CONDITION AND TREND OF NEVADA DEER RANGES

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Abstract. The U. S. Department of Interior, Bureau of Land Management, the Nevada Department of Fish and Game, and the Agricultural Experiment Station, University of Nevada, conducted a 10-year cooperative research program of mule deer habitat in Nevada from 1964 to 1974. Condition and trend data were collected from permanent plots established in 1964 and 1965 and were re-evaluated in 1972 and 1973. Similar plots were used to evaluate pinyon-juniper control techniques and effects of wheatgrass seedings in known mule deer ranges. Deer use was highest in those plant communities exhibiting the highest forage diversity. Heavy spring and summer livestock grazing had harmful effects on deer ranges. Pinyon-juniper invasions reduced deer range productivity. Crested wheatgrass seedings were of no benefit to wintering mule deer. Forage diversity, watershed production, and deer use all benefitted on investigated pinyon-juniper control projects. Mixture seedings provided additional forage availability and diversity in otherwise poor deer ranges.

Introduction

Prior to 1964 many unknowns were present involving Nevada's deer ranges. Locations, season of use, plant community preference, food habits, forage potential, vegetative responses to varying degrees of deer use, interspecific and intraspecific competition for forage, and the effects of various range rehabilitation practices on deer were not intensively investigated. A need for a long term, intensive research project was felt because of declines of Nevada's deer herds. Such a project evolved in 1964 and lasted through 1974. Cooperation between the Bureau of Land Management, Nevada Department of Fish and Game and the Nevada Agricultural Experiment Station of the University of Nevada, Reno, provided funding, data and manpower to make the 10-year research project possible.

The research project was divided into five 2-year programs and cost about $213,000. The first program involved the recognition and evaluation of selected Nevada deer ranges. The second program involved the evaluation

and impact of three crested wheatgrass seedings and two pinyon-juniper control sites. The third program involved present and potential forage productivity of the previously selected deer ranges. The fourth program involved evaluation of various techniques of pinyon-juniper control on seven sites. Food habits data were collected concurrently with the first 8 years. The last program involved condition and trend of the previously selected deer ranges. Dates of the programs were as follows:

1964-1966: Deer Range Evaluations
1966-1968: Crested Wheatgrass Seeding
1968-1970: Forage Productivity
1970-1972: Pinyon-Juniper Control
1972-1974: Condition and Trend

The objectives for this study were:

1) To evaluate the potential forage production and condition and trend in selected big game habitats throughout Nevada.

2) To determine the degree of dual use and competition with livestock on these key areas.

3) To determine characteristics of deer feeds - palatability, nutrition and species preference.

4) To evaluate the effectiveness of alternative procedures useful for improving big game habitats in Nevada.

5) To develop field techniques useful to the Nevada Department of Fish and Game and the Bureau of Land Management when making resource inventories in big game habitats.

Study Sites

Eight important Nevada deer ranges were selected for deer range evaluation. These included: Duck Creek Basin, near McGill in White Pine County (winter range); Fort Ruby, near Ruby Marshes in White Pine and Elko Counties (winter range); Blythe Springs in the Delamar Mountains near Caliente in Lincoln County (winter range, some year-round use); Morey Mountain in the Hot Creek Range northeast of Tonopah in Nye County (winter range); White Rock, near White Rock Peak in the White Rock Mountains north of Ursine in Lincoln County (winter range, with some year-round use); Bates Mountain in the Simpson Park Mountains in Lander County (summer range); Pequop Mountains near Wells in Elko County (winter range); and Fox Mountain in the Granite Range near Gerlach in Washoe County (spring, summer, fall, with some winter use).

Crested wheatgrass seedings and pinyon-juniper control sites were selected for study after a review of projects recommended by Bureau of Land Management personnel. Seedings were selected as areas with high potential for mule deer habitat while pinyon-juniper control sites were selected as a control technique. The intensive study sites selected were the Gardner, Mount Wilson, and Cave Valley crested wheatgrass seedings; the Spruce Mountain chaining, and the Blythe Springs cabling.

Methods and Materials

Macroplots were designed to collect phytosociological characteristics and deer utilization on all vegetation types at all study sites. Data collected were: plant cover and frequency; browse density and vigor; tree cover; deer utilization by pellet group counts; forage yield from three phase deer exclosures; and deer-livestock forage relationships from all the above data.

Vegetation quantification at each site was done using a modification of the method described by Poulton and Tisdale (1961). Canopy cover of shrubs was estimated on four segmented 4 by 50 ft belt transects, each consisting of two contiguous 4 by 5 ft cover plots. The cover estimate for shrub species on each 4 by 5 ft plot was guided by the use of a 1 ft^2 frame equal to 5% of the sample area. On valuable browse plants both live and dead canopy cover were recorded. Nested within each 4 by 5 ft cover plot was a 1 by 2 ft plot used to estimate the basal ground cover of grasses and forbs. Ten transects of ten contiguous frequency quadrants were used depending on plant community. A plant was recorded as present if 50% or more of its base fell within the quadrant.

Position of cover and frequency transects along a 100 ft base line were drawn from a random number table. Direction left or right from the base was determined by flipping a coin.

Density of trees was recorded on a 20 by 100 ft belt transect using, as a center, the 100 ft macroplot base line. Trees were recorded by species and, due to lack of time for age determination, were arbitrarily divided into two simple classes--young, those under 5 ft tall and, mature, those over 5 ft tall. Twenty randomly chosen trees in each transect were measured for two diameters and converted to area in square feet. Multiplying the density and area, percent foliage cover was recorded.

In this study, ten circular plots of 0.01 acre were used to measure relative deer use of the vegetation. The plots were located within each macroplot and all pellet groups in each plot were counted regardless of age. The average defecation rate of mule deer has been widely accepted to be 13 groups per animal per day (Neff, 1968). A minimum of five pellets constituted a group and groups were converted to groups per acre and divided to convert to deer-days use per acre.

A general reconnaissance was made of each study area and plant communities were noted, and an attempt was made to establish macroplots in a minimum of three representative stands within each plant community.

Three-phase exclosures were constructed on representative sites of the eight important deer ranges in northern and central Nevada. The plan of the exclosure is as follows: one acre, hereafter referred to as the "deer exclosure" is fenced against any use by deer and livestock. Contiguous with the deer exclosure is an acre fenced excluding only livestock, hereafter referred to as the "livestock exclosure", An unfenced control equal in size and adjacent to the fenced areas, receives use by all animal classes. This technique assumes the following: Total potential production is achieved in the deer exclosure; deer utilization is represented by the difference in production between the deer exclosure and the livestock exclosure following the foraging season; livestock utilization is derived from production within the livestock exclosure less the control production following grazing. Five temporary exclosures each encompassing an area of 400 ft^2 and allowing no use were located within the control plot at four exclosure sites during the summer of 1968. The temporary exclosures were used to supply a better estimate of site potential than available from the deer exclosures. They provided protection from grazing for one growth season only. Total annual production was derived from the vegetation within these structures and compared to that taken from the deer exclosure. Five of these temporary exclosures have been erected at the Duck Creek Basin and Morey Bench sites since the summer of 1968 and remained in use through the spring of 1974.

Production data were obtained by the clip "before and after" method. Potential was expressed in terms of total vegetation yield. Bitterbrush was clipped on plots 20 by 20 ft, Sagebrush and other shrub species were

clipped from a 10 by 10 ft plot nested within the larger 20 by 20 ft plot. Production of grasses and forbs was obtained by clipping a 4 by 12 ft subplot nested within the bitterbrush plot. By a system of restricted randomization these plots were excluded from clipping the following season and new plot numbers were randomly drawn each year.

Range condition and trend are related terms used to reflect past range abuse and site potential under given land uses. For the purposes of this study condition was defined as present deer forage potential of which the site is capable under sound management. A favorable vegetation response under a given treatment provides important information for management decisions. The exclosures were constructed in the most important plant community at each site prior to and during Berg's (1966) investigations. The surrounding range was also evaluated.

Determination of condition and trend of an entire study site was based primarily on an analysis of relative deer utilization in important plant communities found at each study site. Vegetative and deer utilization changes over 8 years were indicators to condition and trend. The type and amount of changes dictates velocity of change. The cause of any existing change was attributed to changes or lack of changes in land use or management or natural plant succession.

Both vegetation description and range utilization measurements were accomplished at macroplots established perpendicular to the treatment peripheries. Particular attention was given to the periphery since the "edge effect" is a well established wildlife management principle (Leopold, 1933). Macroplot techniques were those described earlier. Transect lengths varied from 400 ft to 1200 ft. Macroplots were placed at various locations along each transect within each treatment for intensive analysis. Some were placed outside of the treatments on the same transect to represent a control.

Results and Discussion

Relative deer use and deer preference of plant communities were influenced by size and diversity of the plant community, edge effects, volume of forage (availability and production), protective cover, water, topography, exposure, human disturbances, weather, and migration of deer herds. The highest preferred plant communities were those with highest forage diversity exhibited by an abundance of browse, forbs and grasses.

Bitterbrush (Purshia spp.) dominated communities were by far the most heavily preferred by deer. Curlleaf mountain mahogany (Cercocarpus ledifolious) communities were also highly preferred. Quaking aspen (Populous tremuloides) also received high preference on summer ranges due to the great diversity of forbs present in the understory.

Plant communities lacking in forage diversity repeatedly received low deer use. Big sagebrush (Artemisia tridentata), black sagebrush (A. nova), and low sagebrush (A. arbuscula) dominated communities received little deer use. Low use was due to lack of browse, particularly bitterbrush, forbs and grasses.

Deer use within singleleaf pinyon pine (Pinus monophyla) and Utah juniper (Juniperus osteosperma) communities was dependent upon the forage diversity within the understory. Closed pinyon-juniper stands received the lowest deer use of any other investigated plant community. There was usually no use within these closed stands.

The importance of browse, particularly bitterbrush, cannot be overemphasized. Deer use was directly correlated with bitterbrush occurrence.

Serviceberry (Amelanchier alnifolia) and mountain mahogany were also very important, especially when bitterbrush was absent. Most of these plants were in poor condition due to over utilization on investigated winter and summer deer ranges.

Food habits data also indicated that deer preferred a diverse diet (Doughty, 1966; Diebert, 1968; Pudney, 1972). Browse made up the bulk of rumen samples, but forbs and grasses were also present (Table 1). Forbs were preferred during spring and early summer. Large amounts of grass were consumed in early spring.

Table 1. Percent plant composition of mule deer rumens from White Rock Mountain.

	Grass	Browse	Forb
March	12	76	12
May	9	70	21
July	1	89	10
September	1	90	9
December	0	100	0
Average	5	85	10

Poor deer range condition and trend has been known to cause poor reproductive rates, poor fawn survival and even direct mortality (Leopold, 1950; Dasmann and Blaisdell, 1954; Julander, 1962; McKean and Bartmann, 1971). In this study, site productivity through forage diversity was the basis for determining condition and trend. Plots investigated in 1964 and 1965 by Berg (1966) were re-evaluated in 1972 and 1973 (Monroe, 1975; Tueller and Monroe, 1975).

Condition was defined as the deer forage potential of which a site was capable under sound management. Trend was defined as the direction of change that the vegetation was exhibiting in regard to its potential.

Heavy spring and summer livestock grazing was responsible for decline of many Nevada deer ranges (Berg, 1966; Tower, 1970). Problems were compounded when heavy deer use also was present. All investigated deer ranges' conditions improved over the study period of 8 years when livestock grazing was controlled, reduced or completely removed.

Critical deer range on Morey Bench was restricted to about 2500 acres of big sagebrush and desert bitterbrush (Purshia glandulosa). Up to 10,000 to 12,000 deer have wintered on Morey Bench (Maier, 1967). In 1964 deer use was 179 deer days use per acre on the big sagebrush/desert bitterbrush community. The entire community received homogeneous deer utilization.

Poor range conditions in 1964 were indicated by a lack of browse yield and reproduction, primarily desert bitterbrush. Perennial grasses and forbs were virtually absent, therefore, bitterbrush received most of the use.

All browse plants were severely hedged and 52% of the bitterbrush plants were decadent. Over 50% of the big sagebrush plants were dead or dying with 75% of big sagebrush cover being dead vegetation.

Past use on Morey Bench was excessive to a proposed 50-65% desired bitterbrush utilization (Dasmann, 1971). Annual deer utilization alone was often greater than 50%. Livestock utilization usually exceeded 27%. Total utilization was often greater than 70% and in 1965 it was 86%.

Fat content of mule deer during 1964 and 1965 winters continually decreased from December to March (Doughty, 1966). The greatest decline in fat content was from December to January. No significant decline followed January.

Diets were not sufficient to maintain a slow downward trend of fat content over the winter season.

In 1968 a fence was constructed to control livestock grazing. By 1972 conditions improved since 1964 and trend appeared to be upward. Deer use remained unchanged at 182 deer days use per acre within the big sagebrush/desert bitterbrush community. The balance of Morey Bench experienced a 60% decline in deer use. The entire range exhibited a positive response to less grazing by livestock.

Since 1964 big sagebrush vigor improved significantly by 1972. Dead canopy cover decreased while live canopy cover increased in the control and completely protected exclosure. Berg (1966) found over 75% of the sagebrush cover was dead. In 1972, only a slight percentage of plants were in this condition.

Live foliage cover of desert bitterbrush increased slightly by 1972. Frequency of dead plants showed no change. Frequency of live plants showed a slight increase (9.5% to 13%) in the unprotected areas.

Bitterbrush density increased since 1964. The livestock exclosure (deer use only) and the control exhibited 30% and 45% more plants per acre in 1972 than in 1964, respectively. No significant increase was found within the deer exclosure (no use). This increase was due to vegetative reproduction (base sprouting). Reproduction by seed was insignificant. This was important since the sprouting plants were originally labeled as dead or decadent in 1964. In any event, they were old plants producing little annual forage in 1964.

Rubber rabbitbrush (Chrysothamnus nauseosus) foliage cover tripled in the unprotected areas since 1964. Frequency was nearly nine times higher in 1972 than in 1964, although no increase occurred in the ungrazed exclosures. Rubber rabbitbrush at Morey Bench was considered undesirable as a forage plant for deer and livestock and received no use by either grazing animal. Rubber rabbitbrush was a major part of the big sagebrush/desert bitterbrush community in 1972. The increase was due to past and continued heavy utilization of preferred forage plants.

In 1964 forage diversity was low in the big sagebrush/desert bitterbrush/Anderson peachbrush community. Grasses and forbs were almost completely lacking but in 1972 were slowly increasing. Livestock control resulted with increased diversity in 8 years, indicating a favorable trend not present in 1964.

Overuse of important browse plants by livestock was also found at the Pequop Mountains winter range (Berg, 1966). The winter range was dissected by Interstate 80, a four-lane highway. Following 1964 investigations livestock were removed south of Interstate 80 by choice of the livestock operator. Deer use increased 59% by 1972 with no detrimental effects to the range resource. Average use was 25.9 and 41.4 deer days use per acre for 1964 and 1972.

Heavy livestock grazing was continued north of Interstate 80. Deer use decreased 34% on investigated big sagebrush/antelope bitterbrush (Purshia tridentata) communities as a result of continued heavy cattle grazing. Deer days use per acre was 43.1 in 1964 and 28.5 in 1972.

No significant vegetative changes affecting deer range occurred since 1964 in terms of plant cover or frequency of occurrence. Browse vigor, however, greatly improved due to livestock removal. Decadent and severely hedged bitterbrush are now virtually absent in the bitterbrush associated communities which received low cattle use.

Serviceberry and bitterbrush densities showed no difference. Reproduction, however, was present in 1972 while none was evident in 1964. Investigated communities north of the highway had no reproduction of bitterbrush. Cattle use presumably prevented seed production and seedling survival. Communities which received no cattle use exhibited high amounts of bitterbrush and serviceberry seedlings and young age classes.

Livestock grazing north of Interstate 80 had a detrimental effect on range productivity. Deer use declined and palatable species became heavily utilized. Bitterbrush plants were all severely hedged. Dead bitterbrush cover increased from 0.2% in 1964 to 1% in 1972. No browse reproduction occurred since some time prior to 1964. Perennial grasses were few and cheatgrass had 100% frequency. Cheatgrass was virtually absent where cattle use was slight. No forbs were recorded north of Interstate 80.

At Duck Creek Basin, three variations of the big sagebrush/bitterbrush/Sandberg bluegrass community was present due to varying degrees of livestock use. Deer use also fluctuated depending upon the intensity of livestock use (Table 2).

Table 2. Relative deer days use per acre for the big sagebrush/bitterbrush/Sandberg bluegrass community at Duck Creek Basin.

Site	1964	1972	Livestock Use	Decadent Bitterbrush %
Timber Creek	112	187	Light	22
Paine Canyon	35	36	Moderate	43
Exclosure Site	15	7	Heavy	48

Timber Creek represented the greatest forage diversity and fewest decadent or severely hedged browse plants. Decadent bitterbrush plants decreased 60% and only 55% were severely hedged. Bitterbrush reproduction was also recorded at Timber Creek while no seedlings were recorded anywhere else within the Basin. The deer use increase had no detrimental effects on the range resource.

A similar situation was present on the Fox Mountain summer range. The situation, however, was more serious. Total utilization of bitterbrush and mahogany in the 1960's exceeded 80% while deer consumed an insignificant amount. Fat content of deer at the end of summer was 20% lower than other investigated summer ranges (Doughty, 1966).

Deer use decreased an average of 82% within the bitterbrush and mahogany associated communities (Table 3).

Table 3. Deer-days use per acre in the big sagebrush/antelope bitterbrush/Idaho fescue community on Fox Mountain.

	1964	1972	Percent Reduction
Winnemucca BLM District	56	15	73
Susanville BLM District	72	7	90
Average	64	11	82

In 1968 a divisional fence was constructed between the Winnemucca and Susanville BLM Districts. Livestock were then contained within their proper allotment. The fence was responsible for an appreciable amount of range recovery. Forage diversity increased. Browse plants recovered

and few were decadent. Reproduction of grasses, forbs, bitterbrush and mahogany was present. Both districts benefitted from the livestock control. The Winnemucca District, however, had a more favorable response than the Susanville District. Heavy livestock use during the spring still occurred on the Susanville side of the fence. Livestock did not reach the summer range until late summer on the Winnemucca side. Therefore, browse was then available when deer preferred it and required it (Doughty, 1966). Deer use also revealed the difference by being 80% greater on the Winnemucca District (Tueller and Monroe, 1974).

Since pinyon-juniper stands received the lowest preference by deer, great concern must be focused on these stands. The only available forage within closed stands were sparse forbs such as lupine and penstemen found in the understory.

Pinyon and juniper trees increased on every investigated deer range where they were present (Table 4). In the short period of this study, some stands often experienced increases much greater than 50%. Seedling pinyons showed the greatest increases.

At White Rock Mountain the big sagebrush/bitterbrush community averaged 80 trees per acre in 1973 which were not recorded in 1965. Seedlings amounted to 71% of the total. Tree encroachment was most significant in those sites nearest pinyon-juniper communities.

Pinyon-juniper invasion has reduced site productivity on investigated closing stands on White Rock Mountain. Forage diversity declined as a result of competition from the trees. Bitterbrush density declined by 50% and deer use decreased 80% from 1965 to 1973 (Table 5).

Table 4. Tree density (plants/acre) on three pinyon-juniper stands at Duck Creek Basin.

	Pinyon				Juniper				Total	
	Young		Mature		Young		Mature			
	1964	1972	1964	1972	1964	1972	1964	1972	1964	1972
Juos/Pimo/Arno	52	160	91	160	58	58	29	29	230	417
Juos/Pimo/Arno	9	15	96	101	18	87	61	66	184	269
Juos/Pimo*	69	90	157	188	52	29	278	217	556	514
Average**	31	88	84	131	38	73	45	48	207	343

*Closed.

**Excludes closed stand.

Juos---Juniperus osteosperma
Pimo---Pinus monophylla
Arno---Artemisia nova

Table 5. Bitterbrush densities and deer use decreased on investigated pinyon-juniper stands on White Rock Mountain between 1965 and 1973.

	Bitterbrush Per Acre		Deer Days Use Per Acre	
	1965	1973	1965	1973
Pimo/Juos/Artr	2200	1227	121	64
Pimo/Juos/Arno	2013	790	129	15

Pimo---Pinus monophylla
Juos---Juniperus osteosperma
Artr---Artemisia tridentata
Arno---Artemisia nova

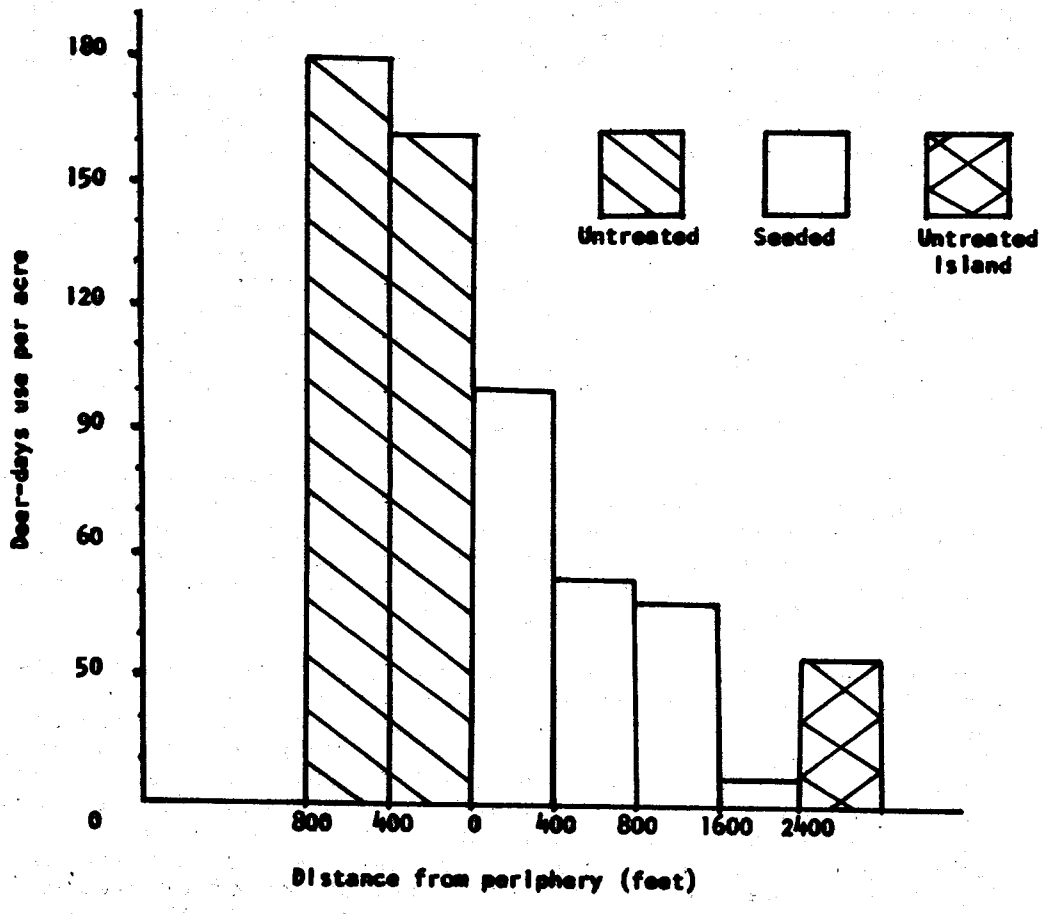

Figure 1. Relative deer-days use at Gardner Seeding.

Investigated seedings varied in size from 1030 acres to 6800 acres and were plowed and drilled in the falls of 1952, 1953 and 1958 with Fairway crested wheatgrass (Agropyron cristatum) at rates of 5.75 to 7.3 pounds per acre. The seedings were managed with grazing systems. Livestock use was cattle and sheep.

Numerous perennial wheatgrass seedings were studied in northwestern and eastern Nevada (Cole, 1968). Only three offered potential for measuring deer use and were subsequently investigated. It was found that mule deer did not use the Gardner, Cave Valley, or Mount Wilson Fairway crested wheatgrass seedings to any great extent. In all cases, the seedings received lower use than the adjacent untreated areas (Figure 1). Peripheries and untreated islands within the seedings received appreciable amount of deer use. Deer use was directly related to the vegetation complex with emphasis on available forage.

Each seeding resulted in a sharp reduction of important browse species and forbs which contributed to low deer use. Loss of cover was evident but more important was the loss of deer forage. Browse gradually invaded the peripheral areas of the older seedings providing forage and some cover. These ecotones received the highest deer use within the seedings. In all cases, use in the untreated areas was higher than any ecotone within the seeding.

Deer use within the seedings was dependent upon browse interspersion and associated forbs. Highest utilization was recorded on areas of highest bitterbrush frequency. Bitterbrush and associated species began reduction at the seeding edge and continued reduction proceeding into the seeding interior until no bitterbrush occurred. Deer use follows the same pattern of reduction only at a faster pace. This was supported by the fact that negligible range utilization was detected in the center of the seeding, away from the browse community edges.

Untreated islands inside seedings provided forage diversity and quality necessary for deer habitat. Deer highly utilized such areas. However, the use was limited to within the island. An insignificant amount of deer use was evident outside the island which corresponded with the lack of deer forage. Even though the island was a considerable distance from the seeding periphery, it still attracted deer.

Crested wheatgrass occurrence increased proceeding into the seeding interior. As the grass increased, browse and forbs had a significant decrease causing a decline of deer use. Deer use was lowest where crested wheatgrass frequency was highest (Figure 2). This included peripheries of an island in the center of one seeding. As the grass became more prevalent, browse, including bitterbrush, and forbs decreased to minimum at the seeding interiors as did deer use. At this point cover may have been a contributing factor, but in some areas deer use remained low even though sufficient cover was available. Deer utilization of crested wheatgrass was insignificant if browse and forbs were present in the untreated area.

The Gardner seeding periphery and island had sufficient browse to encourage deer utilization. The Wilson and Cave Valley seedings lacked such browse diversity. Deer use showed a sharp reduction immediately inside the latter seedings. Reduction in use continued proceeding further within each seeding until no use was evident. At such points crested wheatgrass was dominant while browse and forbs were not present.

Crested wheatgrass seedings without a proper design resulted in a loss of deer habitat. Cover loss was evident, but forage loss was the greatest impact upon deer. These seedings lacked proper design to attain uniform deer utilization. Future attempts should be made to attain forage diver-

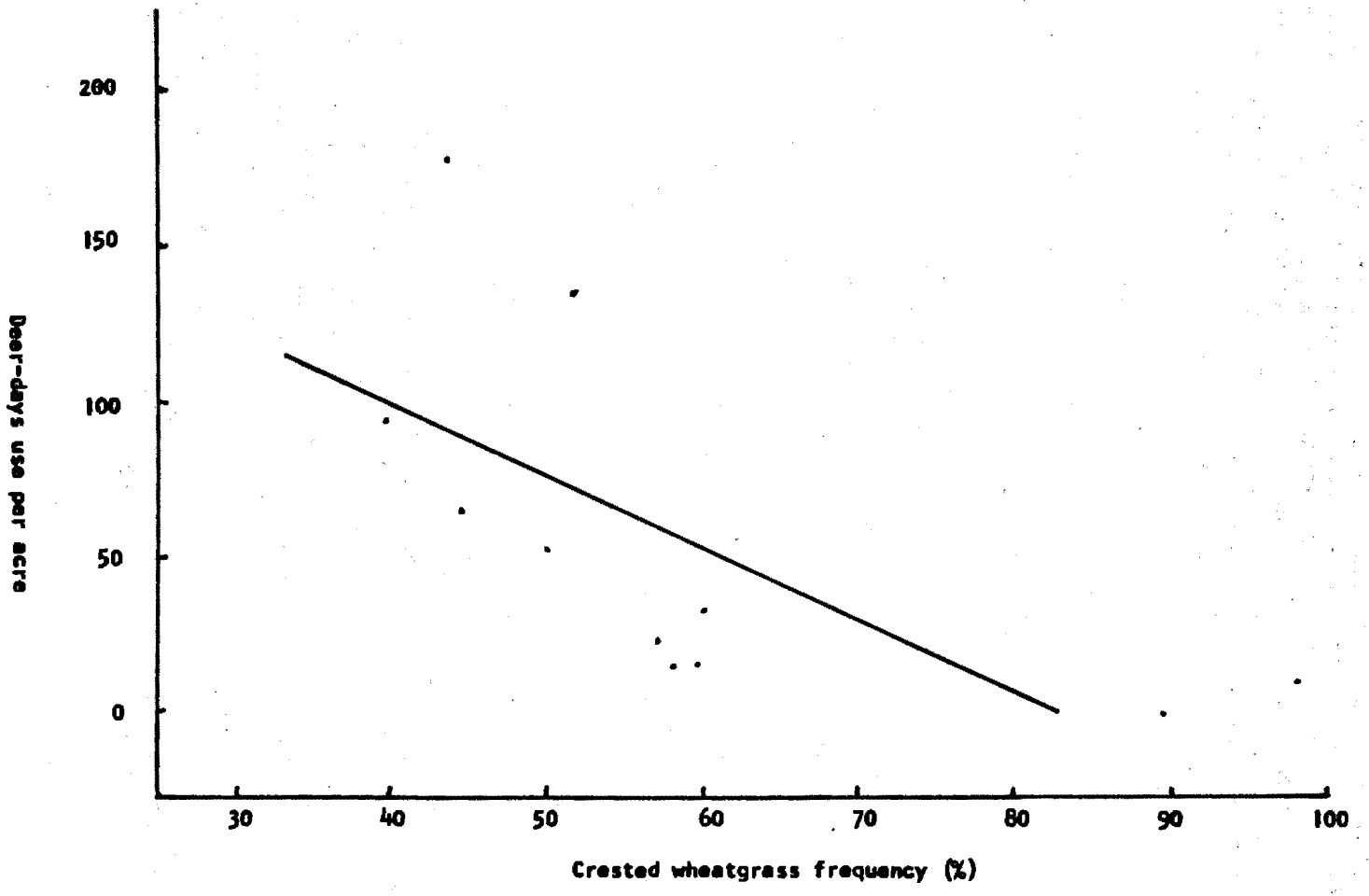

Figure 2. Crested wheatgrass frequency has a negative effect on deer utilization.

sity and quality necessary for mule deer habitat. When seeding an important deer range with sufficient habitat for the purpose of reducing livestock-deer competition, the seedings should be completed in order to produce the least effect upon the existing environment. To achieve this and provide an ecotone, the periphery should be as large and irregular as possible without increasing the treatment acreage. Attempts should not be made to intersperse native browse within the treatment, but to intersperse the treatment within the native browse.

Since the phenology of crested wheatgrass precedes that of almost all native herbaceous species in the spring, potential and previously unavailable forage was produced for an approximate 3-week period of time. Should a seeding be placed in presently unused range adjacent to utilized browse range, such production represents additional forage. If, on the other hand, a seeding is placed in presently used browse range, early spring production of herbaceous forage is achieved at the expense of winter-long browse forage.

A seeding in an area where deer habitat is deteriorating is most critical. Seeding only crested wheatgrass to reduce livestock-deer competition in this type of environment is of no direct benefit to deer. Deer require forage diversity and this must be considered, especially when a diversity of vegetation is not present in the untreated area. This situation requires a seeding mixture to include browse, forbs, and grasses in order to restore the deer habitat. A proper design is then necessary to obtain desired utilization within the seeding and untreated areas. The result is the maintenance of a healthy deer range and healthy deer herd.

Pinyon-juniper control techniques were the primary criteria for selection of pinyon-juniper control sites. These sites were treated due to lack of livestock and big game forage and poor watershed condition. Pinyon-juniper invasion was one of the most important contributors to downward trends of mule deer ranges due to lack of forage diversity.

Control projects studied included one-way chainings, one-way cabling, and double chainings. Techniques as to tree kill and success of forage release in projects with monoculture seeding, mixture seeding, and no seeding were all evaluated. Design of the treatments was also considered.

On all investigated treatments pinyon-juniper kill was good (Cole, 1968; Tausch, 1973).

On Spruce Mountain in Elko County, a one-way chaining with no seeding, pinyon pine density showed a 50% reduction by 1967 to 111 trees per acre (Table 6). Density decreased to 46.8 trees per acre by 1971. Damaged trees continued to die after 1967. Tree reproduction also decreased following the treatment. Seedlings decreased from 65 per acre in the untreated areas to 55 per acre in 1967 and to only 9 per acre in 1971 in the chaining (Cole, 1968 and Tausch, 1971). Non-seedling trees decreased from 160 per acre in the untreated areas to 56 per acre by 1967 and to 38 trees per acre by 1971 in the chaining (Cole, 1968 and Tausch, 1973). The majority of the non-seedling trees within the chaining were age Classes II and III (Blackburn, 1967). This was based on size rather than age where trees were up to 7 ft tall with trunk diameters ranging from 0.75 to 3.5 inches (Cole, 1968). The dominant age class in the untreated areas is Class V where trees were up to 20 ft tall with trunk diameters between 6.5 and 14 inches. Trees within the chaining were younger than the age classes would indicate since chaining was done in 1962.

Utah juniper showed no significant difference in density 5 years after treatment. By 1971 there was a significant difference between the chained area and untreated area. Juniper kill at this time averaged 53% (Tausch,

1973). In 1967 the average kill was only 33%. Surviving trees were knocked down but many were not killed. Many died in the time period between treatment and 1971. Juniper reproduction was little to none.

Table 6. Pinyon and juniper density (Trees/acre) following a one-way chaining on Spruce Mountain.

	Chained		Unchained
	1967	1971	1967
Pinyon Pine	111	47	225
Utah Juniper	220	147	250
Total	331	194	475

At Blythe Springs in Lincoln County, a one-way cabling done for livestock benefit in 1958, pinyon kill ranged from 88 to 90%. The high kill was due to the even age stand of mature trees. Seedling survival, however, was high. Juniper was less affected by cabling with only 33 to 36% kill.

Tree re-invasion was slow at Spruce Mountain, but Blythe Springs had an excessive rate of re-invasion (Table 7). Pinyons and junipers continued to increase in the cabled as well as the untreated range in every plant community. Total trees per acre increased 96% in the cabled area. The exclosure site located near the center of the cabling exhibited a 91% increase. Increases exceeding 100% occurred in the peripheral areas within the cabling. The total number of trees in the uncabled areas increased 32%.

Table 7. Re-invasion of pinyon and juniper trees at Blythe Springs Cabling (1958) was accelerated due to overuse following treatment and poor control of young trees.

	Average Trees Per Acre					
	Pinyon		Juniper		Total	
	1965	1973	1965	1973	1965	1973
Chained	119	205	76	162	195	367
Unchained	296	435	140	138	436	573

Higher tree kills in excess of 90% were present following double chainings. The double chainings were done in 1968 and 1969; therefore, no speculation could be drawn regarding actual kill or re-invasion.

In every case, deer use was significantly greater within the treated areas than on the untreated ranges. In most cases, average deer use doubled or tripled. Larger increases were recorded on specific areas. Treatments also increased deer use within the untreated peripheral areas.

At Blythe Springs, deer use was most concentrated at the cabling periphery (Table 8). An "edge effect" was definitely present. Deer use increased 87.5% along the periphery within the cabling. By 1973, deer use decreased 63% in the untreated areas and only decreased 15% on the treated range. Deer use was about 60% greater in the cabled range than the untreated range in 1973.

Numbers of decadent browse plants did not change in the cabled areas. However, decadent bitterbrush and cliffrose increased 75% in the uncabled range. This was attributed to competition from the tree stand within the untreated range. No increase of decadent browse in the cabled area occurred. In 1973, 63% and 19% of the bitterbrush and cliffrose plants were decadent in the untreated and cabled areas, respectively. All

Table 8. An "edge effect" was present in 1967 at Blythe Springs pinyon-juniper cabling.

	Deer Days Use Per Acre		
	Native	Treated	% Increase
Transect 1	18.1	18.7	
Transect 2	17.3	24.1	
Average (Transects)	17.9	20.6	15.0
Average (Periphery)	24.8	46.5	87.5

*From Cole (1968).

serviceberry plants were severely hedged in 1973. Since deer pellet groups were absent near the serviceberry concentrations and horse signs were plentiful, this hedging can most likely be attributed to heavy grazing by wild horses.

Few bitterbrush and cliffrose seedlings were found in 1965. Counts in 1973 indicate a large increase in the cabled area. Insignificant reproduction occurred outside the treatment. Seedlings within the treatment were vigorous. All seedlings recorded were older than one growing season. No attempt was made to count new shoots since survival rate could not be determined.

Release of the native understory was slow at Blythe Springs due to heavy utilization by deer, livestock and wild horses immediately following treatment. Conditions since 1965 investigations (Berg, 1966) greatly improved by 1972 as indicated by improved browse vigor. The vegetative response is due to treatment and less forage demand by deer and livestock.

The crested wheatgrass that was broadcasted at Blythe Springs following the cable treatment showed a definite decline, particularly on the control site. No crested wheatgrass was present in 1973. Horse and cattle use may have accelerated the decline. The complete lack of crested wheatgrass in the protected areas indicates that the aerial broadcast was not successful. Cabling did not apparently prepare an adequate seed bed or cover the seed following treatment.

On one-way treatments where the chain or cable was dragged in one direction only, deer use was directly related to understory plant cover prior to treatment. Closing tree stands had sufficient understory for release when tree competition was removed. At Spruce Mountain, deer use was directly correlated with black sagebrush cover. Associated plants were bitterbrush and various forbs and grasses. The greatest amount of forage diversity was present where black sagebrush cover was high. Important browse, forbs and perennial grasses showed remarkable increases. Deer use was twice as great in the chained area (Table 9). A three-fold increase in deer use occurred between 1965 and 1966. The increase was attributed to concentrated range use in response to forage availability due to chaining treatment.

Table 9. Deer-days use per acre comparing four consecutive years of data at Spruce Mountain.

Year	Unchained	Chained
1964	2.3	12.9
1965	3.6	15.2
1966	23.4	50.9
1967	24.5	49.8
Average	13.5	32.2

Double chainings with mixture seedings of browse, grasses and forbs were most beneficial to improve depleted pinyon-juniper ranges. Forage diversity was immediately provided. Season of use and animal diversity were also enhanced for deer. The double chainings investigated, however, were not old enough to evaluate deer utilization.

Deer use of edges and aesthetic values greatly influenced proper design of treatments. Smaller fingers of chained vegetation following the land contour received concentrated deer use. Untreated islands also provided escape and protective cover for wildlife. Chainings with proper design blended in with the monotypic vegetation types generally treated.

Economic evaluation of pinyon-juniper control projects and hunter days indicated they were beneficial (Garrett, et al., 1970). Analysis was based upon deer utilization. No attempt was made to include livestock, watershed, and other wildlife benefits. Benefit-cost ratios of 2.09 and 1.65 were determined for Spruce Mountain and Blythe Springs treatments. In other words, $2.09 and $1.65 were returned for every dollar put into the treatment. These projects were not considered the most successful treatments. They were the only investigated treatments with sufficient data for economic evaluations.

For future pinyon-juniper control projects, attempts should be made to (1) reduce the forage demand to minimum until sufficient forage is established (2) provide forage diversity through mixture seeding (3) provide an irregular boundary with no large area of treated range (4) provide a design to meet aesthetic values (5) provide the highest amount of tree control at time of treatment and (6) provide sufficient management to maintain the desired results.

Conclusions

The final conclusions for this study are:

1. Food habits data could not determine range condition.
2. Range condition was reflected in animal condition.
3. Heavy spring and summer livestock use had a negative effect on deer ranges.
4. Deer avoided sites heavily used by livestock where forage was removed prior to deer migration onto these winter ranges. Deer also avoided sites during late summer and early fall where browse was heavily utilized by livestock during spring and early summer.
5. Heavy livestock use reduced deer range productivity.
6. Continued heavy deer use also reduced deer range productivity.
7. Reductions of both heavy livestock and deer use on a deer range provided deer range recovery.
8. Velocity of depleted range recovery depended upon the conditions when reductions of use were made.
9. Deer use was highest in those plant communities exhibiting the highest forage diversity. Monotypic stands of pinyon, juniper, big sagebrush, or black sagebrush received low deer use.
10. Wheatgrass seedings were of no benefit to mule deer.
11. Forage loss was the cause of low deer use in monotypic grass seedings. Cover was also implicated.
12. A mixture of browse and forbs maintained deer use on crested wheatgrass seedings.
13. Pinyon-juniper invasions decreased browse density and cover, thereby reducing range productivity.
14. Pinyon-juniper control projects improved mule deer habitats.
15. Forage diversity and production, watershed and deer use all benefitted on investigated pinyon-juniper treatments.
16. Control projects were also economically feasible, based on deer utilization only.

17. Proper design and mixture seedings with high tree control provided good deer habitat.

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