150 yearling bucks, the standard error of the mean was usually less than 0.8 lb, as in the cases of pooled data representing groups of several hunt areas (e.g. west side areas 1-6). Some individual hunt areas with large samples also had comparably small mean errors (Table 27).

Antler asymmetry was common among 5,228 yearling bucks, of which 11.4% had more points on the right and 10.3% had more on the left. Although this right-left difference among yearlings was not significant ($P \leq 0.05$) over a period of several years with thousands of individuals sampled, there were certain years when the disparity was significantly ($P \leq 0.05$) greater than the above ratio. This prevented the annual calculations of mean antler points per buck prior to 1970, because through 1969, data collection procedures omitted records of points on the smaller antler. Asymmetry increased with age. The rate, for example, was 32% among 1,052 bucks having a cementum age of 2-1/2 years.

Aging Techniques

Prior to use of the cementum technique, which began in 1971, fawns and yearlings were the only age classes which could be reliably identified. Although it is possible to distinguish 2 year olds from the 3 to 5 year class by tooth wear, this was an inaccurate technique in actual practice at the checking station. In comparing these 2 techniques, 16 of 29 of the tooth wear judgments were contradicted by cementum examination (Weaver and Wegge 1972). Among deer older than yearlings the cementum technique had a potential error of 1 to 3 years in 30% of the cases (Phelps 1978).

There were other sources of errors in addition to the possibility of misidentifying cementum layers. The kind suspected most frequently resulted from a tooth specimen labeled with the identification number of the wrong deer at the checking station. An example might be the animal with a checking station record of tooth wear indicating an age of 6-1/2 to 8-1/2 years and a lab report of its cementum age at only 3-1/2 years (Table 30). These errors could seriously bias calculations attempted with small samples of a particular area or age class.

Antlerless Harvests

Conclusions based on harvested fawn:doe ratios assume that human behavior is constant from year to year in those aspects which determine the percentage of hunters who choose to take fawns, or who fail to claim and report fawns which they inadvertently kill. This assumption is supported by the correlations of harvested fawn:doe ratios with the harvested ratios of yearling does to older does. Both age ratios tended to agree as relative indices of juvenile survival and productivity.

DISCUSSION AND SUMMARY

As indicated by correlations of several indices, deer herd recruitment has varied with deer physical condition. That in turn varied with factors which control the per capita food supply, which are the moisture available for growth of forage plants and the numbers of deer and livestock among which the forage is divided (Fig. 25).

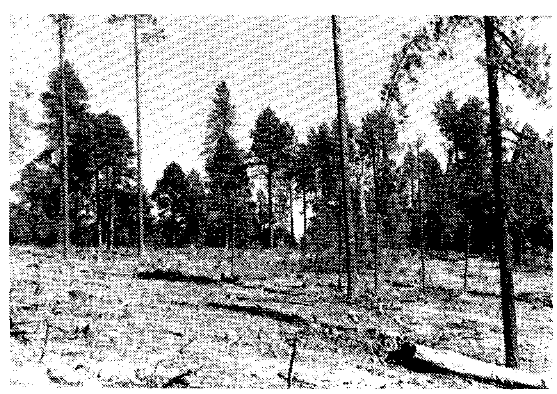
The period between 1979-1984 seemed to have an ideal combination of weather and ungulate numbers (Fig. 15), which allowed optimum production and allocation of forage. Cumulative annual precipitation was high and there was a succession of mild winters. The indices of carcass weight and antler development during that period reached historic maxima for bucks of every sample class that was numerous enough for a comparison of dates; namely ages 1-1/2, 2-1/2, 3-1/2, and 4-1/2 years (Tables 2, 3).

Although deer physical condition began to improve immediately, the peaks did not appear until about 2 years after the start of that unusual wet period represented by the water years of 1979-1983 (Fig. 6). There was some lag not only of deer response, but perhaps also in the response of plant growth to increased precipitation. The desired index of recruitment (HYD2) could not be monitored during this period because there was no hunting of antlerless deer, but the rate of adding young animals to the herd must have been unusually high as judged by the large yearling fractions (HYB2) of the buck harvests (Table 1) and the large and rapid increase in the population index (Fig. 20).

After the peaks that developed during 1981-1984, indices of deer physical condition declined, and annual precipitation after 1983 dropped to average, although not to drought levels (Fig. 7, 15). Concurrent with the declines of moisture and deer physical condition the numbers of ungulates, predominantly deer, remained at unusually high levels. Observation of the female recruitment index (HYD2) was resumed in 1985 after a lapse of 10 years and it indicated only a moderate level of deer production in 1985 and 1986; it was not high by historic standards (Table 1). It is reasonable to suppose that productivity declined after 1984 along with the signs of sub-optimum growth and allocation of forage that were reflected by depressed physical condition.

High deer densities or deer and livestock combined, are not compatible with high rates of production of either trophy bucks or of younger ones. Both game management goals require a generous per capita supply of food. In the case of trophy bucks an over-subscribed forage resource on any seasonal part of their range could delay growth of large

(a)



(b)

Figure 25
Deer persistently used this site in pine timber type prior to the 1986 clearcut shown here. Future history of deer use on sites like this will be shown by the annual pellet counts on permanent sample plots. KNF Fracas Ridge elev. 8,300 ft.

bodies on which large antlers grow. Generous growth and availability of forage tends to produce trophy class individuals at the earliest age that is genetically feasible (Fig. 9). Food abundance enhances trophy buck production in another way also, because when food is scarce juvenile males die at a greater rate than juvenile females (Clutton-Brock et al. 1982).

Under some conditions the doe segment of the population can suppress rather than enhance buck production; more is not necessarily better. Kaibab deer long ago were noted as an example of this principle (Goldman and Locke 1923), but it has been difficult to define the critical limit until after it was greatly surpassed. Recent attempts at a definition seem to be usable to warn when deer and livestock use of the food supply starts to become excessive under observed conditions of weather. If the management goal is a high ratio of bucks to does, it would be better to try to narrow that ratio by hunting antlerless deer than to curtail hunting of bucks during eras when deer densities are high and precipitation is not.

Experience to date suggests that mean carcass weight of yearling bucks (YCW) is likely to fall below 103 lbs if the total ungulate biomass exceeds 22,000 AUMs as indexed on summer range. This carcass weight level is desirable and apparently achievable as a management goal in most years; that is, when precipitation is in the normal range (Table 37). These conditions of moisture and animal numbers would permit a summer deer herd index as high as 16,000 to 17,000 head within what is herein defined as summer range if the cattle fraction of the ungulate index could be limited to 25% of the total AUMs. Antler data ranked by clusters of years also agree with this definition (Table 38). It should be noted that the summer range as we define it represents a minimum amount of used habitat and total population can exceed this number without habitat damage occurring because other areas are used by deer in summer.

The moisture conditions apparently necessary to support maximum numbers of deer in highest physical vigor have occurred once in 60 years, as recorded at the nearby weather station in Kanab. That ideal wet period was 1979-1983 (Fig. 6, Table 19). There was another extended wet period in 1937-1941 but it had less generous total precipitation and presumably did not match the recent one in its effects on this deer herd. During the earlier period the permitted livestock AUMs on the deer habitat included sheep and were at least 2.5 times as great as during the recent wet spell (Murray and Arrington 1950). There were no records of weights, antlers, and ages of deer harvested; and estimates of deer numbers at that early date (Rasmussen 1941) are not directly comparable with recent data.

Whenever there are multiannual periods of favorable precipitation concurrent with modest numbers of livestock, then some hunting of antlerless deer may be necessary to control growth of the deer herd. The normal lion population would be unable to prevent expansion of deer numbers. This prediction is based on estimates of the natural limits of lion population density (40 to 60 resident adults), and the rate of lion predation which was estimated at about 1,280 kills per 40 lions per year (Shaw 1980). Radiotelemetry study showed that deer mortality can be remarkably low from all causes except hunting during years of high precipitation and low to moderate deer and cattle numbers (McCulloch and Brown 1986). Predators seemed not to respond immediately to the increase in deer numbers.

There is a lower as well as an upper critical limit of deer herd size which concerns hunt management. Experience during the 1970s suggested that when the summer herd index declined below 9,000 deer with perennial drought conditions, the population could not sustain other kinds of attrition in addition to harvest and crippling losses of Unit-wide any-deer hunting. Split-unit hunts of antlerless deer can respond to localized overstocking when that is detected by weight and antler data from each of the 12 hunt area subdivisions. Localized antlerless hunts may be desirable even when unit-wide antlerless hunts are not advisable. Generally this alternative would apply to groups of 2 or more rather than a single subdivision.

When drought develops, the available nutrition in deer forage stands can be depleted promptly as plant growth slows while cropping by the animals continues at levels which preceded the drought. Factors other than hunting probably can be counted upon eventually to reduce deer numbers during a drought of 2 or more years. However, reduction by those means tends to be slow in starting and allows deer to cause some lasting damage to the forage plants. To allow factors other than hunting to make major reductions in the deer herd also abandons a pretense of game management. An alternative would be 1 season of increased hunting as soon as range resources show signs of depletion, to minimize the inevitable deer population reduction, range damage, and deterioration of buck quality. As already discussed there are critical limits of herd size which would affect the decision on this kind of hunt which is intended to pre-empt other mortality factors.

Ungulate biomass seems to be no more than a vague index of competition between deer and cattle. The frequently changing botanical and nutritional composition of their food intake has not been investigated in relation to fluctuations of deer production and physical condition, nor to deer and livestock densities. Although there is much overlap in choice of foods by deer and cattle, it is not possible to translate AUM values into the assumption that livestock necessarily eat a certain fraction of the food needed by deer and vice versa.

The effect of animal use on 1 forage species in particular has been a topic of controversy. Cliffrose twig use has been proposed as a key or index to stability of the ecosystem and to welfare of the deer herd. Yet there seems to be no way to relate the use of 1 forage species by itself to several recorded conditions of the deer herd. Instead, deer welfare is likely to be determined by the total diet. In a short term of 4 or 5 years heavy browsing can indeed look like a threat to the survival of stands of cliffrose at the lower elevational limits of that shrub. However, site specific rates of establishment and mortality have not been defined for stand maintenance of this long-lived plant, and in most of its range cliffrose seems adapted to co-exist with the deer herd.

Sex and age ratios were not as reliable as yearling buck weights and antler development as a basis for either forecasting or verifying changes in yearling production and huntable deer numbers. Expressions of gross hunt success, based simply on the number of hunters (SSAD, SSBO) were also not as reliable as yearling buck weights or antler development as estimates of either total herd or buck herd size in most years.

A different expression of hunt success (BHDBO) relates to hunter effort rather than hunter numbers, and was as reliable as the buck:doe ratio of a deer survey to indicate relative change in buck abundance. A low conception rate is 1 possible consequence of a buck shortage. It is not known if such a failure has ever occurred. It is clear, however, that breeding failure did not follow 1 of the lowest recorded levels of BHDBO, which occurred in 1979 (Table 5). Instead there was immediately a high rate of production of yearlings, as indicated by the surge in the herd size index (POP) from 1979 to 1980 and for several years thereafter (Fig. 20).

Relative shortage of mature bucks for viewing and hunting satisfaction is an important management issue. There was some concern about low numbers of mature bucks the early 1980s. The deer population was expanding rapidly and yearlings were consequently abundant. Young bucks were eminently huntable and BHDBO success was high (Table 5), despite the inevitable scarcity of old bucks relative to the large numbers of yearlings.

The indices of annual change in deer numbers based on fecal accumulation rates on summer range have underestimated the herd size seriously only once in 15 years, but collateral evidence has not suggested any overestimate. Data collected at hunter checking stations seemed to provide consistent annual indices of physical condition, which predict the nutritional status and the potential for productivity of the herd. In periods when herd size was great enough to require hunting of antlerless deer, checking stations have also provided intermittent but useful indices of productivity.

Knowledge of the relationship between several deer indices, the weather, and total AUMs can be used to predict relative, though not absolute, change in huntable deer numbers next year; that is, whether there is likely to be a greater or smaller number available. High ratios of fawns:does harvested by hunters would usually forecast high levels of production of yearlings; so would a period of above average precipitation with high average weights and antler development. Conversely, drought or an increase of deer and livestock numbers above moderate levels would usually foretell declining deer production.

Management decisions based on these data would be consistent with proper management objectives in most years. The correlations are useful knowledge in the long run. For any given year, however, there is a minor probability that the forecast will err as some usually unimportant factor temporarily surpasses forage growth and per capita food supply as the main influence on deer survival.

Although food seemed to be the critical factor for deer production most of the time, this herd recently began to live with new environmental disturbances which could increase the relative importance of cover. The period concerned in this report was mostly one with mixed conditions of old growth and light first cuttings in virgin stands of pine and mixed conifer timber on deer summer habitat. Current and planned silvicultural treatments (Fig. 24) will replace the native forest with a less rich mixture consisting of generally larger stands (areas) of smaller trees on the KNF part of the habitat. The average dimensions of discrete units of feeding and hiding areas will expand. This could conceivably reduce the efficiency with which deer utilize their habitat, but deer response to these alterations of cover remains to be observed. Procedures for doing so have been established on the permanent sample plots described above. They offer an opportunity unusual in Arizona to report a sequel of deer densities and distribution associated with vegetation changes.

MANAGEMENT CONSIDERATIONS

1. Adjust hunting and grazing permits frequently and promptly to accommodate changes which weather imposes on habitat quality.

2. Make hunt management decisions on the broadest affordable information base. Continue perennial inventories for the 3 kinds of management information which are most useful; namely, deer physical condition indices, the deer herd size index, and local precipitation within the deer habitat. Keep the ungulate biomass index, defined as POP plus AUK, below 22,000 AUM. Open or close hunting of antlerless deer by permit in each season as follows:
   a. Open all KDH when the mean pellet count index (POP) exceeds 14,000.

   b. Close all KDH when POP declines below 9,000 or when 16-month precipitation to September 30 (YSP) averages less than 10 inches for several stations in KDH between 5,600 to 6,500 ft.

   c. Open by split unit hunts in any 1 of the 12 hunt areas of Unit 12A and the KDH portion of Unit 12B where a sample of at least 75 yearling bucks shows a mean carcass weight (YCW) below 95 lbs, except as subject to constraints of (b.) above.

3. Operate hunter checking stations to obtain weights of at least 75 yearling bucks from each of the 12 hunt areas of Unit 12A and the KDH parts of Unit 12B, subject to obvious limits of the available harvest in each area. Reduce buck hunter permits after buck-only hunter success (BHDBO) declines below an average of 50 bucks per thousand hunter days in a group of non-trophy hunt areas.

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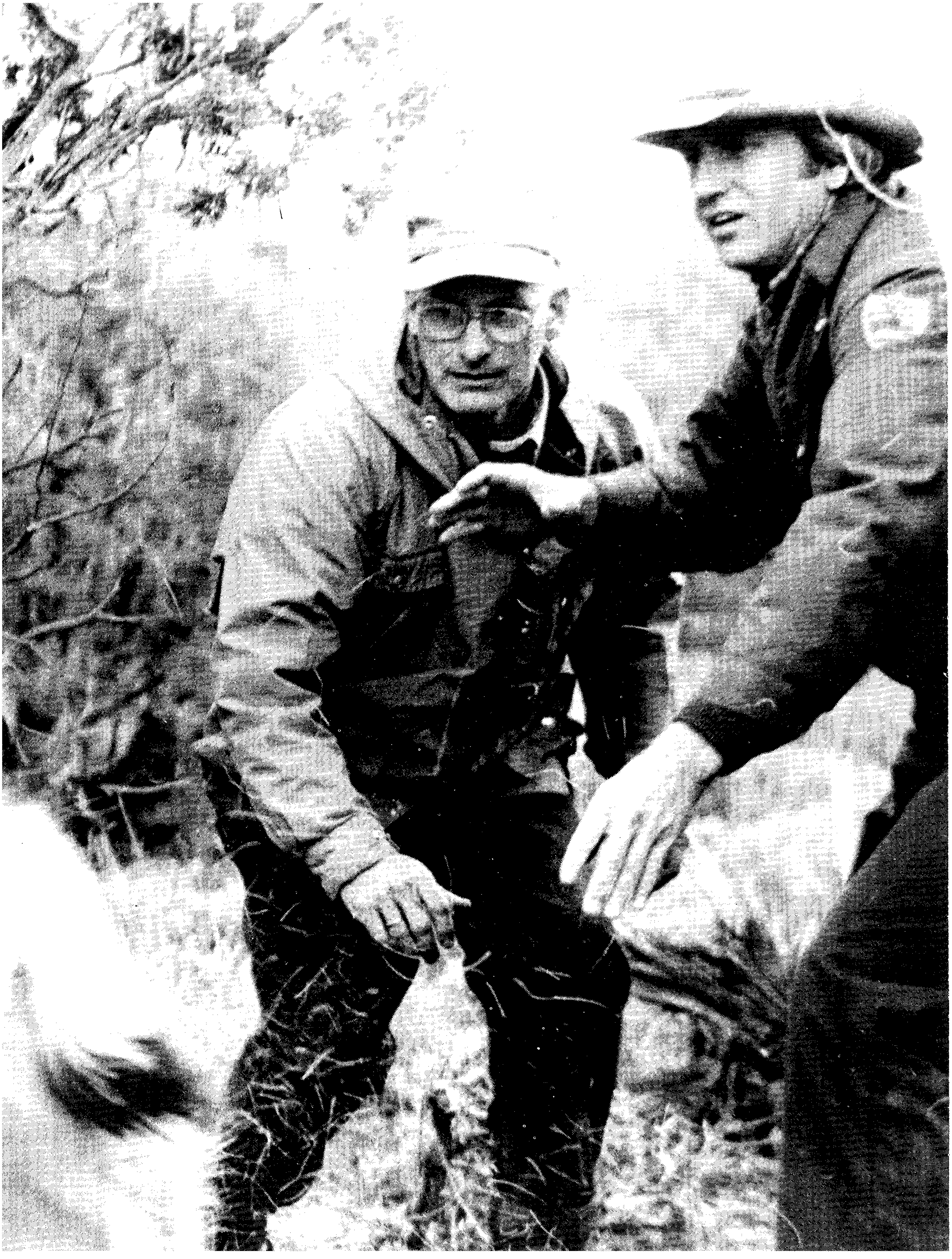

Table 1. Deer herd size 1969-1983 and composition data 1953-1984 (all ratios per 1000)[a].

Variable	Code	1953	1954	1955	1956	1957	1958	1959
Summer hrd size (no.)	POP							
Pre hunt F/D 1+yrs	OFD							
All areas[b]		--	--	346	1169	816	931	--
West only[c]		--	--	--	--	--	--	--
East only[d]		--	--	--	--	--	--	--
Post hunt F/D 1+yrs	DFD							
All areas		868	497	291	789	695	878	515
West only		882	503	291	781	622	870	515
East only		729	455	--	--	986	--	--
Hunter harvested	HFD1							
F/D 1+yrs all areas		275	211	204	382	335	362	269
F/D 1+yrs West only		267	215	197	301	238	205	157
F/D 1+yrs East only		344	193	148	412	350	391	288
F/D 2+yrs all areas	HFD2	402	287	234	454	409	--	646
F/D 2+yrs West only		--	--	--	--	--	--	--
F/D 2+yrs East only		--	--	--	--	--	--	--
Yrl D/D2+ yrs all areas	HYD2	459	361	148	188	221	--	437
Yrl D/D2+ yrs West only		--	--	--	--	--	--	--
Yrl D/D2+ yrs East only		--	--	--	--	--	--	--
Fawns male/fem all areas	HFMF	1160	1222	972	1123	1253	--	1648
Yrl B/B 2+ yrs early hunts	HYB2							
All areas		1466	404	359	587	408	810	2462
West only		--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--
Yrl B/B 2+ yrs late hunts	HYB2							
All areas		389	568	59	112	178	301	406
West only		--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--

[a] Data not included if <50 harvested, <75 classified, or if from Sept. survey
[b] All areas: hunt areas 1-12
[c] West only: hunt areas 1-6
[d] East only: hunt areas 8-11

Table 1. Deer herd size 1969-1983 and composition data 1953-1984 (all ratios per 1000)[a].

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Summer hrd size (no.)	POP										6584
Pre hunt F/D 1+yrs	OFD										
All areas[b]		--	610	--	--	--	--	943	--	1053	--
West only[c]		--	--	--	--	--	--	--	--	--	--
East only[d]		--	--	--	--	--	--	--	--	--	--
Post hunt F/D 1+yrs	DFD										
All areas		320	644	550	636	724	768	783	773	752	829
West only		320	644	698	636	736	767	760	--	787	--
East only		--	--	--	--	--	769	--	--	--	--
Hunter harvested	HFD1										
F/D 1+yrs all areas		240	285	467	594	584	468	389	374	278	451
F/D 1+yrs West only		247	260	478	610	626	438	381	432	270	444
F/D 1+yrs East only		--	295	--	--	--	--	--	--	--	--
F/D 2+yrs all areas	HFD2	303	358	578	916	881	672	543	481	386	596
F/D 2+yrs West only		--	--	--	--	--	--	--	--	--	--
F/D 2+yrs East only		--	--	--	--	--	--	--	--	--	--
Yrl D/D2+ yrs all areas	HYD2	262	259	237	538	507	436	395	287	391	326
Yrl D/D2+ yrs West only		--	--	--	--	--	--	--	--	--	--
Yrl D/D2+ yrs East only		--	--	--	--	--	--	--	--	--	--
Fawns male/fem all areas	HFMF	1090	727	1297	1224	1682	1077	966	1163	1571	1000
Yrl B/B 2+ yrs early hunts	HYB2										
All areas		975	434	--	--	--	985	1570	867	--	--
West only		--	--	--	--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--	--	--	--
Yrl B/B 2+ yrs late hunts	HYB2										
All areas		538	--	459	1464	1425	1197	573	466	824	806
West only		--	--	--	--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--	--	--	--

[a] Data not included if <50 harvested, <75 classified, or if from Sept. survey
[b] All areas: hunt areas 1-12
[c] West only: hunt areas 1-6
[d] East only: hunt areas 8-11

Table 1. Deer herd size 1969-1983 and composition data 1953-1984 (all ratios per 1000)[a].

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Summer hrd size (no.)	POP	7563	9172	9757	8374	8996	8494	6117	6739	4892	4765
Pre hunt F/D 1+yrs	OFD										
All areas[b]		913	879	944	700	782	867	754	574	631	715
West only[c]		--	1024	977	682	857	866	758	617	664	717
East only[d]		--	--	--	--	--	--	--	512	--	--
Post hunt F/D 1+yrs	DFD										
All areas		689	--	--	--	653	664	674	563	418	633
West only		699	--	--	--	653	664	820	518	418	840
East only		--	--	--	--	--	662	397	645	--	--
Hunter harvested	HFD1										
F/D 1+yrs all areas		441	511	463	534	464	378	352	--	--	--
F/D 1+yrs West only		459	500	473	520	495	365	349	--	--	--
F/D 1+yrs East only		372	500	439	593	380	406	--	--	--	--
F/D 2+yrs all areas	HFD2	605	7489	622	805	767	554	529	--	--	--
F/D 2+yrs West only		664	815	711	873	841	571	617	--	--	--
F/D 2+yrs East only		593	645	755	1043	600	542	--	--	--	--
Yrl D/D2+ yrs all areas	HYD2	373	465	344	510	454	465	500	--	--	--
Yrl D/D2+ yrs West only		352	472	361	510	488	529	617	--	--	--
Yrl D/D2+ yrs East only		500	--	309	500	314	312	--	--	--	--
Fawns male/fem all areas	HFMF	1347	1333	1208	1439	1036	790	850	--	--	--
Yrl B/B 2+ yrs early hunts	HYB2										
All areas		1383	--	--	816	--	1309	10761	636	--	2803
West only		1473	--	--	913	--	1308	412	707	--	2212
East only		1094	--	--	603	--	1236	--	400	--	2368
Yrl B/B 2+ yrs late hunts	HYB2										
All areas		--	729	595	--	920	--	--	--	778	--
West only		--	863	718	--	1029	--	--	--	978	--
East only		--	455	460	--	711	--	--	--	530	--

[a] Data not included if <50 harvested, <75 classified, or if from Sept. survey
[b] All areas: hunt areas 1-12
[c] West only: hunt areas 1-6
[d] East only: hunt areas 8-11

Table 1. Deer herd size 1969-1983 and composition data 1953-1984 (all ratios per 1000)[a].

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Summer hrd size (no.)	POP	7889	9726	12394	9027	14197	24698	23055
Pre hunt F/D 1+yrs	OFD							
All areas[b]		606	730	769	849	785	857	749
West only[c]		743	788	780	880	794	883	738
East only[d]		391	632	750	795	745	948	843
Post hunt F/D 1+yrs	DFD							
All areas		702	922	711	869	801	699	748
West only		702	922	683	884	710	625	743
East only		--	--	750	817	928	879	807
Hunter harvested	HFD1							
F/D 1+yrs all areas		--	--	--	--	--	--	
F/D 1+yrs West only		--	--	--	--	--	42.8	
F/D 1+yrs East only		--	--	--	--	--	--	
F/D 2+yrs all areas	HFD2	--	--	--	--	--	--	
F/D 2+yrs West only		--	--	--	--	--	62.3	
F/D 2+yrs East only		--	--	--	--	--	--	
Yrl D/D2+ yrs all areas	HYD2	--	--	--	--	--	--	
Yrl D/D2+ yrs West only		--	--	--	--	--	35.1	
Yrl D/D2+ yrs East only		--	--	--	--	--	--	
Fawns male/fem all areas	HFMF	--	--	--	--	--	--	--
Yrl B/B 2+ yrs early hunts	HYB2							
All areas		1789	2747	1880	4245	3146	DNA	DNA
West only		1896	3208	2153	4680	3549		
East only		1828	2000	1262	2889	1737		
Yrl B/B 2+ yrs late hunts	HYB2							
All areas		--	--	--	1174	1350	DNA	DNA
West only		--	--	--	1180	1790		
East only		--	--	--	528	359		

[a] Data not included if <50 harvested, <75 classified, or if from Sept. survey
[b] All areas: hunt areas 1-12
[c] West only: hunt areas 1-6
[d] East only: hunt areas 8-11

Table 2. Yearling buck mean carcass weights and antler points by hunt areas

Variable	Code	1953	1954	1955	1956	1957	1958	1959
Carcass lbs.	YCW							
All hunt dates								
All areas		--	--	--	--	--	--	85.7
West only		--	--	--	--	--	--	85.7
East only		--	--	--	--	--	--	--
Late hunts only								
All areas		--	--	--	--	--	--	86.7
West only		--	--	--	--	--	--	86.7
East only		--	--	--	--	--	--	--
Points/1000 Bucks	YMP							
All hunt dates								
All areas		--	--	--	--	--	--	--
West only		--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--
Antler Classes %								
Spikes only	YSPT							
All areas		13.1	46.9	53.8	13.0	9.2	9.0	0
West only		--	--	--	--	--	--	0
East Only		--	--	--	--	--	--	--
2 points only	YFK							
All areas		72.8	48.5	42.3	74.8	79.3	67.0	75.6
West only		--	--	--	--	--	--	75.6
East only		--	--	--	--	--	--	--
3+ points only	Y3PT							
All areas		14.1	4.6	3.9	12.2	11.5	24.0	24.4
West only		--	--	--	--	--	--	24.4
East only		--	--	--	--	--	--	--

Table 2. Yearling buck mean carcass weights and antler points by hunt areas

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Carcass lbs.	YCW										
All hunt dates											
All areas		--	108.6	--	--	--	99.8	88.6	98.1	97.6	99.4
West only		--	107.9	--	--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--	--	--	--
Late hunts only											
All areas		--	--	--	--	--	96.8	85.0	96.2	97.6	99.4
West only		--	--	--	--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--	--	--	--
Points/1000 Bucks	YMP										
All hunt dates											
All areas		--	--	--	--	--	--	--	--	--	--
West only		--	--	--	--	--	--	--	--	--	--
East only		--	--	--	--	--	--	--	--	--	--
Antler Classes %											
Spikes only	YSPT										
All areas		10.7	2.1	11.7	6.3	1.5	3.0	8.2	12.7	6.4	13.0
West only		--	3.7	--	--	--	--	--	--	--	--
East Only		--	0	--	--	--	--	--	--	--	--
2 points only	YFK										
All areas		66.4	83.0	58.4	76.7	57.9	67.0	69.7	66.8	61.7	77.5
West only		--	81.5	--	--	--	--	--	--	--	--
East only		--	80.0	--	--	--	--	--	--	--	--
3+ points only	Y3PT										
All areas		22.9	14.9	29.9	17.0	40.6	30.0	22.1	20.5	31.9	9.5
West only		--	14.8	--	--	--	--	--	--	--	--
East only		--	20.0	--	--	--	--	--	--	--	--

Table 2. Yearling buck mean carcass weights and antler points by hunt areas

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Carcass lbs.	YCW										
All hunt dates											
All areas		102.5	102.8	99.6	98.3	92.2	102.0	97.1	95.7	98.2	100.5
West only		103.1	104.3	100.4	98.5	93.6	103.2	99.0	96.6	100.4	100.7
East only		--	98.1	97.1	96.1	86.1	98.5	--	--	92.6	99.7
Late hunts only											
All areas		--	102.8	99.6	--	92.2	--	--	--	98.2	--
West only		--	104.3	100.4	--	93.6	--	--	--	100.4	--
East only		--	98.1	97.1	--	86.1	--	--	--	92.6	--
Points/1000 Bucks	YMP										
All hunt dates											
All areas		4308	4251	4229	4387	4059	4073	4094	4070	4214	4062
West only		4343	4301	4299	4380	4075	4071	4153	4015	4264	4061
East only		4171	4050	4097	4413	4000	4096	--	--	4114	4044
Antler Classes %											
Spikes only	YSPT										
All areas		4.0	4.8	3.8	7.9	8.8	8.8	5.9	7.9	5.2	11.4
West only		3.7	4.9	1.7	6.7	8.0	8.7	4.2	8.6	2.3	9.1
East Only		5.7	2.5	8.1	8.7	8.6	9.8	16.7	6.2	16.7	17.8
2 points only	YFK										
All areas		66.5	69.0	72.7	59.0	70.3	65.3	63.5	77.5	66.1	64.1
West only		65.7	65.0	73.5	60.3	70.4	65.0	62.5	75.7	72.4	66.9
East only		71.4	87.5	72.6	54.3	72.4	67.4	75.0	81.2	41.7	57.8
3+ points only	Y3PT										
All areas		29.5	26.2	23.5	33.1	20.9	25.9	30.6	14.6	28.7	24.5
West only		30.6	30.1	24.8	33.0	21.6	26.2	32.0	15.7	25.3	24.0
East only		22.9	10.0	19.4	37.0	19.0	22.8	8.3	12.5	41.7	24.4

Table 2. Yearling buck mean carcass weights and antler points by hunt areas

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Carcass lbs.	YCW							
All hunt dates								
All areas		105.6	107.8	110.4	110.1	106.8	93.5	89.8
West only		104.9	108.6	110.7	110.0	106.9	93.7	91.0
East only		108.6	106.5	108.9	107.0	102.0	90.0	85.2
Late hunts only								
All areas		--	--	--	110.0	106.4	92.9	
West only		--	--	--	109.9	106.3	93.2	
East only		--	--	--	108.2	100.7	89.8	
Points/1000 Bucks	YMP							
All hunt dates								
All areas		4335	4495	4378	4382	4355	4161	3565
West only		4293	4502	4335	4327	4351	4173	3557
East only		4453	4473	4510	4539	4180	4085	3558
Antler Classes %								
Spikes only	YSPT							
All areas		6.4	2.6	4.0	4.7	4.0	8.0	
West only		7.1	3.2	4.0	5.67	4.1	8.0	
East only		3.8	1.1	3.9	1.1	3.4	8.1	
2 points only	YFK							
All areas		59.7	64.0	64.7	60.0	64.6	67.7	
West only		59.9	61.4	66.5	60.5	64.3	67.0	
East only		60.4	67.4	61.1	62.2	75.0	71.0	
3+ points only	Y3PT							
All areas		33.9	33.4	31.3	35.3	31.4	24.3	14.3
West only		33.0	35.4	29.5	33.9	31.6	25.0	14.1
East only		35.8	31.5	35.0	36.7	21.6	20.8	14.7

Table 3. Mean carcass weights and antler characteristics of bucks age 2 1/2, 3 1/2, years 1971-86 (n ≥ 10.)

Variable	Code	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Bucks 2 1/2 yrs carcass lbs	BCW2														
West[1] only all hunt dates		140.7	136.8	139.6	128.3	141.3	131.7	133.2	134.2	146.3	144.7	150.5	149.6	155.2	151.4
East[2] only all hunt dates		137.5	127.8	130.6	116.3	140.9	130.6	126.2	--	--	--	145.1	148.2	152.4	149.1
Bucks 2 1/2 yrs antler points 1000 bucks	BMP2														
West only all hunt dates		7196	7286	7337	7048	7076	6920	6778	6600	7179	7141	7514	7413	7387	7230
East only all hunt dates		7160	6684	7250	6460	6355	7000	6550	6412	--	7071	7083	7274	7732	7110
Bucks 2 1/2 yrs antler spread inches	BSP2														
West only all hunt dates		--	--	--	--	--	18.4	17.5	18.8	19.0	18.9	19.9	19.5		
East only all hunt dates		--	--	--	--	--	18.6	16.5	16.3	--	18.7	19.1	20.3		
Bucks 3 1/2 yrs carcass lbs	BCW3														
West only all hunt dates		164.3	161.3	165.3	146.2	165.5	163.0	161.8	--	161.9	173.9		180.6	180.3	181.6
East only all hunt dates		146.8	154.1	155.3	143.7	161.2	--	--	--	--	--	--	175.2	185.3	175.5
Bucks 3 1/2 yrs antler points 1000 bucks	BMP3														
West only all hunt dates		7542	8071	8717	7538	7977	8538	8286	8250	7923	8263	8636	8454	8978	8650
East only all hunt dates		8083	8543	7467	7349	8000	--	--	8000	--	--	--	9154	9654	8910
Bucks 3 1/2 yrs antler spread inches	BSP3														
West only all hunt dates		--	--	--	--	--	21.6	23.1	22.9	21.7	22.6	23.2	23.5		26.39
East only all hunt dates		--	--	--	--	--	23.0	22.3	21.6	--	--	--	25.5		24.13

Table 4. Deer hunt success and no. deer harvested by any deer

Variable	Code	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Any deer/hunter	SSAD												
All deer dates		845	757	560	622	614	596	553	401	313	465	547	580
Early hunt		838	740	538	593	551	614	532	335	313	--	--	--
Late hunt		856	779	611	672	655	579	580	491	--	46.5	547	580
Bucks/hunter day	BHDAD												
All hunt dates		194	148	82	95	127	77	72	64	36	83	92	
Early hunt		170	127	68	76	94	80	62	44	36	--	--	--
Late hunt		217	172	114	123	160	74	83	88	--	83	92	119
No. deer taken													
Fawns m & f	FHAD	613	712	209	414	374	941	483	140	114	171	239	296
Does	DHAD	2226	3373	1025	1084	1117	2599	1796	583	400	366	402	507
Bucks	BHAD	3214	3973	1086	1189	1748	2236	1385	785	296	666	787	1039
Early hunt													
Fawns m & f		377	408	170	331	240	573	297	91	114	--	--	--
Does		1300	1881	781	731	605	1336	1060	347	400	--	--	--
Bucks		1393	1778	621	558	647	994	628	291	296	--	--	--
Late hunt													
Fawns m & f		236	304	39	83	134	368	186	49	--	171	239	296
Does		926	1492	244	353	512	1263	736	236	--	366	402	507
Bucks		1821	2195	465	631	1101	1242	757	494	--	666	787	1039
Deer/hunter day	DHAD												
All hunt dates		365	301	176	215	236	199	190	124	98	151	168	211

Table 4. Deer hunt success and no. deer harvested by any deer (continued)

Variable	Code	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Any deer/hunter	SSAD												
All deer dates		381	497	220	376	441	403	484	476	512	460	446	549
Early hunt		371	517	236	--	--	403	--	--	512	--	446	549
Late hunt		391	476	206	376	441	--	484	476	--	460	--	--
Bucks/hunter day	BHDAD												
All hunt dates		54	74	25	68	81	57	100	94	97	69	72	77
Early hunt		65	74	26	--	--	57	--	--	97	--	72	77
Late hunt		45	73	24	68	81	--	100	94	--	69	--	--
No. deer taken													
Fawns m & f	FHAD	406	465	225	54	96	115	113	107	140	169	112	68
Does	DHAD	867	1194	602	194	213	261	221	231	262	364	294	193
Bucks	BHAD	1065	1410	561	352	392	308	517	509	517	588	510	287
Early hunt													
Fawns m & f		195	304	140	--	--	115	--	--	140	--	112	68
Does		426	708	334	--	--	261	--	--	262	--	296	193
Bucks		541	643	243	--	--	308	--	--	514	--	510	287
Late hunt													
Fawns m & f		211	161	85	54	96	--	113	107	--	169	--	--
Does		441	746	268	194	213	--	221	231	--	364	--	--
Bucks		524	767	318	352	392	--	517	509	--	588	--	--
Deer/hunter day	DHAD												
All hunt dates		118	160	61	117	146	127	164	156	172	143	167	147

Table 5. Deer hunt success and no. bucks harvested by buck only permittees 1974-1985 (all ratios per 1000).

Variable	Code	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Bucks/hunter	SSBO												
All hunt dates		379	298	328	218	269	225	288	354	301	355	449	493
Early hunt		--	298	328	218	--	225	288	354	301	329	506	482
Late hunt		379	--	--	--	269	--	-	--	--	387	391	506
Bucks/hunter day	BHDBO												
All hunt dates		90	73	70	53	69	51	64	83	69	90	109	122
Early hunt		--	73	70	53	--	51	64	83	69	85	144	123
Late hunt		90	--	--	--	69	--	--	--	--	95	82	121
No. bucks taken	BHBO												
All hunt dates		159	211	116	342	410	272	424	769	1010	1289	1490	1485
Early hunt		--	211	116	342	--	272	424	769	1010	657	848	778
Late hunt		159	--	--	--	410	--	--	--	--	632	642	707

Table 6. Winter severity indexes 1970-1979

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
West intermediate range Table Rock elev 6500 ft											
Snow cover days	SNOW										
Dec-Jan		3	21	32	58	29	35	39	19	15	62
Nov-Mar		9	31	38	125	41	77	45	19	21	116
Mean daily temp °F											
Dec-Jan	TEMP1	32.8	32.8	30.5	28.2	32.3	30.0	37.2	36.1	37.8	26.4
Dec-Mar	TEMP2	34.7	34.9	37.4	30.2	35.5	32.2	38.4	38.0	39.2	31.4
Mean daily low °F											
Dec-Jan	TEMP3	21.2	22.3	20.8	18.4	22.4	20.8	25.4	24.0	29.3	18.4
Dec-Mar	TEMP4	23.0	23.7	25.7	21.0	24.8	22.2	26.9	25.0	30.0	22.5
Mean daily high°F											
Dec-Jan	TEMP5	44.3	43.6	40.2	38.0	42.2	42.0	48.8	48.2	56.2	36.9
Dec-Mar	TEMP6	46.4	46.1	49.1	39.2	46.2	43.2	50.0	50.9	48.3	41.4
Wind run Dec-Mar miles	WIND	--	23154	23081	19506	22070	22036	17499	18902	21945	14089
East winter range Buck farm elev 6100 ft											
Mean daily temp °											
Dec-Jan	TEMP1	--	31.4	29.8	24.6	28.4	27.6	--	29.9	--	22.6
Dec-Mar	TEMP2	--	35.0	37.2	28.6	32.9	30.8	--	33.6	--	--
Mean daily low °F											
Dec-Jan	TEMP3	--	19.5	18.6	13.0	17.8	16.1	--	17.4	--	12.5
Dec-Mar	TEMP4	--	22.4	24.7	18.2	21.8	19.8	--	20.5	--	--
Mean daily high °F											
Dec-Jan	TEMP5	--	43.4	41.0	36.3	38.9	39.2	--	42.3	--	32.6
Dec-Mar	TEMP6	--	47.6	49.9	39.0	44.1	40.1	--	46.8	--	--
Wind run Dec-Mar miles	WIND	24028	22450	18458	19102	20015	18435	18674	16425	13311	16488

Table 6. Winter severity indexes 1980-1986 (continued)

Variable	Code	1980	1981	1982	1983	1984	1985	1986
West intermediate range Table Rock elev 6500 ft								
Snow cover days	SNOW							
Dec-Jan		7	4	38	28	12	45	1
Nov-Mar		22	14	61	45	27	58	21
Mean daily temp °F								
Dec-Jan	TEMP1	36.3	41.4	35.0	--	--		
Dec-Mar	TEMP2	36.8	40.0	35.8				
Mean daily low °F								
Dec-Jan	TEMP3	27.8	30.8	25.9	--	--		
Dec-Mar	TEMP4	27.9	29.6	26.5	--	--		
Mean daily high°F								
Dec-Jan	TEMP5	44.8	52.0	44.4	--	--		
Dec-Mar	TEMP6	45.6	50.3	45.0	--	--		
Wind run Dec-Mar miles	WIND	23860	23298	--	--	--		
East winter range Buck farm elev 6100 ft								
Mean daily temp °								
Dec-Jan	TEMP1	32.5	39.1	32.9	--	--		
Dec-Mar	TEMP2	--	39.4	35.1	--	--		
Mean daily low °F								
Dec-Jan	TEMP3	23.1	27.0	22.4	--	--		
Dec-Mar	TEMP4	--	51.8	24.6	--	--		
Mean daily high °F								
Dec-Jan	TEMP5	41.8	51.2	43.4	--	--		
Dec-Mar	TEMP6	--	51.8	45.6	--	--		
Wind run Dec-Mar miles	WIND	16488	20224	--	--	--		

Table 7. Precipitation (inches) mean of 3 stations AGF on west winter range 1970-1979.

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	4.39	5.49	4.22	17.71	5.83	11.49	7.17	4.32	13.19	18.82
Summer Jun-Aug 3 mo	SP	1.786	2.97	4.48	1.79	2.11	2.15	2.15	2.17	.66	1.90
Water year Oct-Sep 12 mo	YP	6.87	8.62	9.52	19.50	8.26	14.24	10.63	7.21	14.62	20.73
Fall Sep-Oct only 2 mo	FP	.87	1.87	5.19	.05	2.56	.70	2.00	1.19	2.80	.46
Water year plus preceding summer 16 mo	YSP	10.17	--	12.65	24.80	10.05	16.67	13.38	10.67	17.50	22.15
Water year plus preceding water years 24 mo	Y2P	14.91	--	18.14	29.02	27.76	22.50	24.87	11.34	21.83	35.35
Water year plus preceding water years 36 mo	Y3P	21.17	--	--	37.64	37.28	42.00	33.13	32.08	32.46	42.56
Nov-Mar 5 mo		--	3.74	1.92	10.04	5.50	7.05	4.51	1.45	10.81	15.07

Precipitation (inches) mean of 3 stations AGF on west winter range 1980-1986

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	14.30	8.43	9.99	11.97	6.66	9.40	8.73
Summer Jun-Aug 3 mo	SP	2.93	4.28	4.48	4.76	7.79	1.60	3.27
Water year Oct-Sep 12 mo	YP	18.09	14.20	16.28	19.71	14.45	11.89	14.52
Fall Sep-Oct only 2 mo	FP	2.28	2.91	2.61	3.42	.86	1.60	4.10
Water year plus preceding summer 16 mo	YSP	19.99	17.99	22.05	25.94	21.37	18.50	16.37
Water year plus preceding water years 24 mo	Y2P	38.82	32.29	30.48	35.99	34.16	26.34	26.41
Water year plus preceding water years 36 mo	Y3P	53.44	53.02	48.57	50.19	50.44	46.05	40.86
Nov-Mar 5 mo		12.19	3.87	7.40	10.47	5.08	7.40	6.76

[1] Cedar Knoll 1970 record alone, not a mean of other stations.

Table 8. Precipitation (inches) mean of 3 stations AGF on east winter range 1971-1979.

Variable	Code	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	4.12	4.25	14.69	5.28	9.67	7.73	2.20	9.37	17.56
Summer Jun-Aug 3 mo	SP	3.02	3.09	1.92	1.97	2.94	2.25	3.46	.66	1.10
Water year Oct-Sep 12 mo	YP	7.14	7.97	16.75	7.44	13.93	11.60	5.85	11.47	18.71
Fall Sep-Oct only 2 mo	FP	1.51	6.46	.28	2.57	1.55	1.78	.78	2.47	1.40
Water year plus preceding summer 16 mo	YSP	--	10.99	20.67	9.50	16.09	15.86	9.72	15.12	20.81
Water year plus preceding water years 24 mo	Y2P	--	15.11	24.72	24.19	21.37	25.53	17.45	17.32	30.18
Water year plus preceding water years 36 mo	Y3P	--	--	31.86	32.16	38.12	32.97	31.38	28.92	36.03
Nov-Mar 5 mo		3.09	1.92	8.38	4.77	5.78	5.20	1.47	7.52	15.08

Precipitation (inches) mean of 3 stations AGF on east winter range 1980-1986

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	13.70	6.07	11.38	10.12	5.56	9.05	7.17
Summer Jun-Aug 3 mo	SP	3.07	6.66	5.48	5.16	4.84	2.81	3.92
Water year Oct-Sep 12 mo	YP	17.97	13.26	17.64	18.08	10.40	12.80	12.92
Fall Sep-Oct only 2 mo	FP	1.60	2.59	1.71	2.80	1.03	1.67	2.70
Water year plus preceding summer 16 mo	YSP	19.12	17.53	24.83	24.34	18.06	17.38	16.66
Water year plus preceding water years 24 mo	Y2P	36.68	31.23	30.90	35.72	28.48	23.20	25.72
Water year plus preceding water years 36 mo	Y3P	48.15	49.94	48.87	48.98	46.12	41.28	36.12
Nov-Mar 5 mo		10.70	3.45	6.52	7.88	4.76	6.90	4.74

Table 9. Precipitation (inches) mean of 9 stations AGF on winter and intermediate ranges W, N, E, 1971-1979.

Variable	Code	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	5.78	4.59	16.48	6.12	12.03	7.84	3.50	12.04	19.25
Summer Jun-Aug 3 mo	SP	3.96	4.49	1.92	1.94	2.91	2.34	3.45	0.83	1.52
Water year Oct-Sep 12 mo	YP	9.85	9.98	18.45	8.30	15.89	11.68	7.49	14.05	20.86
Fall Sep-Oct only 2 mo	FP	1.80	5.79	0.17	2.51	1.15	1.87	1.07	2.92	0.83
Water year plus preceding summer 16 mo	YSP	--	14.05	23.84	10.27	18.07	15.54	11.33	18.04	22.87
Water year plus preceding water years 24 mo	Y2P	--	19.83	28.43	26.75	24.19	27.57	19.17	21.54	34.91
Water year plus preceding water years 36 mo	Y3P	--	--	38.28	36.73	42.64	35.87	35.06	33.22	42.40
Nov-Mar 5 mo		4.08	2.27	9.94	5.65	7.48	5.14	1.59	9.75	15.67

Precipitation (inches) mean of 9 stations AGF on winter and intermediate ranges W, N, E, 1980-1986

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	15.05	8.69	10.69	12.21	7.05	10.55	8.85
Summer Jun-Aug 3 mo	SP	3.14	5.33	6.21	5.61	6.77	2.24	3.45
Water year Oct-Sep 12 mo	YP	19.26	15.49	18.19	20.34	14.48	13.51	14.61
Fall Sep-Oct only 2 mo	FP	2.09	3.14	2.15	3.34	1.06	1.49	3.65
Water year plus preceding summer 16 mo	YSP	20.87	19.70	24.99	27.84	22.50	20.02	17.19
Water year plus preceding water years 24 mo	Y2P	40.12	34.75	33.68	38.53	34.82	27.99	28.12
Water year plus preceding water years 36 mo	Y3P	54.17	55.61	52.94	54.02	53.01	48.33	42.60
Nov-Mar 5 mo		12.32	4.30	7.88	9.76	5.82	7.49	6.47

Table 10. Precipitation (inches) mean of 3, 4 stations[1], 20-50 miles west from Kaibab Plateau, 1951-1959

Variable	Code	1951	1952	1953	1954	1955	1956	1957	1958	1959
Winter Oct-May 8 mo	WP	4.75	10.91	3.82	7.77	4.55	4.59	7.56	12.20	3.61
Summer Jun-Aug 3 mo	SP	3.85	3.16	5.09	2.24	3.92	1.68	3.63	1.49	3.14
Water year Oct-Sep 12 mo	YP	9.30	15.12	8.95	11.28	8.48	6.28	11.19	17.96	7.04
Fall Sep-Oct only 2 mo	FP	1.47	0.92	0.42	4.92	tr.	0.63	3.16	3.96	1.32
Water year plus preceding water year 16 mo	YSP	13.22	19.68	13.03	16.41	11.99	10.20	12.89	21.59	11.81
Water year plus preceding water years 24 mo	Y2P	--	24.42	24.07	20.23	19.76	14.76	17.47	29.15	25.00
Water year plus 2 preceding water years 36 mo	Y3P	--	--	33.37	35.35	28.71	26.04	25.95	35.43	36.19
Nov-Mar 5 mo		2.65	7.98	3.04	6.71	4.26	3.99	4.75	8.46	2.76

Precipitation (inches) mean of 3, 4 stations[1] 20-50 miles west from Kaibab Plateau, 1960-1969

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Winter Oct-May 8 mo	WP	7.45	5.79	6.27	4.95	6.27	8.44	8.73	9.71	5.82	10.73
Summer Jun-Aug 3 mo	SP	1.33	3.32	0.68	3.37	1.94	1.52	1.63	4.12	4.28	4.33
Water year Oct-Sep 12 mo	YP	10.05	9.66	8.90	9.64	8.51	10.51	10.97	16.66	10.18	16.14
Fall Sep-Oct only 2 mo	FP	2.78	0.70	3.16	3.00	0.40	1.16	1.22	2.89	0.44	1.55
Water year plus preceding water year 16 mo	YSP	13.43	12.26	12.77	12.29	13.48	12.75	13.03	18.90	17.15	20.50
Water year plus preceding water years 24 mo	Y2P	17.09	19.71	18.56	18.54	18.15	19.02	21.48	27.63	26.84	26.32
Water year plus 2 preceding water years 36 mo	Y3P	35.05	26.75	28.61	28.20	27.05	28.66	29.99	38.14	37.81	42.98
Nov-Mar 5 mo		5.19	3.60	5.82	3.03	3.12	3.58	7.16	7.65	4.77	9.32

[1] Tuweep, Pipe Spring, Fredonia, Kanab elevations 4675-4985 ft.

Table 10. Precipitation (inches) mean of 3, 4 stations[1] , 20-50 miles west from Kaibab Plateau, 1970-1979

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	4.68	4.44	4.30	13.21	4.72	9.79	7.08	3.94	14.04	15.86
Summer Jun-Aug 3 mo	SP	4.13	4.18	2.58	2.49	1.18	3.40	3.48	2.44	0.98	1.73
Water year Oct-Sep 12 mo	YP	9.28	9.10	7.97	15.70	6.49	14.15	10.85	6.88	15.69	17.64
Fall Sep-Oct only 2 mo	FP	0.54	1.57	4.30	0.02	2.57	1.00	2.59	1.18	1.80	0.58
Water year plus preceding water year 16 mo	YSP	14.69	13.71	12.65	19.21	8.98	15.70	14.88	12.28	18.55	19.17
Water year plus preceding water years 24 mo	Y2P	25.42	18.38	17.07	23.67	22.19	20.64	25.00	17.73	22.57	33.33
Water year plus 2 preceding water years 36 mo	Y3P	35.60	34.52	31.76	32.77	30.16	36.34	31.49	31.88	33.42	40.21
Nov-Mar 5 mo		3.89	3.14	2.42	9.14	4.26	5.32	4.23	1.83	11.72	13.55

Precipitation (inches) mean of 3, 4 stations[1] 20-50 miles west from Kaibab Plateau, 1980-1986

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	15.21	7.45	8.45	11.64	4.23	6.84	9.17
Summer Jun-Aug 3 mo	SP	2.80	3.04	4.20	3.51	5.83	1.46	3.17
Water year Oct-Sep 12 mo	YP	18.73	11.50	14.33	16.11	10.67	11.26	13.76
Fall Sep-Oct only 2 mo	FP	2.10	3.35	2.46	2.82	.91	2.05	3.32
Water year plus preceding water year 16 mo	YSP	20.5	15.20	18.51	22.14	16.47	13.91	16.41
Water year plus preceding water years 24 mo	Y2P	36.37	30.23	25.83	30.44	26.78	21.93	25.02
Water year plus 2 preceding water years 36 mo	Y3P	52.06	47.87	44.56	41.94	41.11	38.04	35.69
Nov-Mar 5 mo		12.99	4.10	5.19	8.56	3.38	6.99	8.31

Table 11. Precipitation (inches) at Jacob Lake on kaibab summer deer habitat elevation 7920 ft

Variable	Code	1951	1952	1953	1954	1955	1956	1957	1958	1959
Winter Oct-May 8 mo	WP	6.54+	--	--	--	--	--	8.25	--	--
Summer Jun-Aug 3 mo	SP	8.15	--	--	--	--	3.90	4.27	--	--
Water year Oct-Sep 12 mo	YP	--	--	--	--	--	--	13.11	--	--
Fall Sep-Oct only 2 mo	FP	--	--	--	--	0.00	T	3.92	--	--
Water year plus preceding summer 16 mo	YSP	--	--	--	--	--	--	17.97	--	--
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	--	--	--	--	--
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	--	--	--	--

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Winter Oct-May 8 mo	WP	--	14.06+	--	10.06	14.65	17.67	12.40	11.48	7.46	11.01
Summer Jun-Aug 3 mo	SP	--	--	0.62+	7.09	5.37	2.83	5.29	7.40	8.90	7.22
Water year Oct-Sep 12 mo	YP	--	--	--	18.99	20.75	21.34	18.44	21.88	17.16	19.60
Fall Sep-Oct only 2 mo	FP	5.95	--	2.71	3.18	0.73	1.50	1.40	3.00	1.28	3.26
Water year plus preceding summer 16 mo	YSP	--	--	--	27.92	26.85	25.01	24.48	32.28	26.86	28.15
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	39.74	42.09	39.78	40.32	39.04	36.76
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	61.08	60.53	61.66	57.48	58.64

Table 11. Precipitation (inches) at Jacob Lake on kaibab summer deer habitat elevation 7920 ft (continued)

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	8.53	11.60	7.27	27.32	--	--	--	--	--	--
Summer Jun-Aug 3 mo	SP	6.88	7.31	8.80	2.63	4.24	6.78	2.67	3.66	1.61	2.16
Water year Oct-Sep 12 mo	YP	16.65	19.51	18.77	30.09	--	--	--	--	--	--
Fall Sep-Oct only 2 mo	FP	2.18	3.04	10.04	0.42	2.10	2.32	--	--	--	--
Water year plus preceding summer 16 mo	YSP	24.77	27.42	29.17	32.86	--	--	--	--	--	--
Water year plus preceding water years 24 mo	Y2P	36.25	36.16	38.28	48.86	--	--	--	--	--	--
Water year plus 2 preceding water years 36 mo	Y3P	53.41	55.76	54.93	69.37	--	--	--	--	--	--

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	--	--	14.89	16.73	12.48	15.51	13.13
Summer Jun-Aug 3 mo	SP	2.42	8.29	7.74	9.05	14.45	3.76	3.61
Water year Oct-Sep 12 mo	YP	--	--	--	29.04	27.08	19.15	18.50
Fall Sep-Oct only 2 mo	FP	--	--	3.57	4.78	1.98	1.81	3.68
Water year plus preceding summer 16 mo	YSP	--	--	--	41.35	39.39	22.29	23.87
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	56.12	46.23	37.65
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	75.27	64.73

Table 12. Precipitation (inches) at Bright Angel GCNP North Rim on Kaibab summer deer habitat elevation 8400 ft.

Variable	Code	1951	1952	1953	1954	1955	1956	1957	1958	1959
Winter Oct-May 8 mo	WP	9.43	3.79	8.67	5.27	8.27	5.07	8.47	3.85	5.78
Summer Jun-Aug 3 mo	SP	--	--	--	--	--	--	--	--	--
Water year Oct-Sep 12 mo	YP	--	--	--	--	--	--	--	--	--
Fall Sep-Oct only 2 mo	FP	3.17	2.92	1.24	2.41	0.02	1.57	3.35	--	--
Water year plus preceding summer 16 mo	YSP	--	--	--	--	--	--	--	--	--
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	--	--	--	--	--
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	--	--	--	--

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Winter Oct-May 8 mo	WP	4.00	7.02	4.05	8.25	4.78	4.89	--	--	--	--
Summer Jun-Aug 3 mo	SP	--	--	--	--	--	--	7.01	6.04	6.44	5.23
Water year Oct-Sep 12 mo	YP	--	--	--	--	--	--	--	--	--	--
Fall Sep-Oct only 2 mo	FP	7.76	1.96	2.27	3.16	1.08	3.87	2.27	3.84	1.01	1.31
Water year plus preceding summer 16 mo	YSP	--	--	--	--	--	--	--	--	--	--
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	--	--	--	--	--	--
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	--	--	--	--	--

Table 12. Precipitation (inches) at Bright Angel GCNP North Rim on Kaibab summer deer habitat elevation 8400 ft. (continued)

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	--	--	--	--	--	--	--	--	--	--
Summer Jun-Aug 3 mo	SP	3.91	2.57	2.76	2.13	1.81	4.09	2.09	5.12	1.04	3.27
Water year Oct-Sep 12 mo	YP	--	--	--	--	--	--	--	--	--	--
Fall Sep-Oct only 2 mo	FP	1.38	3.18	--	0.77	4.41	1.48	3.12	2.60	3.77	2.62
Water year plus preceding summer 16 mo	YSP	--	--	--	--	--	--	--	--	--	--
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	--	--	--	--	--	--
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	--	--	--	--	--

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	--	--	--	--	--	--	--
Summer Jun-Aug 3 mo	SP	4.87	6.04	5.53	6.44	6.47	4.21	2.84
Water year Oct-Sep 12 mo	YP	--	--	--	--	--	--	--
Fall Sep-Oct only 2 mo	FP	4.18	4.32	2.39	--	3.07	2.85	--
Water year plus preceding summer 16 mo	YSP	--	--	--	--	--	--	--
Water year plus preceding water years 24 mo	Y2P	--	--	--	--	--	--	--
Water year plus 2 preceding water years 36 mo	Y3P	--	--	--	--	--	--	--

Table 13. Precipitation (inches) at GCNP South Rim elevation 6950 ft.

Variable	Code	1951	1952	1953	1954	1955	1956	1957	1958	1959
Winter Oct-May 8 mo	WP	4.69	15.37	5.38	6.56	5.36	4.51	10.80	14.82	6.28
Summer Jun-Aug 3 mo	SP	4.51	4.70	6.77	3.22	6.01	2.62	--	3.10	2.93
Water year Oct-Sep 12 mo	YP	12.95	22.59	12.15	12.53	11.42	7.13	--	21.77	9.49
Fall Sep-Oct only 2 mo	FP	3.75	2.52	0.39	3.11	0.05	1.09	3.37	4.15	1.62
Water year plus preceding summer 16 mo	YSP	18.71	29.81	18.92	18.50	17.48	9.75	--	28.72	12.90
Water year plus preceding water years 24 mo	Y2P	25.77	35.54	34.74	24.68	23.95	18.55	--	--	31.26
Water year plus 2 preceding water years 36 mo	Y3P	43.50	48.36	47.69	47.27	36.10	31.08	--	--	--
Nov-Mar 5 mo		3.15	10.51	4.44	4.83	4.50	3.94	6.37	9.33	3.61

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Winter Oct-May 8 mo	WP	12.17	10.22	8.35	6.60	7.67	13.62	9.31	10.08	7.60	11.10
Summer Jun-Aug 3 mo	SP	2.07	5.82	2.98	6.37	2.92	1.75	5.14	4.25	6.22	3.99
Water year Oct-Sep 12 mo	YP	16.50	17.48	11.91	14.76	10.87	17.36	14.99	17.73	13.82	16.83
Fall Sep-Oct only 2 mo	FP	6.00	1.64	1.94	2.63	0.28	2.44	1.96	2.88	0.50	2.80
Water year plus preceding summer 16 mo	YSP	20.83	24.74	15.47	22.92	14.07	21.10	20.67	24.66	20.04	22.56
Water year plus preceding water years 24 mo	Y2P	25.99		29.39	26.67	25.63	28.23	32.35	32.72	31.55	30.65
Water year plus preceding water years 36 mo	Y3P	47.76	43.47	45.89	44.15	37.54	42.99	43.22	50.08	46.54	48.38
Nov-Mar 5 mo		9.17	5.71	10.63	3.99	3.88	7.39	7.79	8.16	5.42	9.52

Table 13. Precipitation (inches) at GCNP South Rim elevation 6950 ft. (continued)

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Winter Oct-May 8 mo	WP	9.35	4.56	2.75	17.85	6.49	11.62	6.38	3.20	14.69	20.53
Summer Jun-Aug 3 mo	SP	4.38	4.39	4.94	2.86	5.09	3.50	1.38	4.27	1.38	2.64
Water year Oct-Sep 12 mo	YP	14.46	8.95	8.86	20.98	12.23	14.96	10.08	8.51	16.18	12.17
Fall Sep-Oct only 2 mo	FP	0.99	1.51	7.26	0.43	2.80	0.99	2.44	--	1.87	1.32
Water year plus preceding summer 16 mo	YSP	19.57	13.34	14.97	24.11	17.97	19.27	13.78	13.26	18.32	25.81
Water year plus preceding water years 24 mo	Y2P	31.29	23.41	17.81	29.84	33.21	27.19	25.04	18.59	24.69	39.35
Water year plus 2 preceding water years 36 mo	Y3P	45.11	40.24	32.27	38.79	42.07	48.17	37.27	33.55	34.77	47.86
Nov-Mar 5 mo		7.86	3.57	0.95	11.28	5.62	7.21	4.35	1.60	12.73	17.34

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Winter Oct-May 8 mo	WP	14.50	8.91	13.93+	15.65	--	12.26	11.63
Summer Jun-Aug 3 mo	SP	5.48	7.74	4.99	6.36	7.62	1.68	2.55
Water year Oct-Sep 12 mo	YP	20.89	19.81	18.69	24.70	--	15.22	15.46
Fall Sep-Oct only 2 mo	FP	2.87	4.75	2.65	3.61	--	2.09	3.23
Water year plus preceding summer 16 mo	YSP	27.28	30.71	25.37	33.75	--	23.30	18.42
Water year plus preceding water years 24 mo	Y2P	44.06	40.70	38.50	43.39	--	--	30.68
Water year plus 2 preceding water years 36 mo	Y3P	60.24	63.87	59.39	63.20	--	--	--
Nov-Mar 5 mo		11.63	4.81	7.50	13.38	--	9.73	8.24

Table 14. Hunter permits (no.) authorized 1951-1986

Variable	Code	1951	1952	1953	1954	1955	1956	1957	1958	1959
Any deer	HPAD	5100	7000	8000	12,000	4717	6000	8000	10,000	11,000
Buck Only	HPBO	0	0	0	0	0	0	0	0	0

Variable	Code	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Any deer	HPAD	4500	3200	3000	3000	3750	7000	7000	7500	2001	2000
Buck Only	HPBO	0	0	0	0	0	0	0	0	0	0

Variable	Code	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Any deer	HPAD	2000	2000	2000	2000	2300	1500	1100	0	0	0
Buck Only	HPBO	0	0	0	0	500	800	400	1800	1800	1800

Variable	Code	1980	1981	1982	1983	1984	1985	1986
Any deer	HPAD	0	0	0	0	0	0	3000
Buck Only	HPBO	1700	2500	3000	4000	3600	3250	650
Anterless			0	0	0	0	450	3500

Table 15. Livestock use of forage in KNF portion of deer habitat, animal unit months (AUM) permitted.

Year	West winter habitat	East winter habitat	Summer habitat	North end habitat	All habitat
1950					42,581
1951					33,505
1952					32,893
1953					31,320
1954					31,919
1955					32,517
1956					35,357
1957					32,907
1958					40,479
1959					35,912
1960					34,410
1961					38,828
1962					35,524
1963					25,668
1964	8672	4583	5279	2255	20,789
1965	8437	4183	5142	2400	21,162
1966	8196	4583	4974	2255	20,008
1967	8726	4803	4220	2160	19,909
1968	8095	4003	4210	2280	18,588
1969	7910	4603	4220	2355	19,088
1970	7543	4003	4530	2185	18,261
1971	7543	4303	4530	2235	18,611
1972	7205	3903	4520	2450	18,708
1973	7205	4503	4530	2325	18,563
1974	7101	4403	4639	1750	17,893
1975	6339	3903	5891	2719	18,852
1976	6339	4000	5891	2719	18,949
1977	4056	3700	6104	2719	16,579
1978	4056	3650	6104	2719	16,529
1979	4056	3500	6104	2719	16,379
1980	4056	3500	6104	2719	16,379
1981	4196	2600	6104	2147	15,047
1982	4196	2600	4657	2147	13,600
1983	3536	2600	4849	2147	13,132
1984	3229	2600	7630	2146	15,605
1985	2896	2600	7630	2146	15,272
1986	2979	2600	7630	1464	14,670

Table 16. Special foods abundance indexes[1] (1969-1986) and cliffrose twig use (1953-1968).

Year	Mushroom Index	Acorn Index	Cliffrose Index
1953			4.90
1954			3.43
1955			1.36
1956			1.46
1957			0.76
1958			2.31
1959			1.61
1960			0.98
1961			0.80
1962			0.90
1963			0.59
1964			0.50
1965			1.01
1966			1.30
1967			0.53
1968			0.20
1969	2	2	
1970	2	2	
1971	2	2	
1972	2	2	
1973	1	2	
1974	1	3	
1975	2	2	
1976	2	2	
1977	2	1	
1978	1	1	
1979	2	2	
1980	3	2	
1981	3	1	
1982	3	2	
1983	3	3	
1984	3	2	
1985	1	2	
1986	2	1	

[1] Index of abundance: (1) scarce, (2) common, (3) abundant

Table 17. Location of 9 precipitation storage cans, read seasonally by Arizona Game and Fish Department.

Station	Elevation (ft)	Public Land Survey Description Gila and Salt River Principal Meridian			Record Began
		Section	Township	Range	
Sowats	6200	20	36N	2W	1970
Horse Spring Cattle Enclosure	5800	6	38N	2W	1970
Table Rock Deer Enclosure	6480	27	38N	1W	1970
Ryan	6500	13	38N	1W	1973
Cedar Knoll	5650	19	39N	1W	1973
(Standard rain gauge records by Range Dept. Univ of AZ 1962-1963)					
Winter Road	6500	35	41N	2E	1970
Houserock trick tank	6450	9	38N	3E	1970
Tater Canyon	6400	31	36N	4E	1973
Buck Farm	6200	11	34N	4E	1970

1). Water increments were determined by weight with spring balance readings interpoloted to .07 inch preciptation. Evaporation was prevented by a one-inch layer of electrical transformer oil or G.S.T. 32 pure mineral oil of SAE 10-30 weight. Freezing was retarded by ethylene glycol. Cans were 8 inches in diameter, 26 inches deep. Readings were made at the end of March, May, June, August, September, and October, and irregularly at more frequent intervals at some stations.

Table 18. Pre-hunt shifts in field observed fawn:doe ratios all areas pooled data 1955-86.[1]

Year	1-13 Sep	24 Sep-31 Oct
1955	0.311	0.346
1972	.712	.944
1974	.545	.782
1976	.732	.754
1978	.442	.631
1979	.362	.715
1985	.983	.819
1986	.612	.749
Mean	0.587	0.718

[1] Omitted years with <75 fawns and does observed in either period.

Table 19. Seasonal and administrative distribution of migratory deer population (%).[1]

Land administrative agency	Summer Range	Winter Range			
		West	East	North	South
Kaibab National Forest	75	60	25		
Grand Canyon National Park	25				5
Bureau of Land Management		5		5	
Total	100	65	25	5	5

[1] This subjective estimate includes perhaps 95% of the deer in the occupied area described in the text, and has been used to allocate hunter permits for various parts of the habitat.

Table 20. Seasonal differences of precpitation among sites on and near Kaibab deer habitat.

Station	Period of Record	Annual Precipitation Oct-Sep (in)	Summer Jun-Aug (%)	Winter Nov-Mar (%)	Cool Season Oct-May (%)
Kanab[1]	1904-1984	12.89	21	52	70
Mean of 3 Stations West	1971-1984	14.00	22	51	71
Mean of 3 Stations East	1971-1984	12.73	26	48	68
Grand Canyon South Rim	1904-1983	15.84	28	45	62

[1] Kanab % calculated by deleting years when data were lacking for any season; above % based on whole year records only.

Table 21. Driest and wettest periods of 5 consecutive water years (October-September) since 1922 at Kanab, elev. 4,985 ft at 19 miles west of north end of Kaibab Plaueau.[a]

Precipitation of Driest 5 years			Precipitation of Wettest 5 years	
Dates	Inches, cumulative	% below 1923-83 average	Inches, cumulative	% above 1923-83 average
1924-28	57.36	10		
1932-36	52.19	18		
1937-41			81.83	29
1944-48	54.92	14		
1953-57	51.45	19		
1959-63	49.40	22		
1965-69			77.01	21
1970-74	49.86	22		
1979-83			90.18	42

[a] Mean of all years 1922-83 = 12.73 inches per year, and X 5 = 63.65 inches per 5 years

Table 22. Vegetation type conversions (cumulative acres) 1951-1984.

Variable	1951	1952	1953	1954	1955	1956	1957	1958	1959
Virgin forest thinned by logging[1]									
Pine type	20,510	24,602	30,851	35,625	40,628	45,458	49,866	56,711	61,228
Mixed conifer	0	0	0	400	1,100	1,770	2,270	3,020	4,911
Total logged	20,510	24,602	30,851	36,025	41,728	47,228	52,136	59,731	66,139
Second entry logging									
Pine type	0	0	0	0	0	0	0	0	0
Mixed conifer	0	0	0	0	0	0	0	0	0
Total re-cuts	0	0	0	0	0	0	0	0	0
Wildfire pine type	0	0	0	0	0	0	0	0	0
Wildfire mixed conifer	0	0	0	0	0	0	0	0	0
Total timber	0	0	0	0	0	0	0	0	0
Blowdowns pine type	0	0	0	0	0	0	0	0	0
Blowdowns mixed conifer	0	0	0	0	0	0	0	0	0
Pinyon-juniper woodland bulldozed, chained, burned									
West side	0	0	0	250	2,160	2,160	4,060	5,620	5,620
East side	0	0	0	406	406	406	906	906	1,606
North side	0	0	0	0	0	0	0	0	300
Total P-J covered	0	0	0	656	2,566	2,566	4,966	6,526	7,526
Sagebrush plowed, sprayed, burned									
West side KNF	0	0	0	0	0	0	0	0	0
East side KNF	0	0	0	0	0	0	0	0	0
North side KNF	0	0	0	0	0	0	0	0	0
West side BLM	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000
Total sagebrush converted	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000

[1] Mostly light select cuts prior to 1982 but includes 3000 acres small patch clearcuts mixed conifer 1965-1972.

Table 22. Vegetation type conversions (cumulative acres) 1951-1984.

Variable	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Virgin forest thinned by logging[1]										
Pine type	63,705	69,024	73,337	75,992	79,698	84,167	88,691	93,566	98,240	103,490
Mixed conifer	7,785	10,285	13,459	16,002	18,806	21,306	23,426	24,326	25,366	26,860
Total logged	71,490	79,309	86,796	91,994	98,504	105,473	112,117	117,892	123,606	130,350
Second entry logging										
Pine type	0	0	0	0	0	0	0	0	0	0
Mixed conifer	0	0	0	0	0	0	0	0	0	0
Total re-cuts	0	0	0	0	0	0	0	0	0	0
Wildfire pine type	2,430	0	0	0	0	0	0	0	0	0
Wildfire mixed conifer	4,230	0	0	0	0	0	0	0	0	0
Total timber	6,660	0	0	0	0	0	0	0	0	0
Blowdowns pine type	0	0	0	0	0	0	0	0	0	0
Blowdowns mixed conifer	0	0	0	0	550	0	0	0	0	0
Pinyon-juniper woodland bulldozed, chained, burned										
West side	7,670	8,190	0	0	8,687	8,687	8,687	9,387	11,587	11,587
East side	3,606	3,606	0	0	3,606	3,606	3,956	4,476	4,806	4,806
North side	300	300	0	0	300	300	300	300	300	300
Total P-J covered	11,576	12,096	0	0	12,593	12,593	12,943	14,163	16,693	16,693
Sagebrush plowed, sprayed, burned										
West side KNF										
East side KNF	0	0	0	1,450	1,800	3,800	0	0	3,800	0
North side KNF	0	0	0	0	0	300	0	0	300	0
West side BLM	0	0	0	0	0	3,000	0	0	3,000	0
Total sagebrush converted	1,000	1,000	1,000	1,000	1,000	1,000	0	0	7,979	0
	1,000	1,000	1,000	2,450	2,800	8,100	0	0	15,089	0

[1] Mostly light select cuts prior to 1982 but includes 3000 acres small patch clearcuts mixed conifer 1965-1972.

Table 22. Vegetation type conversions (cumulative acres) 1951-1984.

Variable	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Virgin forest thinned by logging[1]										
Pine type	107,355	111,388	116,971	126,637	131,688	137,292	140,417	150,531	156,801	161,659
Mixed conifer	28,815	29,815	31,930	34,573	37,573	40,361	40,832	46,150	47,272	48,334
Total logged	141,203	141,203	148,901	161,210	169,344	177,653	181,249	196,681	204,073	209,993
Second entry logging										
Pine type	0	0	0	1,500	1,500	1,871	1,871	1,945	5,997	6,837
Mixed conifer	0	0	0	0	0	0	0	0	0	1,501
Total re-cuts	0	0	0	1,500	1,500	1,871	1,871	1,945	5,797	8,338
Wildfire pine type	0	0	0	0	1,113	0	0	1,113	1,113	1,113
Wildfire mixed conifer	0	0	0	0	0	0	0	1,085	1,085	1,085
Total timber	0	0	0	0	1,113	0	0	2,198	2,198	2,198
Blowdowns pine type	0	0	188	0	0	0	188	188	188	188
Blowdowns mixed conifer	0	0	2,050	0	0	0	2,050	1,950	1,950	1,950
Pinyon-juniper woodland bulldozed, chained, burned										
West side	11,587	11,587	11,887	12,287	0	0	0	12,287	12,287	13,217
East side	4,806	5,006	5,006	5,006	0	0	0	5,006	5,006	5,006
North side	600	900	900	900	0	0	0	900	900	900
Total P-J covered	16,993	17,493	17,793	18,193	0	0	0	18,193	18,193	19,123
Sagebrush plowed, sprayed, burned										
West side KNF	0	0	0	0	0	3,800	0	3,800	3,800	3,925
East side KNF	0	0	0	0	0	300	0	300	300	300
North side KNF	0	0	0	0	0	3,00	0	3,000	3,000	3,000
West side BLM	0	0	0	0	0	9,479	0	9,479	9,479	9,479
Total sagebrush converted	0	0	0	0	0	16,579	0	16,579	16,579	16,704

[1] Mostly light select cuts prior to 1982 but includes 3000 acres small patch clearcuts mixed conifer 1965-1972.

Table 22. Vegetation type conversions (cumulative acres) 1951-1984.

Variable	1980	1981	1982	1983	1984
Virgin forest thinned by logging[1]					
Pine type	168,288	170,619	171,063	171,063	171,063
Mixed conifer	53,044	55,711	55,711	55,711	55,711
Total logged	221,332	226,330	226,774	226,774	226,774
Second entry logging					
Pine type	6,837	10,864	17,938	30,495	43,873
Mixed conifer	1,501	1,501	1,501	5,121	5,121
Total re-cuts	8,338	12,365	19,439	35,616	48,994
Wildfire pine type	1,113	1,113	1,113	1,113	1,113
Wildfire mixed conifer	1,085	1,085	1,085	1,085	1,085
Total timber	2,198	2,198	2,198	2,198	2,198
Blowdowns pine type	188	188	188	3,518	3,518
Blowdowns mixed conifer	1,950	1,950	1,950	1,950	1,950
Pinyon-juniper woodland bulldozed, chained, burned					
West side	13,217	13,217	14,657	16,217	16,217
East side	6,006	6,006	6,006	6,006	6,006
North side	900	900	900	900	900
Total P-J covered	20,123	20,123	21,563	23,123	23,123
Sagebrush plowed, sprayed, burned					
West side KNF					
East side KNF	4,133	4,639	4,639	4,639	4,639
North side KNF	300	300	380	380	380
West side BLM	3,000	3,000	3,000	3,000	3,000
Total sagebrush converted	9,479	9,479	10,179	12,879	12,879
	16,912	17,418	18,198	20,898	20,898

[1] Mostly light select cuts prior to 1982 but includes 3000 acres small patch clearcuts mixed conifer 1965-1972.

Table 23. Composition (%) of winter deer diets, range of estimates among rumen and fecal sample techniques and sites and years.

	Rumen samples[a] 1948-50 and 1967 Different years, 3 pooled sites		Fecal samples 1977-81 same year, different sites		Fecal samples 1977-81 same sites, different years	
	min	max	min	max	min	max
Cliffrose (*Cowania mexican*)	tr	36	2	8	10	78
Sagebrush (*Artemisia* spp.)	7	68	11	80	11	79
Grasses	2	24	2	21	12	21
Other foods agregate	26	36	3	47	3	20

[a] Rumen sample, 118 ea. were not stratified by sites comparable with fecal sample site

Table 24. Composition (%) of summer deer diets, ranges of estimates among sample series by habitat types and years 1925 and 1948.

Item		Pine Forest		Mixed Conifer	
		June 1948	Oct 1948	Jul 1925	Jun 1948
	Sample (N)	(5)	(7)	(10)	(10)
Herbaceous Total		59	38	41	64
Milkvetch (*Astragalus* spp.)		7	2	2	22
Oregon grape (*Berberis repens*)		10	9	9	11
Lotus (*Lotus* spp.)		5	tr	1	2
Other forbs <5% each		35	26	27	27
Grasses and Sedges		2	1	2	2
Browse total		41	22	58	36
Aspen (*Populus tremuloides*)		6	1	30	15
White fir (*abies lasiocara*)		tr	7	20	12
Gambel oak (*Quercus gambellii*)		14	0	1	2
Other trees and shrubs <5% each		21	14	7	7
Mast (*Quercus gambellii*)		0	39	0	0
Mushrooms		0	39	0	0
Total		100	100	100	100

Table 25. Composition (%) of summer deer diets, ranges of estimates among fecal sample series by habitat types and years 1977-80 and 1983.

	Pine Areas				Mixed Conifer Areas			
	KNF		GCNP		KNF		GCNP	
Food Items	min	max	min	max	min	max	min	max
Total herbaceous plants	39	96	50	94	52	82	49	87
Lupine and lotus (*Lupinus* spp. *Lotus* spp.)	11	89	28	85	6	36	30	36
Wild-buckwheat (*Eriogonum* spp.)	0	38	0	16	1	59	0	6
Oregon grape (*Berberis repes*)	tr	10	0	7	0	15	0	tr
Pussytoes (*Antennaria* spp.)	0	1	4	7	0	0	0	2
Grasses and sedges	0	4	tr	20	3	14	0	1
Total browse	3	33	6	47	18	48	12	47
Aspen (*Populus tremuloides*)	0	5	0	5	0	13	0	3
White fir (*Abies concolor*)	0	2	0	8	1	30	tr	3
Gambel oak, mast and browse not distinguished (*Quercus gambellii*)	0	6	0	6	0	7	tr	3
Ceanothus (*Ceanothus fendleri*)	2	30	10	13	0	13	0	10
Rose (*Rosa* spp.)	3	7	0	6	0	3	5	5
Raspberry (*Rubus* spp.)	0	9	0	2	0	tr	0	3
Snowberry (*Symphoricarpus* spp.)	0	2	0	8	0	10	0	1
Yarrow (*Achillea lanulosa*)	0	3	0	4	0	3	0	6

Table 26. Deer per mile^2 estimated by fecal accumulation rates in summer habitat on KNF (logged, grazed) and GCNP (old growth timber, not grazed).[a]

	Pine overstory type 7600-8400 ft				Mc overstory type 8300-9200 ft			
	GCNP		KNF		GCNP		KNF	
	Av.	± SE	Av.	± SE	Av.	± SE	Av.	± SE
1972	12.1	5.5	14.9	2.5	32.9	15.2	25.8	8.3
1973	6.1	3.8*	18.4	4.3	9.9	6.3	19.6	5.9
1974	8.1	3.8*	20.5	3.8	21.1	6.7	20.6	2.7
1975	11.3	6.1	15.6	2.6	13.3	7.4	14.1	3.9
1976	4.6	2.6*	11.6	1.9	16.6	11.7	12.4	2.8
1977	9.7	8.3	12.6	2.2	9.7	7.4	11.9	3.6
1978	8.4	5.5	10.7	2.5	8.7	5.4	11.1	1.8
1979	5.3	4.5*	14.9	3.4	3.8	3.8	8.0	2.4
1980	23.9	13.0	11.8	1.8	20.2	14.3	15.4	2.5
1981	22.7	8.2	16.4	2.17	28.7	10.1	21.8	3.2
1982	19.8	6.5	22.9	3.4	19.2	8.3	32.0	4.1
1983	15.7	6.5	20.5	3.4	9.7	5.5	15.2	7.2
1984	34.8	15.4	25.1	4.8	27.5	9.0	27.4	7.9
1985	42.2	17.5	56.6	8.7	32.9	16.1	64.0	19.2
1986	33.1	17.1	42.5	8.6	26.6	14.0*	62.1	17.2

[a] Variance among 24-plot clusters was calculated for each timber type on each administrative area.

* indicates significant differences between means.

Table 27. Yearling buck carcass weights and antler points, variation among habitat subunits and years.

Year	Hunt Area	Man lbs	SE ±	N	Mean Points	SE ±	N
1970	3	103.6	1.9	27	4.38	0.14	47
	4	102.1	1.8	28	4.37	.13	49
	8+10	102.4	1.7	20	4.10	.17	31
1971	1	105.5	1.7	36	4.43	.15	60
	2	103.6	1.2	67	4.19	.09	97
	9+11	98.7	2.3	23	4.03	.12	34
1972	1	102.3	1.6	26	4.42	.17	31
	2	99.4	1.3	57	4.26	.10	85
	9+11	97.5	1.3	39	4.07	.12	61
1973	3	97.1	2.1	34	4.40	.15	58
	4	102.1	2.4	23	4.33	.17	49
	6	96.2	1.8	27	4.46	.22	35
	8+10	96.3	2.2	24	4.36	.20	34
1974	1	95.1	1.9	36	4.02	.12	81
	2	92.0	1.8	48	4.08	.10	106
	9+11	85.9	1.7	23	4.02	.15	55
1975	3	97.1	2.1	34	4.27	.14	59
	4	102.1	2.4	23	4.06	.21	35
	6	96.2	1.8	27	4.02	.14	53
	10	99.2	1.8	32	4.20	.14	55
1976	4+6	96.1	2.2	25	4.21	.14	38
1977	4+6	97.6	1.8	22	4.00	.17	33
1978	2	101.4	1.3	44	4.16	.09	63
	9+11	92.6	2.2	24	4.11	.19	35
1979	6	100.4	1.8	38	3.84	.14	50
	8+10	100.0	2.2	29	4.09	.20	44
1980	3	110.2	2.2	32	4.40	.16	42
	4	103.0	1.4	45	4.36	.13	67
	6	104.6	1.6	34	4.02	.16	43
	8+10	108.6	1.8	29	4.45	.14	53
1981	3	106.8	1.7	48	4.53	.10	88
	4	107.2	1.7	37	4.44	.11	95
	6	109.7	1.5	74	4.44	.10	108
	10	106.4	1.9	44	4.41	.12	64

Table 27. Yearling buck carcass weights and antler points, variation among habitat subunits and years. (continued)

Year	Hunt Area	Mean lbs	SE ±	N	Mean Points	SE ±	N
1982	1+2	112.0	2.4	33	4.47	0.15	43
	3	113.4	1.4	87	4.29	0.08	127
	4	108.6	1.5	69	4.28	.12	78
	6	108.8	1.2	80	4.33	.10	125
	10	108.3	1.8	42	4.45	.12	60
1983	1	110.8	1.3	46	4.43	.16	63
	2	109.1	1.0	77	4.35	.11	91
	3	111.9	1.3	96	4.49	.10	132
	4	109.5	1.4	64	4.13	.13	87
	6	108.3	1.6	100	4.22	.11	127
	7+12	118.9	1.5	29	4.78	.17	32
	10	108.4	2.5	27	4.25	.18	36
1984	1	108.2	1.1	118	4.28	.08	163
	2	105.2	0.8	128	4.38	.07	193
	3	110.9	1.2	102	4.49	.09	
	4	104.4	1.3	87	4.28	.08	
	6		1.8		4.48	.14	
	7+12	114.4	2.1	33	4.79	.15	48
	9	98.3	1.9	20	4.31	.16	32
	10	102.7	2.1	38	4.04	.13	44
1985	1	95.5	1.0	112	4.35	.09	167
	2	92.1	0.7	188	4.09	.07	239
	3	95.0	1.4	65	4.31	.13	77
	4	95.2	1.5	60	4.13	.10	90
	6	90.6	2.1	27	3.72	.20	32
	7+12	100.0	1.8	45	4.24	.16	54
	9	87.7	1.5	45	4.22	.12	65
	10	91.3	1.8	45	4.02	.14	55

Table 28. Differences among classes in carcass weights (lbs) of bucks aged 4-1/2 to 13-1/2 years by cementum, pooled years data 1971-85.

Age years	Mean lbs	SE lbs	Range (lbs)		
			Min	Max	N
4-1/2	182.6	1.3	124	234	275
5-1/2	191.2	1.6	153	242	116
6-1/2 to 8-1/2[a]	195.0	1.8	136	265	150
9-1/2 to 13-1/2[b]	184.6	3.2	129	222	31

[a] There were no significant differences ($P < 0.05$) among ages 6-1/2, 7-1/2, 8-1/2 years.

[b] The oldest buck weighed 190 lbs. with antler spread 29 inches and points 5x6.

Table 29. Weights of antlerless deer carcasses during November 14-28 seasons 1971-76.

Deer Sex-Age Class	Mean lbs	SE ±	Min lbs	Max lbs	N
Fawns					
Male	52.3	0.8	25	89	109
Female	48.5	0.9	35	73	71
Does					
1 1/2 yrs	83.2	0.7	54	97	144
2 1/2 yrs	90.5	0.9	71	111	97
3 1/2 yrs	94.6	1.3	78	115	72
4 1/2 yrs	96.0	1.6			
5 1/2 yrs	101.7	2.0	86	115	32
6 1/2					

Table 30. Biggest bucks taken each year. Age by cementum except as noted.

	Heaviest						Widest Rack				
Year	lbs	Spread* in	Pts LxR	Age yrs	Hunt area	Date	lbs	Spread * in	Pts LxR	Age yrs	Hunt area
1957	235	**									
1958	240	**									
1959	230	**									
1960	212										
1961	255	28+	6x4	8+[a]	6	10-18					
1962	215	**									
1963	225	**									
1964	227	**									
1965	235	**									
1966	224	**									
1067	224	**									
1968	213	**									
1969	226	**									
1970	219		7x5	6-8[a]	1	11-8					
1971	239		3x4	7	9	11-21	197	38	6x4	9	11
1972	216		4x4	5	2	11-16	190	39	7x7	8	9
1973	249	36 1/2	7x7	6	4	11-17	191	41	8x8	4	6
1974	210	31	6x6	5	1	11-15	195	33	4x4	6	1
1975	230	33	9x6	6	10	11-20	230	33	9x7	6	10
1976	217	28	4x4	4	3	11-22	208	34	10x10	8	1
1977	209	26	4x3	6	10	11-19	203	32	7x8	6	3
1978	208	34	6x4	5	2	11-19	198	37	11x9	5	2
1979	241	33	6x5	6	6	10-27	190	33	10x9	5	10
1980	248	31	5x4	9	2	10-31	32	6x6	4	4	6
1981	238	30	5x5	7	3	10-31	34	9x8	3	3	5
1982	265	41	5x6	6	10	11-3	41	5x6	6	6	10
1983	248	36	11x11	3[b]	7	11-5	38	9x7	8	8	12
1984	234	35	4x5	6	3	11-22	41	11x9	5	5	3
1985	222	26	7x7	8	10	11-4	36	6x5	6	6	9

[a] Aged by tooth wear

[b] Possibly a labeling error; tooth wear indicated age 6-8 years

** Indicates records lost

Table 31. Correlation tests of deer welfare indexes with each other.[a]

	All areas 1-12:							West areas 1-6:					East areas 8-11:						All areas 1-12:				West areas 1-6:					East areas 8-11:			Summer Habitat
Period	Y3PT	YMP	YCW	OFD	DFD	HYD2	HFD1	Y3PT	YMP	YCW	OFD	DFD	Y3PT	YMP	YCW	OFD	DFD	HFD1	DFD	HFD1	HFD2	HYD2	Y3PT	YMP	YCW	OFD	DFD	Y3PT	YMP	YCW	POP
All areas 1-12:																															
1953-84 OFD	0				+	0																									
1953-69 Y3PT				0	0	+															0										
1953-67 DFD	0			+		0	0												0	0	+										
1953-76 Y3PT				0	0	+	+				O	0									0										
" HFD1	+			0	0	+															+					+					
" HFD2	+			0	0	+	+														+										
" HYD2	+			0	0		+														+										
1970-84 YCW	+																														
West areas 1-6:																	+														
1953076		+	+								0	0						0				0		+	0						+
HFD1	+										0	0												0	0						+
1970-84 Y3PT	+	+		+							0	+										+		+	+						+
" YMP								0	0	0		0																			0
" YCW			+					0	0	0	0																				0
" OFD																															+
" DFD																															+
" BMP2																															+
" BCW2																															
" BCW3																															
East areas 8-11:																															
1970-84 Y3PT																															0
" YMP																															+
" YCW																															+
Summer: 1969-86 POP	0	0	0					0	0	0			0	0	0							0	-	0			0	-	0		

Table 32. Correlation tests of deer and administrative phenomena.[a]

Period	All areas 1-12:	Test variables of same year					Test row variables vs. next year column variable						
		SSAD	S^b SSBO	S^c SSBO	B^b HDBO	B^c HDBO	HPAD	HYD2	S^b SSBO	S^c SSBO	B^b HDBO	B^c HDBO	POP
1953-67	HFD 1 harvested f/d 1 yr & older	0					0						
"	HFD 2 harvested f/d 2 yrs & older	0					0						
"	HYD2 harvested yrl F/older F	0					0						
"	HPAD any-deer permits	+											
"	SSAD deer/any-deer hunter						+	0					
"	DFD fawn/doe post-hunt						+						
1974-84	POP summer herd no.		+	+					0	0	+	0	
"	Y3PT yrl males % 3-points or more			0							0		
"	YMP yrl males mean antler points			0							0		
"	YCW yrl males mean carcass wt.			0							0		
"	SSBO bucks/hunter, early hunt												0
"	BHDBO bucks/hunter day, early hunt												+

[a] Sign + or - indicates correlation ($P \leq 0.05$); 0, no correlation; blank, no test.

[b] early hunt

[c] late hunt

Table 33. Correlations of precipitation at AGFD stations on deer habitat with deer welfare indexes (DWI)[a].

	AGFD 3 Stations West						AGFD 3 Stations East						AGFD 9 Stations Around						AGFD West		AGFD East		AGFD Stations Around	
Period Deer Variables (DWI)	W P	S P	Y P	Y S P	Y 2 P	Y 3 P	W P	S P	Y P	Y S P	Y 2 P	Y 3 P	W P	S P	Y P	Y S P	Y 2 P	Y 3 P	W P	S P	W P	S P	W P	S P
West side hunt areas 1-6: 1971-84																			0	0				
Y3PT yrl males % 3-pt or more	0	0	0	+	+	+													0	0				
YMP yrl males mean antler pts	0	+	0	0	+	+													0	0				
YCW yrl males mean carcass wt	0	+	0	+	+	+													0	0				
OFD fawn/doe pre hunt	0	0	0	0	0	0													0	0				
DFD fawn/doe post-hunt	0	0	0	0	+	0													0	0				
BCW2 males age 2 mean carcass wt.	0	+	+	0	+	+													0	0				
BMP2 males age 2 mean antler pts.	0	+	0	0	+	+													0	0				
BMP3 males age 3 mean antler pts.	0	0	0	+	0	0													0	0				
BCW3 males age 3 mean carcass wt.	0	+	0	+	0	+													0	+				
East side hunt areas 8-11: 1971-84																								
Y3PT							0	+	+	0	0	0									0	0		
YMP							0	0	+	0	0	0									0	0		
YCW							0	+	+	+	+	+									0	0		
All hunt areas 1-12: 1971-84																								
Y3PT													+	0	+	+	+	+					0	0
YMP													+	0	0	+	+	+					0	0
YCW													0	0	0	+	0	+					0	0
OFD													0	0	0	0	0	0					0	0
DFD													0	+	0	0	+	+					0	0
POP summer herd no.	0	+	0	0	0	+	0	+	0	0	0	+	0	+	0	0	0	+				0	0	

[a] Sign + or - indicates significant correlation ($P \leq 0.05$); blank box represents test not attempted; 0 indicates correlation not significant ($P > 0.05$).

Table 34. Correlation tests of precipitation at 3 and 4 stations 20 to 50 miles west of Kaibab Plateau with deer welfare indexes.[a]

	Off-site station	Precipitation vs. deer variables of same calendar year						Precipitation vs. deer variables of next year	
		WP	SP	YP	YSP	Y2P	Y3P	WP	SP
All hunt areas 1-12:									
1953-69 Y3PT	0	0	0	0	0	0	0	0	0
" OFD	0	0	0	0	0	0	0	0	0
1953-69 DFD	0	0	0	0	0	0	0	0	0
1953-76 HFD1	0	0	0	0	0	0	0	0	0
" HFD2	0	0	0	0	0	0	0	0	0
" HYD2	0	0	0	0	0	0	0	0	0
West side hunt areas 1-6:									
1953-69 DFD	0	0	0	0	0	0	0	0	0
1953-76 HFD1	0	0	0	0	0	0	0	0	0
(not enough east data to test)									

[a] Sign + or - indicates significant correlation ($P \leq 0.05$); blank box represents test not attempted.

Table 35. Correlation tests of annual fluctuations of livestock permits (AUK)[b] on Kaibab National Forest (KNF) with deer welfare indexes (DWI)[a].

		Cattle vs. DWI variables of same year				Lag DWI variables one year aftr AUM			
Period	Deer variables (DWI)	AUK8	AUK6	AUK3	AUK2	AUK8	AUK6	AUK3	AUK2
All hunt areas 1-12:									
1953-86	Y3PT yrl males % 3-pts or more	-				-			
	OFD fawn/doe pre-hunt	0				0			
	DFD fawn/doe post-hunt	0				-			
1953-69	Y3PT yrl males % 3-pts or more	0				0			
	OFD fawn/doe pre-hunt	0				0			
	DFD fawn/doe post-hunt	0				0			
1953-76	HFD1 harvested f/d 1 yr & older	-				0			
	HFD2 harvested f/d 2 yrs & older	-				0			
	HYD2 harvested yrl F/older F	-				0			
West side hunt areas 1-6:									
1970-86	Y3PT yrl males % 3-pts or more		0	0				0	
	YMP yrl male mean antler pts		0	0				0	
1970-86	YCW yrl male mean carcass wt		0	0				0	
	OFD fawn/doe pre-hunt		0	0				0	
	DFD fawn/doe post-hunt		0	0				0	
East side hunt areas 8-11:									
1970-86	Y3PT yrl males % 3-pts or more		0		0				0
	YMP yrl males mean antler pts		0		0				0
1970-86	YCW yrl male mean carcass wt		0		0				0
Summer deer habitat:									
1969-86	POP deer herd exc. fawns	0	+	-	-	0	+	-	-

[a] Sign + or - indicates significant correlation ($P \leq 0.05$); blank box represents test not attempted.

[b] AUK8 - all KNF areas; AUK3 - west winter range; AUK6 - summer range; AUK2 - east winter range

Table 36. Correlation tests of annual fluctuations of total ungulate biomass index (AUM) with deer welfare idexes.[a]

Period	Deer variables DWI	Test AUM vs. DWI variables same year Summer deer habitat[b]	Lag DWI variables one year after AUM Summer deer habitat[b]
West side hunt areas 1-6:			
1970-86	Y3PT yrl males % 3-pts or more	0	0
	YMP yrl male mean antler pts	0	-
1970-86	YCW yrl male mean carcass wt	0	0
East side hunt areas 8-11:			
1970-86	Y3PT yrl males % 3-pts or more	0	0
	YUMP yrl male mean antler pts	0	-
1970-86	YCW yrl male mean carcass wt	0	-

[a] Sign + or = indicates significant correlation ($P \leq 0.05$).

[b] Summer habitat = Kaibab Plateau above 7200 ft, Kaibab National Forest (KNF) plus Grand Canyon National Park (GCNP)

Table 37. Mean weights (lbs) of yearling bucks (YCW-wes) for clusters of years ranked to precipitation (YSP) and ungulate biomass (AUM) 1972-86.[a]

	Low to Moderate AUM (<22,000) on summer range)	High AUM (>25,000) on summer range
Low YSP at 9 AGFD stations < 14.29 inches	96.7 (3)	
Normal YSP at 9 AGFD stations 14.29 to 23.82 inches[b]	102.8 (8)	91.0 (1)
High YSP at 9 AGFD stations > 23.82 inches	110.4 (2)	93.7 (1)

[a] (n) = no. years in cluster

[b] Normal YSP = mean $\pm$ 25%

Table 38. Mean antler points (no.) of yearling bucks (YMP-west) for clusters of years ranked by precipitation (YSP) and ungulate biomass (AUS) 1972-86.[a]

	Low to Moderate AUM (<22,000) on summer range)	High AUM (>25,000) on summer range
Low YSP at 9 AGFD stations < 14.29 inches	4.130 (3)	
Normal YSP at 9 AGFD stations 14.29 to 23.82 inches[b]	4.246 (7)	3.557 (1)
High YSP at 9 AGFD stations > 23.82 inches	4.331 (2)	4.173 (1)

[a] (n) = no. years in cluster

[b] Normal YSP = mean ± 25%

Table 39. Correlation of mushroom, tent caterpillar and acorn abundance indexes with deer welfare indexes (DWI)[a].

Period	Deer Index	MSHR	TCI	ACRN
1953-76	HFD2		(+)	
1953-76	HYD2		(+)	
1969-84	POP	(+)	0	0
1970-84	DFD-west	(+)	0	0
1971-84	YCW-west	(+)	0	0
1971-84	YCW-east	(+)	(-)	(-)
1970-84	YCW-all	(+)	(-)	0
1971-84	YMP-west	(+)	0	0
1971-84	Y3PT-west	(+)	0	0
1971-84	Y3PT-east	+	(-)	0

[a] Sign + or - indicates significant correlation ($P \leq 0.05$); blank box represents test not attempted.

Table 40. Correlations of cliffrose twig use (inches) with indexes of deer welfare (DWI) and hunt management decisions.[a]

All hunt areas 1-12

Paired variables of same year	CTU cliffrose twig use
Y3PT yrl male % 3-point, or more	0
YCW yrl male mean carcass wt	0
OFD fawn/doe pre-hunt	0
DFD fawn/doe post hunt	0
HFD1 harvested f/d 1 yr & older	0
HFD2 harvested f/d 2 yrs & older	0
HYD2 harvested yrl female/older female	0
HPAD any deer permits	+
SSAD any deer hunter success	+
BHDAD buck hunt success amont a-d hunters	+
Variables lagged 1 year after CTU:	
Y3PT	-
YMP	-
YCW	0
OFD	0
DFD	-
HFD1	-
HFD2	-
HYD2	0
Variables lagged 2 years after CTU:	
HYD2	-

[a] Sign + or - indicates significant correlation ($P \leq 0.05$).

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