LIVESTOCK-BIG GAME INTERACTIONS: A SELECTED REVIEW WITH EMPHASIS ON LITERATURE FROM THE INTERIOR PACIFIC NORTHWEST.

PATRICK E. CLARK, Department of Rangeland Resources,
Oregon State University, Corvallis, OR 97331.

Eastside Ecosystem Management Project
112 East Poplar Street
Walla Walla, Washington 99362-1693

Contract No. 43-OEOO-4-9156

Preface

The following report was prepared by University scientists through cooperative agreement, project science staff, or contractors as part of the ongoing efforts of the Interior Columbia Basin Ecosystem Management Project, co-managed by the U.S. Forest Service and the Bureau of Land Management. It was prepared for the express purpose of compiling information, reviewing available literature, researching topics related to ecosystems within the Interior Columbia Basin, or exploring relationships among biophysical and economic/social resources.

Ms report has been reviewed by agency scientists as part of the ongoing ecosystem project. The report may be cited within the primary products produced by the project or it may have served its purposes by furthering our understanding of complex resource issues within the Basin. This report may become the basis for scientific journal articles or technical reports by the USDA Forest Service or USDI Bureau of Land Management. The attached report has not been through all the steps appropriate to final publishing as either a scientific journal article or a technical report.

ACKNOWLEDGEMENTS

I am grateful to Larry Bryant, Jon Skovlin, and Martin Vavra for their critical review of the early draft of this paper and to Mike Borman for his assistance and direction. Access to the literature resources of Larry Bryant, John Cook, Bob Riggs, Jack Ward Thomas, and Martin Vavra was a great help in completing this project and is sincerely appreciated.

TABLE OF CONTENTS

HISTORICAL DISTRIBUTIONS OF BIG GAME POPULATIONS IN EASTERN OREGON, EASTERN WASHINGTON, AND IDAHO:

LIVESTOCK AND BIG GAME: HABITATS, DIETS, AND COMPETITION

Habitats

Diets

Competition

IMPACTS OF LIVESTOCK ON BIG GAME FORAGE AND COVER SPECIES

PREFACE

The literature included in this review was generally obtained from 5 sources: 1) refereed journal articles, 2) theses and dissertations, 3) symposium proceedings, 4) Forest Service research publications, and 5) research publications from the wildlife management organizations of various western states. However, in cases where information from the 5 primary literature sources did not provide adequate treatment of certain topic areas, additional information from alternative sources was included. Cautionary statements pertaining to the application of information from these alternative sources were included at all locations within this literature review where alternative information sources were used.

At the beginning of both, the Habitat section and the Diet section of this literature review, a short description of the limitations of each of the different research methods used in the literature included in these sections was provided. As there were no further cautionary statements included following these sections, the reader should keep in mind the limitations of each of the different research methods when interpreting the information provided in the remaining portion of this literature review.

The scientific names and authorities for the plants and animals discussed in this literature review are listed in Appendix A.

HISTORICAL DISTRIBUTIONS OF BIG GAME POPULATIONS: EASTERN OREGON, EASTERN WASHINGTON, AND IDAHO

ROCKY MOUNTAIN ELK

EASTERN OREGON

Archeological evidence reveals elk have occupied the Columbia Basin for approximately 10,000 years (McCorquodale 1985). Studies cited by Kay (1990) indicate ancient elk remains were present at archaeological sites in eastern Oregon, however, these remains made up only a very small percentage of the total ungulate remains found at these sites. The remains of deer and bighorn sheep were generally much more prevalent at archaeological sites in eastern Oregon than were elk remains.

At archaeological sites in Elk Creek Basin of southern Oregon, Pettigrew and Lebow (1987) reported that deer remains were found in human habitation layers dating back to 3,000 years ago while elk remains were found only in habitation layers which were less that 1000 years old. In three archaeological sites in northeastern Oregon, Reid (1988) noted the remains of bighorn sheep, pronghorn, and bison were present but deer and elk were absent.

Notably, much of the animal remains recovered from archaeological sites in eastern Oregon have been cleaved and broken into small fragments (Minor and Toppel 1984) indicating the ancient human inhabitants of these sites were attempting to extract as much food value from scarce prey resources as possible (Schmitt 1986). Reid (1988) concluded if elk were as prevalent in prehistoric northeastern Oregon as they are currently then, more elk remains should have been found at archaeological sites throughout northeast Oregon.

Early historical accounts of the elk populations in eastern Oregon are often contradictory. Some of the early explorers of the region report sightings and evidence of numerous elk. In 1812, Robert Stuart, leader of John Jacob Astor's Tonquin Expedition remarked that, based on the number of shed antlers nearby, a large population of elk apparently frequented the Hot Lake area within the Grande Ronde Valley of northeastern Oregon (Rollins 1935). In 1829, Peter Skeen Ogden, chief trader in the Oregon Country for the Hudson's Bay Company, reported that the headwaters of the Crooked River in central Oregon contained an abundance of elk. Captain Benjamin Bonneville, in 1834, noted that large numbers of elk wintered in the Grande Ronde Valley of Oregon (Irving 1885).

Other reports seem to indicate a scarcity of elk and large game in eastern Oregon. Lewis and Clark often remarked on the lack of game animals during their travels through the Interior Pacific Northwest (Thwaites 1969). In 1832, John Ball, a member of Nathaniel Wyeth's first expedition considered the sighting of fresh elk tracks along the Powder River of northeastern Oregon noteworthy after finding little evidence of game since leaving the "buffalo country" (Oregon Historical Society 1902) . Narcissa Whitman noted, in 1836, that the Cayuse Indians of northeastern Oregon and southeastern Washington used camas roots rather than meat from game animals as their primary winter food.

These contrasting reports appear to indicate that elk were not evenly distributed throughout Oregon during pre-settlement time. From an ecological standpoint, an uneven distribution of elk in eastern Oregon is not surprising. Elk have been classified as mid seral species and, consequently, are typically found in higher numbers in areas which are rebounding from disturbance. In eastern Oregon, during pre-settlement times, the disturbance most likely to influence elk distribution was fire. It is quite possible that those early travelers who reported a scarcity of elk in eastern Oregon had passed through areas that would have been classified as transitory elk range where the vegetation was at the wrong end of the fire cycle to be attractive to elk. (personal communication: Martin Vavra, Eastern Oregon Agricultural Research Center, September 6, 1994). In 1805, Lewis and Clark noted elk and deer were difficult to find in the Selway River area of Idaho. Large amounts of "fallen timber" (possibly indicative of a dense, stagnated forest) were also mentioned by Clark while in this area (Thwaites 1969). However, after the fires of 1910, elk and deer numbers in the Selway area increased considerably (personal communication: Martin Vavra, Eastern Oregon Agricultural Research Center, September 6, 1994).

During the great westward emigration along the Oregon Trail during the mid 1800s, elk were frequently seen by settlers in eastern Oregon (Bailey 1936). However, by the late 1880s, the combined effect of unregulated hunting, heavy livestock grazing, and tillage of -the native grasslands nearly caused the extirpation of elk in the Blue Mountains of Oregon (Irwin et al. 1994). In 1907, the total elk population in Oregon was estimated to be 200 head (Seton 1927).
Regulated elk hunting was imposed in Oregon in 1904. The following year, elk hunting was banned within the state. Hunting of Rocky Mountain elk in eastern Oregon remained illegal until 1933 (Mace 1971). To augment the remaining population of Rocky Mountain elk in eastern Oregon, translocations of elk from Jackson Hole, Wyoming and Yellowstone National Park to northeastern Oregon were conducted in 1912 and 1913 (Bailey 1936, Couch 1953, Bryant and Maser 1982) .

In northeastern Oregon, Bailey (1936) reported that there was an estimated total of 710 head of elk living in Baker, Umatilla, Union, and Wallowa counties in 1916. Based on information from Bailey (1936) and Shay (1954), Irwin et al. (1994) concluded that the total Rocky Mountain elk population in the Blue Mountains of Oregon and Washington probably numbered less than "a few thousand animals in the 1920s" . By 1932, there were an estimated 3, 000 head of Rocky Mountain elk in Wallowa county alone (Couch 1953).

Elk hunting was reinstated in eastern Oregon in 1933. During the decades of the 1940s, 50s, and 60s the number -of hunters and the number of harvested elk in eastern Oregon generally increased. During the decade of the 1970s, elk populations in eastern Oregon swelled by 45% (Edwards 1992). By 1976, the estimated Rocky mountain elk population for eastern Oregon was 60,000 head (Bryant and Maser 1982) . Irwin et al. (1994) reported that the Rocky mountain elk population for Baker, Umatilla, Union, and Wallowa counties was estimated at 58,500 head in 1980. During the winter of 1993, the Oregon Department of Fish and Wildlife estimated that the Rocky Mountain elk population in eastern Oregon totalled 61,400 (person communication: Tom Thornton, Oregon Dept. of Fish and Wildlife. August 23, 1994).

EASTERN WASHINGTON

As noted above, elk have been present in the Columbia Basin, including eastern Washington, for the last 10,000 years (McCorquodale 1985) - Kay (1990) reported that elk remains were found in 38 of the 58 archaeological sites in the Columbia Basin region of Washington. The ungulate remains at most of these sites were dominated (76%) by deer remains. Elk remains represented only 5% of the total ungulate remains found at these sites. As with the ungulate remains found at eastern Oregon 'sites, most of the ungulate remains found at eastern Washington archaeological sites was high fragmented. Olson (1983) noted that even the mandible and phalanges were cracked open to extract the marrow. Marrow extraction from these bones is highly labor-intensive and evidence of this type of processing is indicative of food or meat scarcity (Binford 1978, Olson 1983).

Historical accounts regarding the Rocky Mountain elk population in eastern Washington are apparently not as numerous as those of eastern Oregon. However, it is probably reasonable to assume that the historical influence on the elk in eastern Washington were similar to those in eastern Oregon. Rocky Mountain elk were probably unevenly distributed throughout the Blue Mountains of Washington, portions of northeastern Washington, and to a limited extent, the Columbia Basin region of Washington (McCorquodale 1985, Kay 1990).

As in eastern Oregon, elk were nearly extirpated from eastern Washington in the late 1880s as a result of resource overexploitation (Bryant and Maser 1982). Seton (1927) estimated that the total elk population in Washington was 1,500 head in 1907. Elk hunting was outlawed in eastern Washington until 1927. Translocations of elk from Yellowstone National Park to Pomerory and Walla Walla, Washington occurred in 1913 (Bailey 1936). In 1918 and 1931, elk were translocated from Yellowstone National Park to Walla Walla and Dayton, Washington, respectively (Couch 1953). Rocky Mountain elk populations in eastern Washington generally increased until the late 1970s. In 1979, the Rocky Mountain elk population in eastern Washington was reported as "stable" at an estimated 24, 000 head (Washington Department of Game 1979) . In the spring of 1994, the population estimate for Rocky Mountain elk living in eastern Washington was 25,000 (personal communication: Rolf Johnson, Washington Dept. of Wildlife. August 26, 1994).

IDAHO

Kay (1990) reported archaeological sites in the eastern Snake River Plains contained primarily bison remains while ungulate remains from sites in the western Snake River Valley are predominately bighorn sheep and deer. Of 15 Idaho sites examined only 5 contained elk remains accounting for only 1% of the total remains recovered.

After crossing over the Bitterroot Divide into Idaho in 1805, Lewis and Clark noted that no elk and only a few deer were killed by their hunters. Humbird (1975) suggested that, historically, elk were distributed throughout most of Idaho but the most dense population occurred in the mountains of the eastern portion of the state. During pre-settlement times, elk were probably not abundant in the northern, panhandle region of Idaho (Bryant and Maser 1982). Seton (1927) described all of Idaho except the extreme southwestern corner as being "primitive" or historical elk range. As with eastern Oregon, these contradictions concerning the historical distribution of elk in Idaho suggest elk were unevenly distributed throughout Idaho possibly in response to fire disturbance patterns (personal communication: Martin Vavra, Eastern Oregon Agricultural Research Center, September 6, 1994).

Following the discovery of gold in Pierce, Idaho in 1860 the elk population in Idaho began to decline (Bryant and Maser 1982). Seton (1927) estimated that the elk population of Idaho in 1907 was 5,000 head. In 1926, following the exploitative era of the late 1800s and early 1900s, the distribution of elk in Idaho was limited to a narrow strip, including the Bitterroot Mountains and the Upper Salmon River, in the eastern portion of the state (Seton 1927).

Translocations of elk from Yellowstone National Park and Jackson Hole, Wyoming to various areas within Idaho occurred between 1915 and 1946 (Humbird 1975). Elk were eventually re-established in 40 of the 44 counties of Idaho. In 1976, the Rocky mountain elk population was estimated to be 51, 000 head (Bryant and Maser 1982) . In 1994, the Idaho Department of Fish and Game did not calculate formal population estimates for Rocky Mountain elk in Idaho. Instead, bull to cow and calf to cow ratios were used as indices of elk population status. In 1994, elk herds within 34 of approximately 60 big game management units had bull to cow ratios ranging from 15 to 25 bulls per 100 cows. Management units in the Upper Snake River area supported calf to cow ratios of 55 calves to 100 cows (personal communication: Lloyd Oldenberg, Idaho Dept. Fish and Game. September 16, 1994).

ROCKY MOUNTAIN MULE DEER

EASTERN OREGON

As noted above, ungulate remains recovered from archaeological sites in eastern Oregon were dominated by deer and bighorn sheep (Kay 1990). Reid (1988) reported that, in the Stockhoff and Ladd Canyon sites in northeastern Oregon, deer remains were the only ungulate remains found. However, at the Marsh Meadow site, deer remains were missing but the remains of bighorn sheep, pronghorn, and bison were present.

Deer and other ungulate remains found at Oregon sites were often highly fractured (Minor and Toppel 1984, Kay 1990) suggesting that intensive processing was applied in an attempt to extract as much food value as possible from the remains (Schmitt 1986). Given this evidence, it is possible, although deer were the most prominent northeastern Oregon ungulate in the ancient human diet, deer were not abundant or easily-obtained prey.

Early historic records indicated that deer were the most common ungulates killed by explorers and early settlers in eastern Oregon (Irving 1885, Oregon Historical Society 1902, Thwaites 1969). However, the frequent notations, made in the journals and diaries of these early travelers, about hardship and starvation due to lack of meat seems to indicate that deer were not abundant in eastern Oregon during that time.

As with elk, the population of mule deer in eastern Oregon declined during the exploitative era of the late 1800s and early 1900s. By the late 1920s, the mule deer population of Oregon was estimated to be as low as 39,000 head (Bailey 1936). Under improving resource conditions and better wildlife management mule deer populations in eastern Oregon have generally increased since the 1920s. In the spring of 1994 the population of mule deer in Oregon was estimated to be 216,600 (personal communication: Tom Thornton, Oregon Dept. of Fish and Wildlife. August 23, 1994).

EASTERN WASHINGTON

Archeological evidence indicates deer (probably mule deer) were one of the most common ungulates in the diet of prehistoric human inhabitants of eastern Washington. However, this evidence also suggests that deer were not abundant in eastern Washington during prehistoric times (Kay 1990).

Historical descriptions of the mule deer populations of eastern Washington are apparently quite limited. However, the journals of Lewis and Clark (Thwaites 1969) and Wyeth (Wyeth 1899) indicate that although mule deer were present in southeastern Washington during pre-settlement times, mule deer were not abundant enough to provide a steady food source for an expedition party of several dozen persons.

Following a decline in the late 1800s and early 1900s, mule deer populations in Washington began to increase during the 1930s. By the 1940s, the Washington mule deer population began to stabilize and remained fairly stable during the 1950s. Just prior to the winter of 1968, the mule deer population in Washington was estimated to be 200,000. However, during the winter of 1968, a massive die-off occurred reducing the mule deer population in Washington by 40%. In 1994, the Washington mule deer population appears to have again reached a plateau, stabilizing at 145,000 head (person communication: Rolf Johnson, Washington Dept. of Wildlife. August 26, 1994).

IDAHO

Of the archeological studies reviewed by Kay (1990), the ungulate remains recovered in eastern Snake River Plains were predominately bison remains. Deer remains were more common in the western Snake River Valley. Working near the Middle Fork Salmon River, Leonhardy (1985) found the remains of at least 10 deer among the other ungulate remains within a ancient human habitation site. It was noted all the ungulate remains had been processed by humans into very fine fragments indicative of meat or marrow scarcity.

In 1805, the hunters of the Lewis and Clark Expedition found deer were not abundant in the Bitterroot Mountains of northeastern Idaho. However, as the expedition party moved into northwestern Idaho the hunters were more successful at procuring deer (Thwaites 1969). John Ball, member of Nathaniel Wyeth's first expedition, noted in 1832 that deer and other game were scarce in southern Idaho (Oregon Historical Society 1902).

Mule deer populations in Idaho declined during the exploitative era of the late 1800s and early 1900s. However, mule deer were probably less affected by market hunting than were elk or bison (Seton 1927).

In 1994, the population status of mule deer in Idaho was good and improving. The buck to doe ratio for the big game management units in Idaho ranged from 8 to 25 bucks per 100 does. The fawn to doe ratio in some portions of southwestern Idaho have increased to 35 fawns per 100 does personal communication: Lloyd Oldenberg, Idaho Dept. Fish and Game. September 16, 1994).

CALIFORNIA AND ROCKY MOUNTAIN BIGHORN SHEEP

Buechner (1960b) provided a map of the probable pre-settlement distribution of bighorn sheep in the United States. On this map, most of the eastern half of Oregon, a narrow strip through central

Washington, and central and extreme southern Idaho were depicted as bighorn sheep range.

Kay (1990) reviewed archeological studies conducted in eastern Washington, eastern Oregon, and central and southern Idaho. The remains of bighorn sheep were often the most common ungulate remains recovered in these studies.

EASTERN OREGON

Based on a review of archaeological studies conducted in Oregon, Kay (1990) reported deer and bighorn sheep remains were the most common ungulate remains recovered at sites throughout Oregon except for along the Pacific Coast. When the remains of only bighorn, deer, and elk were considered, bighorn remains formed 17% of the remains recovered in the reviewed studies while deer made up 79% and elk 4%. Reid (1988) noted that, at the Downey Gulch sites in northeastern Oregon, the remains of bighorn sheep and pronghorn made up 80% of the total ungulate remains recovered.

California Bighorn Sheep

In 1826, near present-day The Dalles, Oregon, David Douglas (1829) collected the skull and the horns of what was described as a California bighorn sheep. There is some controversy over where the specimen collected by Douglas had actually lived. Douglas believed the bighorn sheep in question had lived in the Cascade Mountains near Mount Hood, Oregon. Buechner (1960b) suggested the Douglas specimen probably had lived in The Dalles area where it had been collected. Buechner (1960b) supported his argument by citing a bighorn sheep killed by Peter Skeen Ogden in the Mutton Mountains 45 miles south of The Dalles, Oregon during the winter of 1825 (Elliott 1909) . Bailey (1936) suggested that California bighorn sheep were common in the lower Deschutes River area and throughout the lava plains between present-day Bend and Burns, Oregon. California bighorn sheep historically summered in the Steens mountains of southeastern Oregon and wintered in the Warner Valley and Summer Lake area (Buechner 1960b) .

During the early 1900s, heavy livestock grazing and disease transmission between domestic sheep and bighorn sheep took their toll on the bighorn sheep population in eastern Oregon. The California bighorn sheep disappeared from. their historical ranges in southeastern Oregon around 1916. By that time, domestic sheep occupied much of the traditional bighorn range in southeastern Oregon (Bailey 1936).

California bighorn sheep from near Williams Lake, British Columbia were translocated to the Hart Mountain National Wildlife Refuge in southern Oregon during 1954 (Buechner 1960b) . In 1960 and 1961, a total of 11 head of California bighorn sheep were translocated from the reintroduced herd on the Hart Mountain Nation wildlife Refuge to the Steens Mountains, Oregon (Van Dyke 1978).

Spalding and Mitchell (1970) reported in 1969 most of the Oregon population of California bighorns were localized in three areas of southeastern Oregon, the Hart Mountain (150 head) (also see Kornet 1978) and the Steens Mountains (35 head) , and Mahogany Mountain (24 head). In 1975, Van Dyke (1978) noted the California bighorn population on the Steens Mountains was stable at approximately 100 head. In 1994, the California bighorn sheep population in Oregon was estimated to be 2,500 (personal communication: Tom Thornton, Oregon Dept. of Fish and Wildlife. August 23, 1994).

Rocky Mountain Bighorn Sheep

Buechner (1960b) suggested the historical distribution of Rocky mountain bighorn sheep in Oregon was centered in the Wallowa Mountains. Scattered populations also occurred in the Blue Mountains but this area apparently only provided marginal bighorn habitat. Bailey (1936) reported large numbers of Rocky Mountain bighorns remained in the Wallowa Mountains until 1897. However, by 1915 most of the Rocky Mountain bighorn sheep in the eastern Oregon were gone and much of the historic range of bighorn sheep was being grazed by domestic sheep. At that time, the distribution of the few remaining Rocky Mountain bighorn sheep in eastern Oregon had been reduced to rugged, remote pockets of habitat within the Wallowa Mountains and the Imnaha Canyon (Buechner 1960b) .

Between 1924 and 1933 the USDA Forest Service-estimated the Rocky Mountain bighorn population in eastern Oregon was between 40 and 60 head. Rocky Mountain bighorn were completely extirpated from northeastern Oregon shortly after 1933 (Buechner 1960b)
In 1960, Buechner (1960) suggested the Wallowa Mountains of Oregon had a good potential for successful reintroduction of Rocky Mountain bighorn sheep and translocations of sheep from other states to the Wallowa Mountains should be attempted.

Rocky Mountain bighorn sheep have been re-established in the Wallowa Mountains since the 1960s. By 1993, there were an estimated 500 Rocky Mountain bighorn sheep living in Oregon with most of the population occurring in the Wallowa Mountains. (personal communication: Tom Thornton, Oregon Dept. of Fish and Wildlife. August 23, 1994) .

EASTERN WASHINGTON

Kay (1990) reported the remains of bighorn sheep represented 9% of the total ungulate remains recovered from 54% archaeological sites in the Columbia Basin region of eastern and central Washington. Galm and Masten (1985) found remains of bighorn sheep in the Columbia Basin of Washington which were at least 3,000 years old.

California Bighorn Sheep

Historically, California bighorn sheep existed in much of the rugged terrain of northcentral Washington and along the Columbia River in central Washington. The heaviest concentrations of California bighorns in Washington were thought to have existed on the east slope of the Cascade Mountains near the WashingtonCanadian border (Buechner 1960b) . Grinnell (1928) observed bighorn sheep (presumably California bighorn) in the Ashnola district of southern British Columbia in 1887. It was also noted that G. D. Elliott had seen a considerable number of bighorn sheep in northern Washington, across the international border from the Ashnola district, during the same year (Grinnell 1928) . California bighorn. sheep were also historically observed in the Chopaka Mountain area (Buechner 1960b), Azurite Peak (Cowan 1940), Douglas and Grant counties (Cowan 1940, Dalquest 1948) . Livestock overgrazing, market hunting, and disease contributed to the near extirpation of California bighorn from Washington during the early 1900s.

The only natural population of California bighorn sheep in Washington migrate back and forth across the. Washington-Canadian border near the Ashnola Mountains of British Columbia (Buechner 1960b) . In 1957, California bighorn sheep from Williams Lake, British Columbia were translocated to the Sinlahekin Game Range in northcentral Washington. Latter other translocation operations were attempted in central and southeastern Washington. By 1969 Spalding and Mitchell (1970) reported the Washington population of California bighorn sheep was localized in three areas: Sinlahekin (153 head), Wenatchee (80 head), and Pomeroy (70 head).

In 1994, the Washington Dept. of Wildlife estimated there were 706 California bighorn living in Washington. A herd introduced into the Yakima, Washington area was the largest (190 head) California bighorn herd in Washington in 1994 (personal communication: Rolf Johnson, Washington Dept. of Wildlife. September 27, 1994).

Rocky Mountain Bighorn Sheep

Historically, Rocky Mountain bighorn sheep occupied the mountains and rugged canyon walls of southeastern Washington (Buechner 1960b) . As with the bighorn sheep in neighboring northeastern Oregon, the Rocky Mountain bighorn sheep in Washington were severely impacted during the exploitative era of the late 1800s and early 1900s. The last known native Rocky Mountain bighorn in Washington was killed near Deadhorse Spring on the Middle Fork Asotin Creek in 1917 (person communication: Rolf Johnson, Washington Dept. of Wildlife. August 26, 1994).

Reintroductions of Rocky Mountain bighorn into southeastern Washington have been moderately successful. Population estimates indicate 335 Rocky Mountain bighorn sheep were living in Washington during the summer of 1994 (personal communication: Rolf Johnson, Washington Dept. of Wildlife. August 26, 1994).

IDAHO

Kay (1990) reviewed archaeological studies conducted in Idaho. Most of the bighorn sheep remains recovered in these studies came from sites in the mountainous areas of Idaho and in the western Snake River Valley. Comparing the remains of only bighorn sheep, deer, and elk, the remains of bighorn sheep accounted for 77% of the minimal number of individuals (MNI) found at the 15 sites examined. Working at an archaeological site near the Middle Fork Salmon River, Leonhardy (1985) observed that the remains of bighorns were eleven times more common than the remains of the second most common ungulate. The archaeological evidence suggests that bighorn were the most common ungulate in eastern and northern Idaho during prehistoric time but today deer are the most common ungulate in these areas and bighorn sheep are the least common (Kay 1990).

California Bighorn Sheep

Buechner (1960b) makes no mention of a historical California bighorn population in Idaho. However, it is probable that California bighorns inhabited southwestern Idaho during prehistoric times given the proximity of this area to the Steens Mountains area which was known to have supported a native California bighorn population.

Spalding and Mitchell (1970) reported that, in 1969, as a result of translocations from British Columbia, Idaho had a California bighorn sheep population of 90 head. Eighty of these bighorns were living in the Owyhee River drainage and 10 head were living in the Jacks River drainage.
In 1993, the lamb to ewe ratio for California bighorn population in Idaho was 20 lambs per 100 ewes following the hard winter of 1992-1993. The lamb to ewe ratio notably increased to 41 lambs per 100 ewes after the mild winter of 1993-1994. The status of California bighorn in Idaho during 1994 was within the range dictated by the management objectives of the Idaho Dept. of Fish and Game (personal communication: Lloyd Oldenburg, Idaho Dept. of Fish and Game. September 16, 1994)

Rocky Mountain Bighorn Sheep

Buechner (1960b) researched the journals of Lewis and Clark for historical information on bighorn sheep distribution in Idaho. At the time of Lewis and Clark's travels (1803-1806), Rocky Mountain bighorn sheep were apparently abundant in the Bitterroot Mountains of western Montana and in the Clearwater Mountains of north-central Idaho. The greatest concentration of Rocky Mountain bighorns in Idaho appeared to be near the Bitterroot divide which separated

Idaho from Montana. Lewis and Clark learned from local indians that bighorn populations also existed on the Clark Fork river and near the confluence of the Snake and Salmon rivers (Coues 1893). Buechner (1960b) suggested, at the time of Lewis and Clark, larger concentrations of Rocky Mountain bighorn sheep may have been present in the Seven Devils area of Idaho and in the Wallowa mountains of Oregon than were present at the confluence of the Snake and Salmon rivers.

During the winter of 1832, Captain Bonneville reported bighorns were abundant on a winter range near present-day Salmon, Idaho (Irving 1885). Seton (1929) reported that in the late 1800s large numbers of bighorns had been observed in the Lost River Mountains of Idaho. Notably, by 1954 less than "a few dozen" Rocky Mountain bighorn sheep were reportedly living in the Lost River Mountains (Smith 1954). During the late 1800s, Merriam (1891) reported plentiful numbers of bighorns in the headwaters of the Pahsimeroi River, the Salmon River Mountains, and the Sawtooth Mountains of Idaho. Buechner (1960b) cited a personal communication indicating bighorns were nearly absent from the Sawtooth and Pahsimeroi. Mountains in 1957.

Buechner (1960b) concluded the historical range of bighorn sheep in Idaho was mainly limited to a belt-shaped region running across the central portion of the state. In 1960, the largest bighorn sheep populations in Idaho were in the Middle Fork of the Salmon River with scattered populations in the Seven Devils area, in the Salmon River Mountains, and south to the Sawtooth Mountains.

Buechner (1960b) cited a study being conducted at the time by Dwight R. Smith which indicated bighorn sheep numbers in Idaho had more than doubled since the 1920s when the population was at an historical low of 1,000 individuals. In 1960, the Rocky Mountain bighorn sheep population of Idaho was estimated at 2,400 to 2,800 in 1960.

In 1994, the status of Rocky Mountain bighorn sheep in Idaho varied a great deal between herds. Some herds had lamb to ewe ratios as low as 3 lambs per 100 ewes while other herds had lamb to ewe ratios of 25 lambs per 100 ewes which were close to the management objectives for those herds (personal communication: Lloyd Oldenberg. Idaho Dept. of Fish and Game. September 16, 1994).

In general, efforts to reintroduce or enhance existing bighorn sheep populations within their former range have often been slow to succeed (Jahn and Trefethen 1978) . Increases in population size and dispersal into new habitats have been hampered by the innate tendency of bighorn sheep to remain on traditional range being reluctant to pioneer new habitat (Geist 1971). Much of the currently suitable bighorn habitat occurs as isolated patches separated by livestock range, crop fields, roads and other human developments which likely hinder the dispersal of bighorn sheep.

PRONGHORN ANTELOPE

Nelson (1925) estimated there were 35,000,000 pronghorn in North American during the time of the Lewis and Clark expedition in 1805. In just 75 years, the great herds of pronghorn observed by Lewis and Clark declined to fewer than 20,000 individuals (Yoakum 1968) . Market-hunting, modernization and expansion of transportation networks, livestock interactions, alteration of habitat by homesteading, farming, ranching, and other human development have been suggested as reasons for the rapid decline of the pronghorn in North America.

Based on an extensive review of the literature, Yoakum (1968) concluded 3 factors: 1) Institution of controlled hunting seasons (Buechner 1960a, Mathison 1962, Rush 1944), 2) reversion of humanaltered lands within historic pronghorn rangeland back to pronghorn habitat (Leister 1932, Benson 1946), and 3.) enlightened wildlife management (Buechner 1960a, Forsyth 1942, Russell 1937, Bark 1948, Wilcox 1963), were primarily responsible for the striking increase of pronghorn from possibly their lowest numbers in history during the early 1900s to the large populations of 1964.

EASTERN OREGON

Pronghorn remains were common among the ungulate remains recovered from archaeological sites in northeastern Oregon (Kay 1990). Early historical records possibly indicate that pronghorn were present in eastern Oregon but were not abundant in northeastern Oregon (Wyeth 1899, Oregon Historical Society 1902).

Nelson (1925) reported the population of pronghorn in Oregon between 1922 and 1924 was estimated to be just over 2,000 head. By 1964, the pronghorn population in Oregon had increased to 8,950 head (Yoakum 1968).

During their 1993 pronghorn census, Oregon Department of Fish and Wildlife counted 11,639 pronghorn in Oregon. The final 1993 population estimate for Oregon will probably range between 13,000 and 15, 000 pronghorn (person communication: Tom Thornton Oregon. Dept. of Fish and Wildlife. August 23, 1994).

EASTERN WASHINGTON

Yoakum (1968) provided a map illustrating the historical range of pronghorn in North America. Most of eastern Oregon and southern Idaho historically supported herds of pronghorn but no early documentation has been found which indicates that pronghorn were native to Washington. However, Brown (1977) and Kay (1990) cite archeological studies conducted in eastern Washington which report pronghorn remains constituted a substantial percentage of the total ungulate remains recovered from ancient human habitation sites.

However, by, the time of white settlement, there were no pronghorn remaining in eastern Washington (personal communication: Rolf Johnson. Washington Dept. of Wildlife. August 26, 1994). Yoakum (1968) reported that, as result of pronghorn translocations from other states, the 1964 Washington pronghorn population was estimated at 120 head. Apparently, these translocations of pronghorn into Washington eventually failed. In 1994, no pronghorn were found in Washington (personal communication: Rolf Johnson. Washington Dept. of Wildlife. August 26, 1994).

IDAHO

Based on the total ungulate remains found at 15 archaeological sites examined throughout Idaho, pronghorn formed 5% of the minimum number of individuals (ungulate individuals) present at those sites. Bison (51% MNI) , bighorn sheep (23% MNI) , and deer (22% MNI) were the most common ungulate remains present at those sites (Kay 1990). Initial examination of these results suggests pronghorn were uncommon in Idaho. However, 3 of the 15 sites examined contained a substantial amount of pronghorn remains while the other 12 sites contained almost no pronghorn remains. Given this information, it is more likely that pronghorn were very unevenly distributed throughout Idaho during prehistoric time.

A map provided by Nelson (1925) suggests the pre-settlement distribution of pronghorn in Idaho covered most of the southern half of the state. By 1924, pronghorn were found only in the southeastern quarter and the extreme southwestern portion of the state. Forty years later, the pronghorn distribution was limited to southcentral and the extreme southwestern portions of Idaho. Nelson (1925) reported the population of pronghorn in Idaho between 1922 and 1924 was estimated at just under 1,500 head. However, by 1964, the Idaho pronghorn population had increased to an estimated 4,700 head (Yoakum 1968).

In 1994, the population status of Idaho pronghorn varied between big game management units. Some units had fawn to doe ratios of as high as 75 fawns per 100 does. However, the average fawn to doe ratio for the Idaho pronghorn population ranged between 30 and 35 fawns per 100 does (personal communication: Lloyd Oldenburg. Idaho Dept. of Fish and Game. September 16, 1994).

LIVESTOCK AND BIG GAME: HABITATS, DIETS, AND COMPETITION

HABITAT

TYPES OF METHODOLOGY COMMONLY USED TO EVALUATE HABITAT USE

There are various methods commonly used by researchers to quantify habitat use by animals. This section describes the habitat quantification methods that were used in the literature cited in this review.

Direct observation: This method generally involves establishment of observation routes or view points as part of the experimental design. From these observation routes or view points, the animals are observed, either with aided or unaided eye, and their locations relative to identified habitat types are recorded. Often the behavior (feeding, resting, social, alert, and ect.) of the animals is also noted. The location and behavior data can then be used to evaluate the frequency and duration of animal occupancy and animal activity within different habitat types. Use of direct observation to assess habitat use allows the researcher to visually confirm animal locations and associated activity. Also, individual animals may be identified by markings, horn configuration, radio-collars, or ear tags and their habitat use patterns can individually be recorded. However, the validity of the observation data is limited by completeness of the observational coverage in space and time. Logistics (man-power, expense, travel time, available daylight and equipment requirements) may limit the completeness observation coverage. Additionally, this method may be biased if the animals are aware of the presence of the observer.

Fecal group counts: This method usually entails the establishment of belt transects or plots within each habitat type to be studied. Counts of pellet-groups or cow chips encountered in the transects or plots are tallied and used as an index of animal occupation within the sampled area. The habitat use indices used with this method are usually based on the documented daily defecation rate for the animal species being studied. Generally, a specific number of encountered fecal groups is considered to be equivalent to one day of animal use given the defecation rate of that animal. This method is less labor-intensive and, consequently, less expensive to use when compared to the direct observation method. However, the application of this method is limited by the tendency for animals to defecate more often while doing certain activities than while doing others. Consequently, if an animal spent equal amounts of time in two different habitat types but, defecated more in one habitat type than the other because the activities that the animal conducted in each habitat were different, then the habitat use results would be biased towards the habitat where the animal conducted activities which were associated with higher defecation rates. Additionally, the fecal group count method currently cannot be used to evaluate animal activity within different habitat types as can the direct observation method.

Forage utilization: This method involves estimation of forage consumption within each habitat type being studied. Forage consumption is most often assessed by the ocular estimate by plot method (Pechanec and Pickford 1937) or by comparison of the forage weight between paired plots where one plot is excluded from animal use (caged) while the animals are allowed free access to the other plot. The forage utilization method provides a way to evaluate habitat use by foraging animals. However, this method does not allow evaluation of habitat use by animals involved in other activities (resting, social, traveling, and ect.) besides foraging. Additionally, in situations where different animal species are consuming the same forage species in the same areas, it may not be possible to evaluate the habitat use of each animal species using this method.

Radio-telemetry: This method generally includes equipping wild or tame animals with radio-collars to enable relocation of these animals at specified time intervals once they are released and allowed to roam freely throughout the habitat types being studied. The radio-collared animals are generally relocated using triangulation of radio signals from two or more vantage points. The accuracy of this triangulated location may be all that is required for some studies. However, in many studies, once the general location of a radio-collared animal is obtained through triangulation then, an attempt is made to get a visual conformation of the location of the animal and the activity the. animal is engaged in. Consequently, the radio-telemetry method often involves direct observation methodology as well. The applicability of the radio-telemetry method is limited by its relatively high expense.

Time-lapse photography: This method entails establishment of timelapse cameras at vantage points chosen to maximize the practical field of view of each camera and to provide the most complete coverage of the habitat types to be studied. The duration of occupation of an individual animal within a specific habitat type can be evaluated by reviewing how may consecutive photographic frames contain the animal within that particular habitat. The frequency at which an individual animal or animal species used a particular habitat can be evaluated by counting the number of frames which contain that individual or that species within the specified habitat type. The activities an animal is engaged in while in the different habitat types can also be determined by reviewing the photographic frames. Given infrared and starlight photography technologies, it is possible to gather animal location and activity data day or night at whatever collection interval the researcher chooses. However, the applicability of this method is limited by the relatively high cost of the cameras, labor-intensity of the photo interpretation, and the limited practical field of view of these cameras. In large study areas containing several habitat types of interest, it may be logistically impractical to obtain statistically adequate camera coverage of the areal especially if the habitat types contain dense vegetation or undulating topography. The time-lapse photography method is probably most applicable in open habitats such as riparian meadows, open forest on level terrain, and grassland ridgetops.

CATTLE: PREFERRED HABITATS

Section Abstract

Cattle prefer grassland, open forest, and clearcut forest habitats when foraging and rarely use dense forest habitats except when resting during harsh climatic conditions. Seasonally, cattle use of uplands generally begins to decline in mid summer while use of riparian zones increases. Cattle use in riparian zones peaks in late summer. In some cases, cattle shift habitat use from the riparian areas back to the uplands during late summer and early fall. Cattle made similar or heavier use of riparian zones in the late season pastures of deferred-rotation grazing management systems compared to cattle use of riparian zones in pastures of continuous grazing management systems. Increases in stocking rate can provide more even distribution of cattle throughout a pasture of variable topography. Cattle generally avoid slopes of greater that 20%. However, the presence of trails, logging roads and other access improvements generally allows cattle to climb and traverse steep slopes more readily but any increases in cattle use on steep slope are usually limited to short distances away from the access improvements. Attempts to alter Cattle distribution on rangelands with strategic location of water developments and salt are likely to be only variably successful.

Summer and Fall Cattle Habitats

Based on forage utilization and direct observation, Roath and Krueger (1982) determined cattle exhibited a preference for bluegrass meadows over other habitats on a forested range in the southern Blue Mountains of Oregon during summer. Eighty-one percent of the forage eaten by cattle on the study area came from the bluegrass meadows.

On a cattle allotment within the watershed of the Middle Fork of the John Day River in Oregon, Gillen et al. (1984) used direct observation and forage utilization sampling techniques to evaluate summer habitat use by cattle. They reported cattle exhibited a strong preference ($P<0.05$) for meadow communities under both continuous and deferred-rotation grazing management. Preference for meadow communities among the 2 grazing systems was highest in the late season pasture of the deferred-rotation system. Logged forest communities were preferred ($P<0.05$) by cattle while in the early season pasture but no preference for these communities was exhibited by cattle in the late season pasture of the deferred-rotation system. Mixed conifer communities and ponderosa pineDouglas fir communities were used less than their availability ($P<0.05$) by cattle under the deferred-rotation system. Although cattle did not exhibit a preference for the ponderosa pine-Douglas fir communities, nearly 1/4 of the cattle use in the early and late season pastures of the deferred-rotation system occurred in these communities. Ponderosa pine-Douglas fir communities were used according to their availability in the continuously grazed pasture. Cattle in the continuously grazed pasture avoided ($P<0.05$) the mixed conifer and grand fir communities. Cattle use of the grand fir community group was not studied in the deferred-rotation pastures.

While studying summer forage utilization by cattle within grassland, forest, and clearcut forest habitats in the foothills of the Wallowa Mountains of Oregon, Miller and Krueger (1976) noted although seeded clearcuts represented only 31% of the study area, forage from the clearcuts made up 63% of cattle summer diets. Orchardgrass and timothy made up 55% of the diet of cattle grazing in the clear cuts. Forested areas represented 41% of the study area while only 8% of forage consumed by cattle came from forested areas.

In the foothills of southeastern Wyoming, Hart et al. (1991) used direct observation to assess habitat use by cattle. They noted cattle preferentially used the lowland areas on the study area over the upland areas despite changes in stocking rate from very light (0.034 AUM/ha) to moderate (0.28 AUM/ha). At the very light stocking level, cattle made almost exclusive use of the most productive loamy and shallow loamy range sites. Increased stocking rates resulted in more even use of the study area. Distance traveled from water increased with stocking rate. Use of steep slopes also increased with stocking rate and seasonal progression.

On a foothill rangeland in southwestern Montana, Marlow and Pogacnik (1986) directly observed and recorded cattle behavior and habitat use. They reported cattle use of upland range decreased steady from mid summer until fall while use in riparian zones increased. During early July, cattle foraged and rested significantly ($P< - 0.05$) more in the uplands than in the riparian zones. However, by late August, significantly ($P<0.05$) more observations of feeding cattle were made in the riparian zones than in the uplands.

Gillen et al. (1985) used time-lapse photography to study cattle use of riparian meadows within the watershed of the Middle Fork of the John Day River in northeastern Oregon. They concluded total cattle occupation and frequency of cattle occupation in riparian areas was less in pastures grazed during the early period (early June to early August) of a deferred rotation system than in a pasture which was continuously grazed from early June to mid October. Grazing during the late period (early August to mid October resulted in levels of total cattle riparian occupation which were similar to those in found in the continuously grazed pasture. However, late season grazing tended to increase the frequency of cattle occupation in the riparian meadows when compared to continuous grazing. Cattle use of riparian meadows was highest during the afternoon hours regardless of the grazing system used.

While directly observing cattle use of riparian and upland habitats within the Starkey Experimental Forest and Range of northeastern Oregon, Bryant (1982) noted that both, in pastures with predominately southerly aspects and in pastures with northerly aspects, cow-calf pairs and yearling cattle exhibited a preference for riparian habitat over upland habitat during midsummer but shifted their preference to the upland habitat during late summer and early fall. While in the uplands during late summer, cattle preferred to occupy the forested plant communities more than the grassland communities. During early fall, yearlings and cow-calf pairs used different plant communities within the upland habitat. Cow-calf pairs tended to make more even use of the pastures than did yearlings. Both yearlings and cow-calf pairs preferred slopes of less that 35%. Neither, the distance from free water or the distance from salt appeared to influence cattle distribution within the pastures.

Miller and Krueger (1976) reported the distance from water and salt could be used to explain 79% of the variability in forage use by cattle. Inclusion of soil depth and canopy closures factors allowed for 99% of the variability in use to be explained. Slopes on their study area rarely exceeded 15%. Consequently, slope was not a factor affecting. cattle distribution within this study. They concluded strategic location of clearcuts and water and salt sources could be used to manipulate cattle distribution to meet a broad range of management objectives on forested rangelands of low to moderate relief.

Roath and Krueger (1982) noticed only 62% of the variability in forage utilization on their study area could be accounted for by distance to water and salt. multiple regression analysis on the water and salt distance factors was compounded by the vegetation type.

Gillen et al. (1984) reported while distances from water or salt had no significant effects, slope gradient was negatively associated with cattle distribution under both the continuous and deferred-rotation grazing systems. Cattle preferred slopes of less than 10%, especially in the late season pasture of a two pasture, deferred- rotation system. Cattle exhibited an aversion to slopes of greater than 20% during all seasons of use. Pinchak et al. (1991) observed 79% of cattle use occurred on slopes of less than 7% and areas within 366 m of water sources received 77% of the use by cattle.

Based on cow chip counts, Mueggler (1965) noted 81% of the variability in cattle use patterns on bunchgrass rangeland in southwest Montana could be explained by the steepness of slope and the distance up slope from canyon and draw bottoms. In northern Utah, Cook (1966) measured 21 possible factors influencing cattle distribution on slopes. Regression analysis of these 21 factors explained only 52% of the variability in use.

Roath and Krueger (1982) reported on moderate to steep slopes the vertical rise from water explained 94% and 82% of the variation in utilization of bearded bluebunch wheatgrass and giant wildrye, respectively, during 2 consecutive years of their study. However, on gentle slopes the trail distance from water model could probably have replaced the vertical rise model for predicting cattle use of upland species. They also noted on steep terrain, logging roads and skid trails received considerable use by cattle as travel routes. Roads appeared to allow cattle to use forage in steep terrain that normally would not have been utilized. In rugged areas, cattle use of forage decreased rapidly with increased distance from roads. Use of access improvements as a method to improve livestock distribution on rugged rangelands was also discussed by Williams (1954) and Workman and Hooper (1968).

SHEEP: PREFERRED HABITATS

Section Abstract

In general, habitat use by sheep on open rangelands is strongly influenced by the management practices of the sheep herder. Desiring to fatten lambs, a herder may concentrate the sheep in areas where he or she believes the best lamb feed exists. In the face of heavy predation, the sheep may tend to remain in the open rather than venturing into forested areas. The sheep herder may also bed the sheep near the camp to minimize night losses to predators. Use of different elevational zones and the vegetation types associated with those zones is largely dependent on the sheep herder and the camp rotation schedule. However, despite these human-imposed controls on sheep habitat preference, the literature does identify some "natural" use patterns of sheep in different habitat types.

Summer and Winter Sheep Habitats

In the Elkhorn Mountains of western Montana, Stevens (1966) observed that sheep heavily used the open park habitat in the high elevation spruce-fir zone during summer. He noted the sheep were herded to and from the open parks. Mature lodgepole pine stands were used as resting areas during midday.

Warren and Mysterud (1991) used radio telemetry to evaluate summer habitat use of domestic sheep on forested range in Norway. Sheep used meadow/old field and spruce forest habitats significantly ($P<0.01$) more than their availability. Spruce/blueberry and pine/heather/lichen habitats were used less than their availability.

Time of day was significantly ($P<0.01$) related to summer habitat use by sheep. Use of meadow/old field and. spruce forest habitats occurred during the morning and early afternoon. The spruce /blueberry and pine /heather/ lichen habitats were used during

the evening and at night. Open areas which were higher than the surrounding topography were preferred bedding areas for sheep. These areas were apparently desirable because they provided good visibility allowing early detection of approaching predators (Warren and Mysterud 1991).
Based on pellet group counts, McDaniel and Tiedeman (1981) reported sheep in New Mexico preferred open ridgetops as bedding areas during winter. They also noted unherded sheep tended to use the same bedding area night after night.

Warren and Mysterud (1991) observed sheep habitat use varied significantly ($P<0.01$) with the progression of the summer grazing season. Use of the meadow/old field habitats was relative high during the early portion of the grazing season but decline as the season progressed. Conversely, sheep use of the forest habitats increased as the season progressed.

McDaniel and Tiedeman (1981) noted steep slopes did not preclude winter use by sheep. However, the amount of forage utilization by sheep on slopes steeper than 45% was 55 to 75% less than the forage utilization of more gentle slopes. Ridgetops were preferred as foraging areas by sheep. The aspect of the slope and the distance of an area from water did not signficantly influence the distribution of sheep in this study.

ELK: PREFERRED HABITATS

Section Abstract

In montane areas, elk generally use upland grassland habitats as spring and fall range. Small openings of upland grassland habitat are preferred by elk over large openings. Elk prefer to use riverine (riparian) forest, old-growth grand fir, mixed conifer stringer, and wet meadow habitats during the summer with elk use of these habitats peaking during late summer and early fall. Canyon grassland habitats are usually avoided by elk between June and September. Logging disturbance can have variable effects on elk habitat use. In general, elk use decreases in open habitats such as clearcuts and grasslands and increases in habitats containing hiding cover during and, for a variable amount of time, after human disturbances. Summer and winter elk home ranges generally contain a cover to forage ratio of 40% cover habitats to 60% forage habitats.

In shrub-steppe areas, cow elk prefer rolling topography and riparian areas during the spring, especially during the calving period. Cow elk tend to increase the use of flat terrain as the season progresses. Peak use of flat terrain by cow and bull elk occurs in the fall. Shallow drainages are preferred as bedding sites by cow elk throughout the spring and most of the summer. Shrub stands serve as preferred bedding sites for cow elk during the late summer and fall. Cow elk generally remain close (< 1 km) to free water sources during times of hot weather.

Summer Elk Habitats in Northeastern Oregon

Thomas et al. (1979) recommended that optimum habitat for elk in the Blue Mountains of Oregon and Washington should be defined as land area having a ratio of 40% cover habitat types and 60% forage habitat types where potable water is within 0.8 km of any point in the land area.

In northeastern Oregon, Pedersen et al. (1980) reported the Douglas fir/grand fir-dominated, upland mixed forest habitat type served as summer foraging and resting areas, travel. routes, and hiding and thermal cover for radio-collared elk. The upland mixed forest type was used by elk slightly more during the night than during the day. Elk use of the upland mixed forest type increased as summer progressed and peaked in September.

The old-growth grand fir habitat type was highly preferred during the summer, providing travel routes, resting areas, thermal cover, and wallows for radio-collared elk. Human disturbances increased elk use of this habitat type. The old-growth grand fir type was also preferred for night bedding sites by elk. Like the upland mixed conifer type, use of the old-growth grand fir habitat type increased as summer progressed (Pedersen et al. 1980).

The old clearcut habitat type (10 years or more since timber harvest) was primarily used by radio-collared elk for foraging but it was not a preferred habitat type. Forage utilization was highest during late summer and early fall. Use of the old clearcuts declined with human disturbance (Pedersen et al 1980).

The upland grassland habitat type was used during the spring and fall for foraging. This was the first habitat type used by radiocollared elk returning from lower elevation winter ranges. Elk preferred small openings of the upland grassland habitat over large openings. Night use of this type often exceeded day use (Pedersen et al. 1980).

The north slope conifer habitat type served as water sources, foraging areas, travel routes and, thermal and hiding cover. This habitat type represented 27% of the study area. Radio-collared elk used this habitat type in proportion to its availability. Day and night use of this habitat type were approximately equal. Use of the north slope conifer type remained at a relatively constant level throughout the summer with some decrease in use occurring in September. Human disturbance did not appreciably affect use in this habitat (Pedersen et al. 1980).

The canyon grassland habitat type was used the least by the radiocollared elk in this study. Elk use of this habitat type was always proportionally less than its availability. Night use of this habitat type generally exceeded day use. The canyon grasslands were used primarily in the late spring and fall as foraging areas (Pedersen et al. 1980).

The mixed conifer stringer habitat type was highly preferred and served as travel routes, foraging areas, and hiding cover for radio-collared elk. This habitat type was of limited value as thermal cover. During this study more elk locations were found in this habitat type than in any other. Elk use of the mixed conifer stringer type was high in early to mid summer, then decreased in late summer, and finally peaked in early fall. Human disturbance resulted in, decreased use of this habitat type (Pedersen et, al. 1980).

The riverine (riparian) forest habitat type was the most preferred habitat type by radio-collared elk in this study. This habitat type provided, forage, water, thermal and hiding cover, travel routes, bedding sites, and wallows. This habitat type apparently served as cover for elk attempting to evade human disturbance. Use of the riverine forest type was generally high throughout the season (Pedersen et al. 1980).

Elk use of the new-logged area habitat type increased with time after the logging disturbance. One area within this habitat type was highly preferred by radio-collared elk on the third year following the end of logging activity. Day use exceeded night use in this habitat type. This habitat type was primarily used for foraging but there was some indication it also provided some thermal cover. Elk use of the new-logged area habitat type was highest in late summer and early fall (Pedersen et al. 1980).

Elk Cover to Forage Ratios in Northeastern Oregon

Directly observing radio-collared elk in the Blue Mountains of Oregon, Leckenby (1984) noticed that cover-to-forage ratios within summer elk home ranges averaged 56%. Elk made preferential use of cover in home ranges where the cover-to-forage ratio was less than 35%. Increases in the cover-to-forage -ratio resulted in smaller home range sizes during summer. Winter elk home ranges contained an average of 40% cover. During winter, home range size did not vary with the cover-to-forage ratio. These results substantiated the elk cover management recommendations made by Thomas et al. (1979).

Summer Elk Habitat in Southcentral Washington

Working with radio-collared elk in the shrub-grasslands of south central Washington, McCorquodale et al. (1986) found that during spring, late summer, and fall cow elk selectively used lower elevation sagebrush communities. Riparian communities were preferred in the fall and, for calving and lactation during the late spring. Cow elk used rolling terrain significantly more

($P<0.05$) than other available terrain on the study area during the spring. Cow elk were observed on flat terrain 28% of the time during the summer and 54% of the time during the fall. For all seasons, except during the calving period, more than 75% of cow elk observations occurred in the flat or rolling terrain. Foothill terrain received 56% of the cow elk observations during the calving period. Bulls did not exhibit a topographic preference during spring and summer but preferred ($P<0.05$) flat areas (56% of observations) and avoided ($P<0.05$) foothills (only 9% of observations) during the fall.

Cow elk preferred to bed in gullies or shallow drainages during the spring (72%), calving (86%), and summer (61% of observations) periods. Bedding occurred on flat terrain for 51% of the fall cow elk observations. Sagebrush stands were preferred for resting/ ruminating during late summer and fall. It was suggested that elk were taking advantage of the more favorable microclimate created by the shading of the sagebrush (McCorquodale et al. 1986)

Cow elk use near springs and free water sources increased with ambient temperature. Most cow elk observations occurred within 1 km of free water sources during the mid summer. Use of riparian areas by cow elk increased between sundown and sunrise. Bull elk also tended to remain close to free water sources during the summer but, were occasionally observed at least 18 km from known water sources (McCorquodale et al. 1986).

Elk Habitats in Other Areas of the West

Collins et al. (1978) directly observed the distribution patterns of tame elk within segments of lodgepole pine habitats in northern Utah. They reported tame elk preferred wet and dry meadows, clearcuts, and reseeded logging roads for grazing while wet meadows, reseeded logging roads, and mature forest were preferred for bedding and resting. Comparison of preference quotients for each habitat segment indicated the wet meadows were highly preferred over the other habitat segments for both foraging and resting.

Irwin and Peek (1983) reported non-migratory, radio-collared elk in northern Idaho did not exhibit a significant preference for habitat type, successional stage, canopy closure, elevation, or distance to an opening. However, elk winter home ranges selectively included southwesterly aspects.

During the spring, radio-collared elk tended to feed in the grassshrub and shrub seral communities within the grand fir habitat type. Most of the elk use within the grass-shrub and shrub seral communities occurred in areas: 1) having less than 25% canopy closure, 2) having less than 650 trees/ha, 3) having shallow slopes or ridges, 4) within 200-400 m of water, and 5) within less than 200 m from large openings (>1 ha) . During the spring, elk were generally rested in tall brush fields or in stands of pole timber where the trees were less than 12 m. tall and had 50 to 75% canopy closure. Resting areas were: 1) higher in elevation than the feeding areas, 2) on westerly aspects or on ridgetops, 3) greater than 400 m, from traveled roads, and 4) less than 200 m. from large openings (>1 ha) (Irwin and Peek 1983).

The seral shrub communities within the grand fir-myrtle pachistima habitat type were often used by feeding radio-collared elk during the summer. Elk tended to rest on ridges during the summer in stands of pole timber which were greater than 400 m. for traveled roads and had 50 to 75% canopy closure (Irwin and Peek 1983).

Irwin and Peek (1983) found fall habitat selection by radiocollared elk differed from spring and summer. Elk tended to feed and rest in similar areas during the fall. Pole timber in the western hemlock-myrtle pachistima habitat type was used more than its availability while the grand fir-myrtle pachistima and the subalpine fir types tended to be avoided. Within the western hemlock-myrtle pachistima. type, elk made disproportionately high use of ridgetops and rarely used south slopes. Increased road traffic apparently caused elk to almost always remain greater than 400 m from roads and between 400 and 600 m from large openings (>1 ha).

MULE DEER: PREFERRED HABITATS

Section Abstract

Winter habitat use by mule varies somewhat between regions and locations. However, forest habitats universally appear to be important as bedding sites, escape cover, and to a lesser degree as foraging areas for wintering mule deer. Shrub habitats are apparently valuable as foraging and bedding areas during the daytime. Grassland habitats may serve as foraging areas during the daytime but are probably most important as foraging and bedding areas during the nighttime.

During spring, mule deer use of grassland and shrub-grassland habitats increases with Sandberg bluegrass and new shrub growth becoming important dietary items.

Use of open pine and juniper forest habitats by mule deer tends to increase during the summer. The shrub-grassland habitats generally remain valuable throughout the summer but the importance of the grassland habitats often decreases as the summer progresses. Douglas fir habitat types were also important summer mule deer habitat, especially as fawning and hiding cover.

Shrub and open forest habitats remain important to mule deer during the fall. Browse from shrubs and juniper becomes even more valuable as forage for mule deer during the fall.

Winter Mule Deer Habitats

Leckenby (1978) used direct observation techniques to evaluate winter mule deer habitat use along four observation routes in the Silver Lake-Fort Rock mule deer winter range of southcentral Oregon. Mule deer occupation of plant communities in the forest habitat type was similar to or greater than the occupation of the shrub habitat type along 3 of the 4 observation routes. Mule deer occupation of the grassland habitat was greater than the occupation of the shrub habitat type along 2 of 3 observations routes where comparisons between grassland and shrub habitat types could be made.

Shrub habitats comprised of bitterbrush- Sandberg bluegrass, silver sagebrush-Sandberg bluegrass, or low sagebrush-Sandberg bluegrass communities were preferred by wintering mule deer. In forest habitats there was a great deal of variability among the four observation routes as to which plant communities were selectively, occupied by wintering mule deer. Unexpectedly, mule deer within forest habitats did not exhibit a preference for bitterbrush communities. However, mule did appear to prefer forest habitats which contained a juniper overstory with a gray rabbitbrush/big sagebrush shrub component and cheatgrass brome/bottlebrush squirreltail graminoid component. In grassland habitats, wintering mule deer preferred plant communities that contained crested wheatgrass, winter rye, and Newberry cinquefoil (Leckenby 1978).

Mackie (1970) used direct observation of marked individuals to study the habitat selection of mule deer in the Missouri River Breaks, Montana. During 2 of the 3 winters of the study, mule deer were most often observed in the sagebrush-wheatgrass habitat type. During the remaining winter, mule deer use of the sagebrushwheatgrass and pine-juniper habitat types were similar. During all three winters of the study, mule deer use of the sagebrushwheatgrass habitat type increased as the winter progressed indicating an increased reliance on big sagebrush as a forage source.

The pine-juniper habitat type was the second most preferred habitat of wintering mule deer. The pine-juniper habitat type was most heavily used during and shortly after winter storms. Foraging use by mule deer in the pine-juniper habitat type generally occurred while traveling to and from bedding sites (Mackie 1970).

Based on direct observation and radio telemetry data, Hamlin and Mackie (1989) reported mule deer in the Missouri River Breaks, Montana preferred forested habitats over shrub and grassland habitats during all seasons. In winter, Douglas fir-open juniper, Doulas fir-burned juniper, and pine-fir-burned juniper were the most preferred habitat types by mule deer. The river riparian and silver sagebrush habitat types were strongly avoided by wintering mule deer.

Kufeld et al. (1988) used radio-collared mule deer to study winter habitat selection in 8 vegetation types of the Front Range of Colorado: 1) mountain mahogany, 2) grassland (brome and needlegrass species), 3) ponderosa pine 10-39% canopy closure (CC), 4) P. pine 40-69 CC, 5) P. pine 70-100 CC, 6) sumac-hawthorne-cherry (SU-HACH), 7) mountain meadow, and 8) rock outcrop. Daily activity was observed during four 6 hour time periods: 1) Sunrise (3 hrs prior to and following sunrise), 2) day (3 hrs prior to and following midday, 3) sunset (3 hrs prior to and following sunset), and 4) night (3 hrs prior to and following midnight) .

During the sunrise period, foraging mule deer preferred ($P<0.05$) to occupy the mountain mahogany vegetation type while avoiding ($P<0.05$) the moderate and high pine canopy closure types. Foraging mule deer spent 44% of the time in the mountain mahogany type and 39% in the grassland vegetation type. Although, mule deer spent a large percentage of their foraging time in the grassland type, this type was not preferred but was used in proportion to its availability. Mule deer preferred ($P<0.05$) to rest in the mountain mahogany type and avoided ($P<0.05$) the moderate and high pine canopy closure and rock outcrop types. Resting mule deer spent 47% of the time in the mountain mahogany type and 35% in the grassland type which, again, was used as available (Kufeld et al 1988).

Mule deer foraging during the day period preferred ($P<0.05$) the mountain mahogany type and while the grassland, SU-HA-CH, and mountain meadow were used significantly less than their availability ($P<0.05$). However, mule deer still spent 28% of their foraging time in the grassland type and 51% in the mountain mahogany type. Resting mule deer preferred ($P<0.05$) the mountain mahogany type and avoided ($P<0.05$) grassland and SU-HA-CH types. The mountain mahogany type was used 54% of the time for daytime resting and the grassland 26% (Kufeld et al. 1988).

During the sunset period, foraging mule deer preferred ($P<0.05$) the mountain mahogany type whereas the high pine canopy closure, SU-HA-CH, and mountain meadow types were used less ($P<0.05$) than their availability. Sunset foraging occurred in the mountain mahogany type 46% of the time and in the grassland type 35%. Resting mule deer used the mountain mahogany type significantly ($P<0.05$) more than its availability. The 7 remaining vegetation types were used according to their availability by resting mule deer. Mule deer rested in the mountain mahogany type 44% of the time and in the grassland 35% (Kufeld et al. 1988).

Foraging mule deer preferred ($P<0.05$) the grassland type at night while the moderate and high ponderosa pine canopy closures, mountain meadow, and rock outcrop vegetation types were avoided ($P<0.05$) at night. The grassland was used 51% of the time by mule deer foraging at night and the mountain mahogany type was used 32% of the time. During the night, resting mule deer preferred ($P<0.05$) the grassland type while they avoided all the ponderosa pine types, the mountain meadow type, and the rock outcrop type. Resting mule spent 46% of the time in the grassland type and 36% in the mountain mahogany type (Kufeld et al. 1988).

Spring Mule Deer Habitats

Miller et al. (1981) studied spring mule deer and elk use of plant communities within clearcut, bunchgrass, and forest habitat types in the foothills of the Wallowa Mountains of northeastern Oregon. They noted, based on forage utilization sampling, that mule deer and elk fed primarily in the timothy-orchardgrass and the mallow ninebark-timothy communities of the clearcut habitat type and in the Sandberg bluegrass-Kellogg onion and the ponderosa pine-bluebunch wheatgrass communities of the bunchgrass habitat type, during March. Deer pellet groups were concentrated primarily in the plant communities of the forest habitat type and in the ponderosa pine-bluebunch wheatgrass community of the bunchgrass habitat type during March (Miller et al. 1981) . These results suggest mule deerforaged in the open habitats and returned to the forested habitats, to rest given known defecation habits of mule deer.

From April to mid May, forage utilization by mule deer and elk, occurred mostly in the timothy-orchardgrass community of the clearcut habitat type with a notable amount of use also occurring in the Sandberg bluegrass -Kellogg onion community of the bunchgrass habitat type. Deer pellet groups were fairly evenly dispersed between the plant communities of the bunchgrass habitat type and the forest habitat type from April to mid May. Notably, no deer pellets were found in the mallow ninebark-timothy or the timothy-orchardgrass communities of the clearcut habitat type during either the March or April-mid May sampling efforts (Miller et al. 1981). The complete absence of deer pellets in these two communities suggests the forage utilization that occurred within these communities probably could be attributed primarily to elk. Deer foraging from March to mid May probably occurred predominately in the bunchgrass habitat type.

The Kentucky bluegrass -yellow salsify community within the clearcut habitat type and the ponderosa pine-bluebunch wheatgrass community within the bunchgrass habitat type were the primary plant communities used by feeding mule deer and elk from mid May to June. During mid May to June, deer pellet groups were dispersed between the bunchgrass habitat type and the forest habitat type with the greatest concentration of deer pellets occurring in the Sandberg bluegrass-Kellogg onion community of the bunchgrass habitat type (Miller et al. 1981).

While directly observing mule deer in the Missouri River Breaks, Montana, Mackie (1970) found the sagebrush-wheatgrass habitat type was the most preferred habitat of mule deer during the early spring (late March-early April) . Western wheatgrass and bluegrasses were the important forage species of mule deer during the early spring.

Use of the sagebrush-wheatgrass habitat type rapidly decreased after mid April. The pine-juniper and greasewood-wheatgrass habitat types received increased mule deer use after mid April. New shrub growth was important mule deer forage in the pine-juniper habitat and Sandberg bluegrass and associated forbs were the predominate forages in the greasewood-wheatgrass habitat (Mackie 1970).

Based on direct observations and radio telemetry relocations conducted during the spring, Hamlin and Mackie (1989) noted pinejuniper-scattered shale outcrops and pine-juniper-scattered grass were the most preferred habitat types by mule deer in the Missouri River Breaks, Montana. The river riparian habitat type was strongly avoided by mule deer during the spring.

Based on forage utilization sampling, Edgerton and Smith (1971) reported mule deer and elk on Starkey Experimental Forest and Range in northeastern Oregon fed primarily in grassland and open forest habitats during the spring when succulent forbs were available. As the forbs matured during the summer, mule deer and elk use of forested habitats increased while use of grassland habitats decreased. This shift in habitat use during the summer reflected a shift from spring-early summer diets of primarily forbs to mid-late summer diets containing substantial amounts of elk sedge and browse species. Dense forest habitats were most important in the fall when browse species formed a considerable portion of mule deer and elk diets.

Summer Mule Deer Habitats

Mackie (1970) -found the pine-juniper habitat type was the most preferred habitat of mule deer during summer. Mule deer spent most of the foraging time in the pine-wheatgrass association. The pinejuniper and pine-sagebrush associations within the pine-juniper habitat type were important during the early summer. The pinesagebrush association was commonly used for bedding sites and as escape cover.

The sagebrush-wheatgrass habitat type was the second most preferred mule deer habitat during summer. Mule deer within the sagebrushwheatgrass habitat most commonly foraged in the sagebrush-western wheatgrass association, especially where yellow salsify and other associated forbs occurred (Mackie 1970).

The Douglas fir-juniper habitat type was ranked third in importance to mule deer during summer. This habitat type was used as fawning cover during June and as bedding and escape cover during the most of the summer. The dense cover common to the Douglas fir-juniper habitat type may have precluded observation of all the mule deer which used this habitat type. Consequently, mule deer may have used of this habitat type more than was recorded in this study (Mackie 1970).

During summer, Hamlin and Mackie (1989) noted Douglas fir-burned juniper and pine-juniper-scattered shale outcrops were the most preferred habitats of mule deer in the Missouri River Breaks, Montana. The river riparian habitat type was strongly avoided by mule deer during summer.

Working in the Spokane Indian Reservation of eastcentral Washington, Lauver (1983) reported, based on fecal group counts, mule deer preferred ($P<0.01$) Douglas fir-pinegrass and Douglas firmallow ninebark habitat types during the summer and early fall. Ponderosa pine-Idaho fescue, Douglas fir-common snowberry, grand fir-myrtle pachistima, and riparian habitat types were used in proportion to their availability by mule deer during the summer and early fall. Mule deer avoided ($P<0.05$) ponderosa pine-bitterbrush and ponderosa pine-common snowberry habitat types during summer and early fall.

Fall Mule Deer Habitats

Mackie (1970) noted mule deer in the Missouri River Breaks, Montana preferred to use the sagebrush-wheatgrass and pine-juniper habitats during fall. Within the sagebrush-wheatgrass habitat type, the sagebrush-western wheatgrass association was commonly used by foraging mule deer, especially where gray rabbitbrush and Sandberg bluegrass occurred. Mule deer most often foraged in the pinewheatgrass association while within the pine-juniper habitat type.

Also in the Missouri Breaks, Montana, Hamlin and Mackie (1989) observed mule deer strongly preferred Douglas fir-scattered juniper and Douglas fir-burned juniper habitat types during the fall. The silver sagebrush habitat type was strongly avoided by mule deer during the fall.

BIGHORN SHEEP: PREFERRED HABITATS

California Bighorn Sheep: Section Abstract

California bighorn sheep occupy montane-alpine habitats from east central California to central British Columbia. California bighorn sheep prefer to forage in meadow habitats during spring, summer, and fall. Cliffrock shrub habitats are preferred year round foraging areas. Cliffrock habitats serve as preferred bedding and lambing areas and as escape cover. Shrub-bunchgrass habitats are generally only used by California bighorn sheep in the fall and winter.

California Bighorn Sheep Habitats in Southeastern Oregon

Van Dyke (1978) used direct observation to study the habitat preferences of California bighorn sheep in the Steens mountains of Oregon. In general, habitat use by California bighorns was strongly influenced by snow depth and the availability of succulent forage.

Areas of deep snow were avoided. Areas of green, succulent forage attracted bighorns. Lauer and Peek (1976) made similar observations while working with Rocky Mountain bighorn sheep in Idaho. Choice of foraging and resting habitat by Californina bighorn sheep varied within and between seasons (Van Dyke 1978).

The meadow habitat was preferred ($P<0.01$) for foraging during summer, fall and winter but avoided ($P<0.01$) during spring. The meadow habitat provided high quality forage almost year-round. However, during the spring the phenological development of forage in the meadow habitat was generally behind the forage in the cliff rock-shrub and mountain mahogany habitats which were preferred ($P<0.01$) by California bighorn sheep. In the fall, bighorns exhibited a preference ($P<0.01$) for the meadow habitat for bedding sites (Van Dyke 1978).

The cliffrock habitat was preferred ($P<0.01$) as bedding areas during the spring, summer, and winter but was used as available during the fall. The cliffrock habitat was avoided ($P<0.01$) by foraging California bighorn sheep during summer, fall, and winter but was used in proportion to its availability during spring. Because of its very shallow, rocky soils, the cliffrock habitat generally produced only a limited amount of forage when compared to the other habitats in this study. Most of the forage in the cliffrock habitat tended to mature early in the season in response to the rapid dehydration that occurred in the shallow, rocky soils. Consequently, bighorn use of the cliffrock habitat was limited to the early spring when the forage was still green and succulent (Van Dyke 1978).

Van Dyke (1978) cited other authors who have reported that the cliffrock habitat type was highly valuable as lambing habitat (Blood 1963, Irvine 1969, and Geist 1971) and as escape cover (Woolf 1968, Geist 1971, and Frisina 1974) for bighorn sheep. Van Dyke (1978) noted that the location of cliffrock habitat and its value as escape cover influenced the bighorn use of the other habitats examined in the study. California bighorns were seldom observed more than 400 m from some form of escape cover.

California bighorn sheep preferred ($P<0.01$) the cliffrock-shrub habitat as foraging areas during all seasons and as resting sites during spring, summer, and winter. The cliffrock-shrub habitat possesses escape cover and an ample forage component that the cliffrock habitat lacks which explains the year-round preference for the cliffrock-shrub habitat type (Van Dyke 1978). Van Dyke (1978) cited other authors (Oldemeyer et al. 1971, Erickson 1972, and Frisina 1974) with similar findings in the cliffrock-shrub type.

California bighorn sheep preferred ($P<0.01$) the shrub-bearded bluebunch wheatgrass habitat for resting and foraging only during the fall and winter. This habitat type was avoided ($P<0.01$) as resting and foraging areas during the spring and summer. Generally, the shrub-bearded bluebunch wheatgrass habitat occurred at elevations lower than bighorn sheep commonly used during the spring and summer. Van Dyke (1978) suggested that deep snow and harsh weather forced bighorns down into the shrub-bearded bluebunch wheatgrass habitat during the fall and winter (Van Dyke 1978).

The shrub-Idaho fescue habitat was generally located on northerly aspects which were colder and, consequently, had deeper snow, retained snow longer into the spring, and were slower to green up in the spring. California bighorns avoided this habitat type during all seasons (Van Dyke 1978).

The mountain mahogany habitat type was preferred ($P<0.01$) in the spring as lambing and rearing habitat and as foraging and resting areas. This habitat type was avoided ($P<0.01$) by foraging California bighorn sheep during the rest of the year. Bighorns preferred ($P<0.01$) to. rest in mountain mahogany type during the summer but used it in proportion to its availability during the fall and winter (Van Dyke 1978).

Rocky Mountain Bighorn Sheep: Section Abstract

The most widely distributed bighorn sheep subspecies, Rocky Mountain bighorn sheep occur in montane-alpine habitats in western Canada, Montana, Idaho, southeastern Washington, northeastern Oregon, Wyoming, and Colorado (Seton 1929, Cowan 1940, Buechner 1960b).

During the winter, Rocky Mountain bighorn sheep prefer to use grassland habitats that occur on steep slopes or on ridgetops that are frequently blown free of snow. Shrub-bunchgrass and open forest habitats which are near escape cover are preferentially used by wintering Rocky Mountain bighorn sheep. Habitats which obstruct the field of view are)generally avoided by wintering bighorn. Grassland and mountain shrub habitats are preferred by bighorn during the spring. Rocky Mountain bighorn sheep prefer southerly and southwesterly aspects with slopes greater than 80 to 100% during the winter and spring.

Rocky Mountain Bighorn Sheep Habitats

Working on 3 Rocky Mountain bighorn sheep winter ranges in Yellowstone National Park, Oldemeyer et al. (1971) reported bighorns were most often observed in the grassland vegetation type which occurred on steep terrain or ridgetops. Resting bighorns were within 95 m of escape terrain in 85% of the observations. Bighorns foraged in the grassland type within 95 m of the escape terrain in 75% of the observations.

Tilton and Willard (1982) used direct observation and pellet group counts to evaluate winter habitat selection by Rocky Mountain bighorn sheep in the Thompson Falls area of Montana. They noticed bighorn appeared to avoid: 1) elevations in excess of 1463 m (permanent snow cover on south slopes only extended down to 1554 m), 2) drainage bottoms, 3) slopes of 11-35%, 4) areas beyond 332 m from steep terrain (> 80% slope), and 5) the closed conifer forest vegetation type. Bighorns preferred ($P < 0.1$) : 1) cliffs, 2) slopes greater than 80%, 3) areas within 332 m. of steep terrain or cliffs, and 4) grass-shrubland and open conifer forest vegetation types. Southerly aspects were most preferred. Bighorns selectively used. grass-shrubland and open conifer forest types as foraging areas apparently because of the relatively high forage production on these types and the less obstructed field of view. Rockland types were used as bedding sites because they provided both cover and good visibility. Closed conifer forest types were avoided due to their lower forage production and poor visibility.

Working in east central Idaho, Lauer and Peek (1976) reported data from direct observations of wintering Rock Mountain bighorn sheep indicated Wyoming big sagebrush-bearded bluebunch wheatgrass communities were preferred as foraging areas over all other plant communities on the winter range.

Risenhoover and Bailey (1985) used radio-telemetry and direct observation to study Rocky Mountain bighorn habitat selection from January to June in Waterton Canyon, Colorado. They recognized bighorn selectively used open habitats where vegetation or local topography did not obstruct the field of view. Openings dominated by grass, mountain shrub, and open mountain shrub vegetation were preferred. These vegetation types not only provided less visibility restriction than other vegetation types but, also provided a greater availability of preferred forage. Bighorns were most often found on east and southwest aspects and on slopes ranging from 101-150%.

PRONGHORN: PREFERRED HABITATS

Section Abstract

In general, pronghorn of the Great Basin prefer open habitat where shrub and grass cover are low enough to allow uninterrupted visibility but high enough to provide hiding cover for juvenile pronghorn. Habitats containing a mix of graminoids and forbs with a sparse to light coverage of low browse plants are preferred by pronghorn. In optimal pronghorn habitat, water sources are evenly distributed within 5 to 6.5 km of each other. Pronghorn generally winter in habitats where the snow depth does not exceed 23 to 34 cm.

Optimal Pronghorn Habitats

Yoakum (1974) compiled the results of pronghorn-range relationship studies conducted in the sagebrush-grass land communities of 6 western states: California, Montana, Nevada, Oregon, Washington, and Wyoming. The vegetative composition within the sagebrushgrassland community was determined at 18 different study sites distributed throughout these 6 states. Pronghorn range relationships within the sagebrush-grass land community were evaluated based on direct observations. A summary describing the abiotic and biotic components of habitat required by pronghorn antelope in sagebrush-grassland range was provided in this report. Pronghorn require large open areas of undulating topography with minimal impediments to cross-country travel. On winter range, pronghorn require areas where the snow depths do not exceed 23 to 34 cm for a extended period of time. on summer and winter range, pronghorn watering sources should optimally be distributed within 5 to 6.5 km of each other. The optimal vegetative composition of. pronghorn range would be 40-60% graminoids, 10-30% forbs, and 5-10% browse. The species composition of pronghorn habitat should optimally contain 5 to 10 grass species, 20 to 40 forb species, and, 5 to 10 browse species. Pronghorn will avoid habitats where the vegetation exceeds 55 cm because of limited visibility. Optimum cover height for pronghorn would be 28 to 55 cm.

Cook and Irwin (1985) evaluated vegetative, topographic, and pronghorn population data from 29 pronghorn winter ranges in central Montana, southeastern Idaho, northwestern and northeastern Colorado, and Wyoming. These data were used to test an existing habitat suitability model (see Allen and Armbruster 1982). Results obtained while using a modified version of the habitat suitability model indicated pronghorn density within a landscape was related ($P<0.001$) to shrub cover, shrub height, shrub diversity, topographic cover, and herbaceous cover. However, they noted shrub height, shrub. diversity, and herbaceous cover were all intercorrelated with shrub cover.

HABITAT OVERLAP

Using pellet-group counts as an index for deer and elk days of use in the Blue Mountains of northeastern Oregon, Skovlin et al. (1968) reported mule deer selectively used forested areas (mean of 1.8 deer use days/ha) over grassland openings (mean of0.61 deer use days/ha). Elk did not exhibit a preference between forested areas (mean of 0.65 elk use days/ha) and openings (mean of 0.53 elk use days/ha). They also noted cattle spent approximately half their time in grassland habitats and half in forested habitats. Increased cattle stocking on dual-use (cattle and big game) ranges resulted in increased big game use of grassland habitats but the overall big game use of moderately and heavily stocked dual-use ranges decreased. Elk spent significantly (P<O. 05) more time on big game-only ranges than on dual-use ranges. Although, not statistically significant, deer use was apparently higher on big game-only ranges than on the dual-use ranges. Higher availability of ungrazed forage was suggested as the factor that attracted deer and elk to the big game-only ranges.

Yeo et al. (1993) directly observed cattle, elk and mule deer from a fixed-wing aircraft while studying the seasonal habitat selection response of these ungulates to a rest-rotation cattle grazing management system in the steep terrain of eastcentral Idaho. During summer-fall, cattle made increasingly greater use of high elevations ($P=0.0001$) and steep slopes with each successive year after the rest-rotation system was implemented.

In summer-fall, elk use of riparian and forested habitats was nearly twice as high in the pastures grazed by cattle as in the rested pastures. Elk did not use the riparian habitats in either the grazed or rested pastures during winter. Winter elk use of the forested habitats was higher in the grazed pastures than in the rested pastures. During spring, elk made similar use of the riparian habitats in the grazed and rested pastures but did not use the forested habitats in the grazed pastures (Yeo et al. 1993).

Summer-fall habitat use by mule deer was similar between the grazed and rested pastures. During winter, mule deer in the rested pastures made heavier use of draws and areas of high elevation and less use of benches than did mule deer in the grazed pastures. In spring, mule deer in the grazed pastures used steeper slopes than mule deer in the rested pastures. Mule deer in the grazed pastures were observed more frequently on slope faces while mule deer in the rested pastures were more often seen in draws (Yeo et al. 1993).

Working on a ponderosa pine-bunchgrass range in central Arizona, Wallace and Krausman (1987) noticed sightings of elk and mule deer along an observation route were significantly ($P<0.05$) lower in pastures which were being grazed by cattle than in pastures where cattle were absent. Habitat use by elk shifted from open forestgrassland and logged areas in pastures without cattle to heavily forested areas when cattle were brought into a pasture. Deer habitat use was not influenced by the presence or absence of cattle.

Stevens (1966) reported that direct observations of elk on his study area in the Elkhorn Mountains of Montana indicated nearly 100% of elk winter use and 90% of elk early spring use occurred in a habitat zone dominated by Idaho fescue and bearded bluebunch wheatgrass. Early summer elk use was more evenly distributed across the three habitat zones (fescue-wheatgrass zone, Douglas fir zone, and Engelmann spruce-alpine fir zone) identified on the study area. Later in the summer elk tended to prefer the higher elevation, Engelmann spruce-alpine fir zone.

Three cattle allotments were located in the Elkhorn Mountains study area. Two of these allotments occurred in the fescue-wheatgrass and the Douglas fir zones while the third, higher elevation allotment occurred in the Douglas fir and Engelmann spruce-alpine fir zones. Cattle grazing on the lower two allotments occurred from June to mid October. During early and late day feeding periods cattle tended to use the fescue-wheatgrass zone and were concentrated in fescue-wheatgrass and sagebrush-fescue vegetation types. The aspenwillow vegetation type, located in the drainage bottoms of the fescue-wheatgrass zone, was used by cattle for resting during the heat of the day. Cattle foraging in the Douglas fir zone occurred primarily in the grass-forb park vegetation type while the aspenwillow and Douglas fir vegetation types were used for resting. Cattle grazing in the higher elevation allotment occurred from July to mid September. Cattle used the Engelmann spruce-alpine fir zone almost exclusively during that time. The grass-forb park was the most preferred vegetation type for cattle foraging. Cattle used the mature lodge-pole vegetation type for resting (Stevens 1966).

Sheep used the Elkhorn Mountains study area between mid July and late August. The sheep were herded according to a camp rotation schedule, feeding from park to park within the Engelmann spruce-alpine fir zone. Resting occurred primarily in the mature lodgepole vegetation type (Stevens 1966).

In the foothills of southeastern Wyoming, Hart et al. (1991) reported little overlap in habitat use between cattle during the summer and elk during the winter. Cattle preferred to utilize the gentler terrain while elk used the more rugged uplands. Based on their findings about elk and mule deer food habits during severe winter weather in northeastern Oregon, Skovlin and Vavra (1979) advised that forage allocation strategies should designate open ridges and upper south slopes for big game winter use and management activities which promote cattle use of upper slopes may be undesirable on big game winter ranges.

Using direct observation, Ganskopp and Vavra (1987) studied the distribution of cattle, feral horses, mule deer, and California bighorn sheep relative to the degree of slope within a study area in southeastern Oregon. Cattle used the study area from April to late October. The mean slope of sites where cattle were observed was 5.8%. Feral horses were year round residents of the study area. The mean slope of sites used by horses was 11.2%. Mule deer used the study area from October to late April. The mean slope of sites where mule deer were observed was 15.7%. California bighorns were year round residents of the study area. The mean slope of sites used by bighorns was 42.5%.

All cattle observations occurred on slopes of less than 40% except for one sighting on a 70% slope. Cattle preferred ($P<0.02$) sites having slopes between 0 and 9%. Cattle used slopes of 10 to 19% in proportion to their availability. Slopes greater than 20% were avoided ($P<0.02$) by cattle. It was suggested that cattle confined in pastures having a relatively high mean slope and only small areas of gentle terrian available would make use of steeper slopes than would cattle confined in pastures having a relatively low mean slope and large areas of gentle terrain available (Ganskopp and Vavra 1987).

Feral Horses were always observed on slopes of less than 50% except for one group which was sighted in an area having a slope of 100%. Horses were apparently attracted to level or gentle sloping benches and ridgetops and would navigate rugged terrain to reach these areas. Slopes greater than 30% were avoided ($P<0.02$) or not used by horses (Ganskopp and Vavra 1987).

Mule deer preferred ($P<0.02$) gentle slopes of 0 to 9%. Slopes of 10 to 39% were used in proportion to their availability by mule deer. Mule deer avoided ($P<0.02$) slopes of greater than 40%. However, mule deer were observed on slopes as steep as 75% (Ganskopp and Vavra 1987).

California bighorn sheep were observed on slopes as steep as 150% but most observations were made on slopes of 110% or less. Slopes of 70 to 79% were preferred ($P<0.02$) by bighorn sheep. All other slopes of less than 80% were used in proportion to their availability by bighorn sheep (Ganskopp and Vavra 1987).

Ganskopp and Vavra (1987) concluded the slope use patterns of cattle, horses, deer, and bighorn sheep were significantly ($P<0.01$) different from each other. However, the differences in slope use exhibited by cattle, horses, deer, and bighorn sheep did not infer there was no spatial overlap between these ungulate species.

DIETS

TYPES OF METHODOLOGY COMMONLY USED FOR DIET DETERMINATION

There are various methods commonly used by researchers to study the diet of herbivores. This section describes the diet analysis methods used in the literature cited in this review.

Bite count: This method usually involves observing foraging herbivores and counting the number of bites taken from different forage species. Tame animals are most often used so the observer can remain close enough to the foraging animals that accurate bite counts can be made. Use of tame animals also allows the observer to collect simulated bites of the forage species that the animals are foraging on. The simulated bite samples can then be used to evaluate, on a species basis, the amount of forage by weight the animals consumed. Diet quality analysis procedures can also be conducted on these simulated bite samples. The bite count method for diet analysis in tame animals depends on the assumption that tame animals, foraging in a particular areas, will have the same diet as the wild animals foraging in the same area. The diet experience and previous handling received by the tame animals can influence their diet selection, thus, introducing bias into the result. However, conducting bite counts with wild animals, in order to avoid the potential bias associated with the use of tame animals, is logistically difficult. Bite counts on wild animals must be conducted from a distance vantage point in order to avoid disturbing the foraging animals. Determining bites on individual forage species is often difficult even with the aid of powerful binoculars or spotting scopes. Simulated bite samples usually can not be collected while conducting bite counts on wild animals. Consequently, bite count data on wild animals allows determination of forage time spent consuming specific species but, not the amount (weight) of each forage species consumed.

Esophageal fistulation: Tame animals are also normally used in this method of diet analysis. A fistula is surgically installed in the esophagus of the study animals. The animals are then allowed to forage in the study area. After an acclimation period, forage samples are taken from the collection bag attached to the fistula. Plant epidermal fragments in the fistula samples are then identified to species using microhistological (Sparks and Malechek 1968) techniques. The frequency of plant fragments for species is used to determined percent of the diet represented by each species However, as with the bite count method, the esophageal fistulation method may be biased by factors associated with the use of tame animals rather than wild animals.

Fecal analysis: In this method, fecal samples are collected from the droppings of the herbivores under study. Microhistological techniques are then used to determine the frequency of plant epidermal fragments from each forage species in the herbivore diet. The frequency data is then used to determine the percent of the diet represented by each species. The fecal analysis method of diet determination generally over-estimates the dietary percentage of graminoids, which contain substantial proportions of indigestible material, while under-estimating the dietary percentage of highly digestible forb species. The accuracy of fecal analysis for determining the browse content of the diet is variable between browse species. Vavra and Holechek (1980) reported the percent of snowbrush ceanothus in hand-compound samples was highly overestimated while common snowberry was under-estimated when fecal analysis was used to determine the composition of the samples. They suggested when microhistological analysis is used for diet determination, regression equations should be developed to correct for differential digestibility between forage species in the diet.

Foraging site examination: Under this method, foraging sites are identified by direct observation of foraging animals. The percent utilization by weight of each of the forage species within the identified foraging sites is then ocularly estimated. The percent utilization by weight for each forage species is then expressed as the dietary percent for each species. It should be noted that utilization sampling only at identified foraging sites may introduce bias into the results. For example, use of this method may result in over-sampling of open habitats where foraging animals are more observable while under-sampling habitats with heavier cover where animals are less observable.

Forage utilization analysis: The utilization by weight of individual forage species is estimated either by the ocular estimate by plot method outlined by Pechnac and Pickford (1937) or by comparison of caged and uncaged paired utilization plots.

The utilization by weight percent in used as an expression of the percent of the diet represented by each forage species. Unlike the foraging site examination method, the area examined with the forage utilization method is not limited to identified foraging sites. Forage utilization sampling is usually conducted at randomly located sampling points. Consequently, any bias associated with sampling location should be eliminated by randomization. However, the forage utilization method can be very labor- intensive. In large study areas with a diverse variety of habitats and associated forage species, it may be logistically difficult to obtain a statistically valid data set of forage utilization on a habitat by habitat basis. Additionally, since the species of herbivore foraging at each sample point is not visually confirmed when using the forage utilization analysis, it may be difficult to determine the diets of individual herbivore species in areas which are occupied by more than one herbivore species at any one time.

Rumen analysis: In this method, rumens are collected from harvested or sacrificed animals. In some older studies, the rumen was open and a grid frame was positioned over the rumen contents. The frequency of identifiable plant fragments within each grid section was ocularly evaluated and recorded. In more recent studies, rumen samples are collected and microhistological analysis is conducted on the samples to determine the dietary composition. Inherently small sample sizes is the primarily limitation of this method.

CATTLE DIETS BY SEASON, FORAGE GROUP, AND SPECIES COMPOSITION

Section Abstract

Cattle diets are the most diversified during the spring. The forb content in the diets of cattle grazing in both, forested and grassland habitats is generally higher during the spring than during any other season. Consequently, the diets of cattle grazing in early season (late spring-mid summer) pastures of a deferredrotation grazing system tend to be more diversified than do cattle diets in late season (mid summer-early fall) pastures.

The summer diets of cattle grazing in grassland habitats are made up of almost exclusively graminoids. Graminoids also dominate the summer diets of cattle grazing in forested habitats. Increases in cattle stocking rates tend to increase the utilization of perennial grasses. The utilization of the perennial grasses compared to that of the other available forage species tends to be higher in late season pastures than in early season pastures of deferred- rotation grazing systems. In forested habitats, cattle use of perennial grasses tends to decrease with increasing tree density. Browse use by cattle in forested habitats may increase slightly in late summer

as the palatability of the perennial grasses and forbs decreases. However, fall cattle diets are generally almost exclusively made up of graminoids.

Comparison of cattle diets on rangelands of different condition classes indicates the dietary composition is partially dependent on forage availability. on rangelands in good condition, having nearly a full complement of perennial grasses, summer cattle diets tend to contain almost entirely graminoids. On degraded rangelands, where much of the perennial grasses have been replaced by weedy forbs, summer cattle diets tend to contain a relatively high percentage of forbs.

Summer Cattle Diets in Northeastern Oregon.

In the Starkey Experimental Forest and Range in northeastern Oregon, Skovlin et al. (1976) reported, based on ocular estimates of forage utilization, the summer diets of cattle grazing in bunchgrass-dominated grasslands contained 96% graminoids while graminoids formed 88% of cattle diets from forested areas. Elk sedge was the most prominent forest graminoid species in cattle diets. Bearded bluebunch wheatgrass dominated cattle diets in the grasslands.

In 1948, Pickford and Reid (1948) theorized that as range conditions improved on the then depleted rangelands of the Starkey Experimental Forest and Range, the percentage of graminoids in cattle diets would increase. This theory is supported by a comparison of cattle diet composition (72% graminoids) in the Pickford and Reid (1948) study with the Skovlin et al. (1976) study during which the range conditions on the Starkey Experimental Forest and Range were fair to good.

Also working on cattle summer range in northeastern Oregon, Miller and Krueger (1976) evaluated forage utilization by cattle using paired exclosed (caged) and unexclosed plots. They reported 63% of the total forage consumed by cattle came from logged forest habitats. Seeded grasses made up 55% of the forage utilized by cattle in the logged forest habitats. Forage from bunchgrass-dominated grasslands made up 29% of the total forage utilized by cattle. Sandberg bluegrass and bearded bluebunch wheatgrass were the predominate forage species utilized by cattle while in the grassland habitats. Only 8% of the total forage utilized by cattle came from forested habitats.

Clary et al. (1978) reported forage utilization estimates indicated perennial grasses formed 97% of the summer cattle diet on ponderosa pine-bunchgrass range in northern Arizona. They also noted 75% of the variability in forage utilization could be explained by the combination of two variables; perennial grass production and ponderosa pine density (basal area/ha). Forage consumption increased with increased perennial grass production and decreased ponderosa pine density. In southeastern Washington, Lauver (1983) also noted, based on cow chip counts, cattle use of forested habitats decreased with increased tree density.

Holechek et al. (1982a) reported based on forage samples collected from esophageally-fistulated cows, Idaho fescue, bearded bluebunch wheatgrass, and Sandberg bluegrass were the most prominent species in summer cattle diets on grassland habitat in the Blue Mountains of Oregon. Idaho fescue was preferred over bearded bluebunch wheatgrass. Sandberg bluegrass was the most abundant grass on the study area but was utilized much less than its availability. Forage preference in cattle was related to plant phenology. The diversity of cattle diets was higher during late spring than during the rest of the grazing season. Forbs made up as much as 41% of the late spring cattle diet. Important forbs were western yarrow, arrowleaf balsamroot, and lupine. As the forbs matured in early summer, cattle diets switched to an almost complete dominance of grasses. Late summer and fall diets continued to contain almost exclusively grasses. Browse consumption remained relatively static, ranging from 3 to 8% of the diet throughout the grazing season.

In forested habitats of the Blue Mountains, Holechek et al. (1982b) noted cattle forage samples collected via esophageal fistulas indicated Idaho fescue and elk sedge were the primary items in cattle diets during the summer grazing season. Forbs made up as much as 36% of late spring cattle diets. Important forbs werewestern yarrow, heartleaf arnica, and lupine. Forb use declined with seasonal and phenological progression. Browse use increased as the palatability of graminoids and forbs decreased. Common snowberry, spirea, and wax currant were the most common browse species in the diet.

Using fecal analysis techniques, Sheehy (1987) reported summer cattle diets in foothill bunchgrass and ponderosa pine-bunchgrass communities in northeastern Oregon consisted of 67% perennial grasses, 15% annual grasses, 6% grasslikes, 6% half-shrubs and forbs, 1% trees, and 5% other. Dominate perennial grasses in the diet were Kentucky bluegrass (24%), bearded bluebunch wheatgrass (19%), and Idaho fescue (17% of the summer diet) . Elk sedge was the most important grasslike species making up 3% of the summer diet.

Fall Cattle Diets in Northeastern Oregon

Fall cattle diets in the foothills of northeastern Oregon contained 87% perennial grasses, 1% annual grasses, 1% grasslikes, 5% halfshrubs and forbs, 1% trees, and 5% other.
Bearded bluebunch wheatgrass (46%) was the most prominent perennial grass in the fall diet followed by Idaho fescue (36%). Hoods phlox (4%) was the most important forb in the diet (Sheehy 1987).

Influences of Stocking Rate and Grazing System on Cattle Diets

In the Star key Experimental Forest and Range in northeastern Oregon, Skovlin et al. (1976) reported the utilization of primary grass species by cattle was positively ($P<0.05$) related to cattle stocking rates. Shrub and forb use were not significantly affected by stocking rates. Overall forage utilization was not significantly different between season-long and deferred-rotation grazing management systems. However, utilization of bearded bluebunch wheatgrass was 6% higher ($P<0.05$) on season-long ranges than on deferred-rotation ranges. Loss of quantity and quality in the early maturing annual grasses and forbs explained why cattle made heavier use of the principal forage species on the late season ranges as compared to the early season ranges of the deferred-rotation system.

SHEEP DIETS BY SEASON, FORAGE GROUP, AND SPECIES COMPOSITION

Section Abstract

Spring sheep diets in low elevation montane habitats are dominated by graminoids with forbs playing a secondary role in the diet. However, in low elevation shrub-steppe habitats, spring sheep diets may contain considerable amounts of browse. Graminoids dominate sheep diets in low elevation montane habitats during the summer but forbs are the principal summer dietary component in high elevation meadow and parkland habitats. The availability of palatable forbs can influence the dietary composition as the grazing season progresses. Sheep tend to increase their consumption of graminoids as the available forbs mature and desiccate. Additionally, the consumption of forbs by sheep decreases with each successive visit to a particular feeding site. In forested habitats, containing a high proportion of palatable browse but limited amounts of herbaceous forage, summer sheep diets may be predominated by browse species.

Spring and Summer Sheep Diets

On a degraded, high elevation rangeland in northeastern Oregon, Pickford and Reid (1943) reported forage utilization estimates indicated summer sheep diets consisted of 66% forbs, 33% graminoids, and 1% browse. Knotweed, lupine, hawkweed, Grays ligusticum, and littleflower penstemon were the most prominent forbs in the diet. Major graminoid species were subalpine needlegrass, elk sedge, and other sedges.

Hanley and Hanley (1982) noted, based on fecal analysis, spring sheep diets in northeastern California and northwestern Nevada consisted of 47% graminoids, 12% forbs, and 41% browse. Summer sheep diets contained 68% graminoids, 22% forbs, and 10% browse.

In western Montana, Stevens (1966) reported feeding site evaluations indicated summer sheep diets were dominated (70%) by forbs. The major forb species in the diet were pale agoseris, lupine, and hawkweed. Graminoids formed the remainder of the summer diet. Sedges, bromes, danthonias, and wheatgrasses were the most important graminoids. Dietary differences were apparent between the first and subsequent visits by sheep to a feeding area. During the first visit the forb content of the diet was usually higher (as much as 89% of the diet) than in subsequent visits. Graminoids increasedin the sheep diet with the number of visits to a feeding area.

On pumice soils in south central Oregon, Stuth and Winward (1977) noted, based on forage utilization estimates, summer sheep diets in meadow communities contained an average of 81% graminoids and 19% forbs. Diets in the logged lodgepole pine-antelope bitterbrush-western needlegrass community were made up of 74% browse (primarily antelope bitterbrush), 24% graminoids, and 2% forbs. Summer diets in the unlogged lodgepole community consisted of nearly 100% antelope bitterbrush browse.

ELK DIETS BY SEASON, FORAGE GROUP, AND SPECIES COMPOSITION

Section Abstract

Elk winter diets are generally dominated by graminoids. However, the winter elk diet composition appears to be related to the type and quantity of forage available on each particular winter range. On winter ranges dominated by graminoids, the graminoid content of late winter-early spring elk diets tend to be higher than the graminoid content of late fall-early winter diets. The graminoid content of late season elk diets consists primarily of green growth. Graminoids also dominate the spring elk diet. During the summer, elk tend to shift to a forb dominated diet. However, summer elk diets in subalpine-alpine habitats often exhibit an graminoid dominance. In the fall, elk generally shift from a forb preference back to a graminoid preference. However, on fall elk ranges where the vegetative composition is dominated by browse species, fall elk diets tend to be composed primarily of browse.

Winter Elk Diets in Northeastern Oregon

Skovlin and Vavra (1979) used microhistological techniques to evaluate winter elk diets from pellet collections made in early winter (December 1973) and in late winter-early spring (March-April 1974) on winter ranges within five different big game management units in northeastern Oregon. Idaho fescue was the most prominent species in winter elk diets. On three of the five management units the highest consumption of Idaho fescue by elk occurred during the late season. Early and late season elk diets contained 43% and 77% grasses, respectively. Grasses in late season elk diets were primarily green, new growth. Dietz and Nagy (1976) and, Vavra and

Sneva (1978) also noted grasses predominated big game diets during the late winter-early spring. Skovlin and Vavra (1979) reported elk use of forbs was minimal during both the early and the late season. Browse species made up only 5% of the winter elk diet. It should be noted big game winter ranges in northeastern Oregon lack the extensive shrub communities common to other big game winter ranges throughout the West (Skovlin and Vavra 1979) . However, since the results of this study were based on . fecal analysis without adjustment for differential digestibility of dietary constituents, the role of browse and forbs in the winter elk diet may have been under-estimated while the role of graminoids may have been overestimated.

Sheehy (1987) used fecal analysis to study winter elk diets in foothill bunchgrass and ponderosa pine-bunchgrass communities in northeastern Oregon. Perennial grasses formed 50% of the diet while grasslikes made up 30%, half-shrubs and forbs 5%, trees 8%, shrubs 2%, and other forage 5%. The most prominent perennial grasses in the winter diet were Idaho fescue and bearded bluebunch wheatgrass, each made up 21% of the diet. Elk sedge was the dominant grasslike forming 30% of the diet. The half-shrub Oregon grape constituted 4% of the winter diet. Ponderosa pine was the only tree browsed and formed 8% of the diet. Antelope bitterbrush made up 2% of the elk winter diet. As a result of differential digestibility of dietary components, the forb and browse content of winter elk diets may have been under-represented in this study as well.

Spring Elk Diets in Northeastern Oregon

Based on analysis of fecal and rumen samples, Sheehy (1987) reported spring elk diets in the foothills of the Blue mountains of Oregon consisted of 65% perennial grasses, 15% grasslikes, 4% half shrubs and forbs, 5% trees, 1% shrubs, and 9% other forage. Two perennial grasses, Idaho fescue and bearded bluebunch wheatgrass formed 30% and 19% of the spring elk diet, respectively. Elk sedge made up 15% of the diet. Oregon grape was the dominate half shrubforb consumed by elk forming 2% of the diet. Ponderosa. pine made up 5% of the spring elk diet.

Sumer Elk Diets in Northeastern Oregon

Using fecal analysis methodology, Korfhage et al. (1980) noted during the late spring, elk diets in northeastern Oregon contained mostly graminoids (60%) . As the season progressed into summer, elk increased their consumption of forbs while decreasing their graminoid intake. Forb and browse use peaked during late summer, averaging 46% and 41% of the diet, respectively. The principal grasses in elk summer diets were bearded bluebunch wheatgrass, mountain brome, elk sedge, orchard grass, and sheep fescue. Dominate forbs in elk summer diets were American trail plant, Oregon falsebugbane, and Columbia monkshood. Oceanspray, mallow ninebark, and Pacific yew were the most common browse species in the summer diets. The differential digestibility of dietary components was not accounted for in this study.

Seasonal Elk Diets in Other Areas of the West

Using methodology similar to that of Kufeld et al. (1973), Kufeld (1973) reviewed 48 elk food habit studies which had been conducted in different areas throughout the western United States. The seasonal composition of elk diets were summarized as both, percentages of 3 major forage groups; browse, forbs, and graminoids, and by ranking the prominence of individual forage species in elk diets.

Kufeld (1973) concluded elk winter dietary composition was strongly influenced by forage availability. Elk wintering on grasslands in Montana had diets which consisted of 63 to 100% grasses, with browse and forb content averaging 9% and 8%, respectively (Casagranda and Janson 1957, Morrison and Schwartz 1957, Greer: 1959, Constan 1967, Gordon 1968, and Greer et al. 1970). In Montana and portions of northern Idaho and northeastern Washington, elk winter diets consisted of 65% grasses, 2% forbs, 15% browse, and 5% lower plants (DeNio 1938). In Jasper Park, Alberta, elk wintered almost entirely on grasses with 97% of their diet coming from that forage group (Cowan 1947). In New Mexico, Manitoba, Colorado, and Idaho, browse constituted 95% (Lang 1958), 62% (Blood 1966), 57% (Boyd 1970), and 82% (Trout and Leege 1971) of elk winter diets, respectively. Elk use of grasses in the 4 studies just mentioned averaged 22% with little or no use of forbs (Kufeld 1973).

Eight Montana studies reviewed by Kufeld (1973) indicated elk spring diets included an average of 87% grasses (Morris and Schwartz 1957, Rouse 1957, Kirsch 1963, Stevens 1966, Eustace 1967, Gordon 1968, Greer et al. 1970, and Mackie 1970). In 1973, the only acceptable spring elk diet data available outside of Montana came from a Manitoba study (Blood 1966) where elk diets contained 54% grasses, 37% browse, and 9% forbs (Kufeld 1973).

Based on feeding site examinations, Stevens (1966) reported grasses made up 77% of spring elk diets in the Elkhorn Mountains of Montana. Idaho fescue was the most dominate grass in the diets. Forbs formed the remaining portion of the diet. As spring progressed, elk diets tended to increase in forb content.

Forbs were the most important forage group during the summer for elk in Montana. Kufeld (1973) compared the findings of 7 Montana studies and found elk summer diets included 64% -forbs, 30% grasses, and 6% browse (Morrison and Schwartz 1957, Rouse 1958, Kirsch 1963, Stevens 1966, Eustace 1967, Greer et al. 1970, and Mackie 1970) . Two Colorado studies, Nichols (1957) and Boyd (1970) reported grasses were the most important summer elk forage making up 58% and 78% of elk summer diets, respectively. Young and Robinette (1939) in Idaho and Blood (1966) in Manitoba both found that browse formed the largest portion of elk summer diets, 55% and 52%, respectively (Kufeld 1973).

Working on alpine- subalpine summer ranges in Rocky Mountain National Park, Colorado, Baker and Hobbs (1982) reported, based bite count analysis, tame elk diets consisted primarily of graminoids. The amount of graminoids in elk diets remained similar ($P > 0.31$) throughout the summer rather than changing with the phenological progress of the available forage species. Elk summer diets contained similar ($P > 0.11$) quantities of graminoids between the 3 habitat types on the study area: 1) willow park type, 2) Krummhotz ecotone type, and 3) alpine tundra type. Within the willow park type; sedges, baltic rush, tea-leaved willow, and blueberry dominated elk summer diets. Elk primarily fed on sedges, tea-leaved willow, short-fruited willow, kobresia, and tufted hairgrass in the Krummhotz ecotone type. Elk diets in the alpine tundra type were dominated by sedges, rush, tufted hairgrass, tealeaved willow, alpine avens, and elkslip marshmarigold.

Collins et al. (1978) used bite count techniques to study the summer diets of tame elk in lodgepole pine habitats of northern Utah. Forbs were the most prominent forage group in the elk summer diets followed by grasses with browse being of limited importance.

In his review, Kufeld (1973) , found elk in Montana tended to shift from forbs to grasses in the fall. Data for elk fall diets from 9 Montana studies indicated grass constituted an average of 73% of diet (Rush 1932, Morrison and Schwartz 1957, Rouse 1957, Greer 1959, Greer 1960, Kirsch 1963, Peek 1963, Greer et al. 1970, and Mackie 1970). In the only Colorado study reviewed which contained fall diet data (Boyd 1970), grasses formed 92% of the fall elk diet. Fall diets were apparently quite variable between different areas of New Mexico. Burt and Gates (1959) noticed that fall elk diets contained 84% grass while Lang (1958), also in New Mexico, reported browse formed 77% of the fall diets and grasses only 21%. In areas of Manitoba (Blood 1966) and Idaho (Young and Robinette 1939), browse use was also high reaching 55% and 40%, while forbs reached 37% and 40%, and grasses 8% and 20%, respectively (Kufeld 1973).

Using data from the elk diet studies he reviewed, Kufeld (1973) calculated dietary prominence rankings for each forage species identified in the review. Bearded bluebunch wheatgrass, sedges, elk sedge, Idaho fescue, rough fescue, prairie junegrass, and bluegrasses were ranked as principal grass species in elk diets. Dietary importance varied seasonally for most of the graminoids just mentioned. Only elk sedge and prairie junegrass were ranked as "highly valuable" and "valuable" year-round forages, respectively. Pale agoseris and sticky geranium were the important forbs in summer elk diets. Lupine was noted as a highly preferred fall forb. Aster was found to be an important year-round forage. Serviceberry, red stem ceanothus, snowbrush ceanothus, quaking aspen, common chokecherry, antelope bitterbrush, Gambel oak, and willows were "highly valuable" browse species for elk (Kufeld 1973).

MULE DEER DIETS BY SEASON, FORAGE GROUP, AND SPECIES COMPOSITION

Section Abstract

A review of the mule deer food habit research (Kufeld et al. 1973) conducted throughout the West that winter mule deer diets are primarily composed of browse with forbs being of secondary importance and graminoids occurring only in limited amounts in the winter mule deer diet. However, studies carried out in northeastern Oregon reveal winter mule deer diets are composed of primarily graminoids, specifically Idaho fescue and bearded bluebunch wheatgrass (Skovlin and Vavra 1979) . Since palatable browse species do not form a substantial portion of the vegetative composition of mule deer winter ranges in northeastern Oregon, it is probably reasonable to assume the observed differences in winter mule deer diets between winter ranges is related to the availability of each forage group. Use of graminoids by mule deer peaks during the spring when succulent, green growth is available in the perennial grasses. The importance of graminoids in the mule diet declines during early summer while the importance of forbs increases. On mule deer ranges where palatable browse species are abundant, mule deer tend to shift towards a browse-dominated diet during the fall. on mule deer ranges, similar to those found in northeastern Oregon, which lack a significant palatable browse component, fall mule diets tend to contain varying amounts of forb and graminoids.

Winter Mule Deer Diets in Northeastern Oregon

Based on fecal analysis, Skovlin and Vavra (1979) reported winter mule deer diets in five different big game management units in northeastern Oregon contained a substantial amount of graminoids. During the early season (late fall-early winter), mule deer diet's contained 20% grasses. Late season (late winter-early spring) mule deer diets contained 46% grasses. Grass in the late season mule deer diet consisted primarily of the new, green growth taken from perennial grasses. Browse species formed 25% of the winter mule deer diet.

Sheehy (1987) observed, based on fecal analysis, winter-spring mule deer diets consisted of 49% perennial grasses, 2% grasslikes, 21% half-shrubs and forbs, 14% trees, 4% shrubs, and 10% other forage. Idaho fescue, the most dominate species in the diet, represented 17% of the winter-spring forage consumed by mule deer. Other perennial grasses that were important in the winter-spring diet were Sandberg bluegrass (11%), bearded bluebunch wheatgrass (10%), and Leiberg bluegrass (8%). Hood phlox was the most prominent forb in the diet, representing 16% of the winter-spring forage consumed by mule deer. Browse from ponderosa pine trees also formed a substantial percentage (13%) of the mule deer diet.

Seasonal Mule Deer Diets Throughout the West

Kufeld et al. (1973) examined the findings of 99 mule deer diet studies. Forage species identified. in these studies were classified by season of use and ranked according to the level of deer use. The number of studies used to form the ranking for each forage species was listed so the reader could evaluate the validity of the ranking. The season of use and ranking data were used to summarize the seasonal components of mule deer diets throughout most of their native range in the western United States.

Mule deer winter diets contained an average of 74% browse from shrubs and trees, forbs averaged 15%, and graminoids accounted for 11%. Winter use of graminoids varied greatly between the studies examined, making up 0 to 53% of mule deer diets (Kufeld et al. 1973).

In the spring, the percentage of browse in mule deer diets declined to an average of 49% while forbs and graminoids increased to 25% and 26%, respectively. Mule deer use of graminoids, was the highest in the spring but percentages of the diets varied widely (4 to 64%) between studies (Kufeld et al. 1973).

Browse in summer mule deer diets remained at 49% while forbs increased to 46%, and graminoids decreased to 3% of the diets. Forb content in the diets was greatest in the summer. but was highly variable (3 to 77%) between references. Graminoids were used least in the summer. Reported dietary percentages for grasses varied from 0 to 22% (Kufeld et al. 1973).

Fall diets of mule deer averaged 60% browse, 30% forbs, and 9% graminoids. Again, the forb content of the mule diet diets reported in the reviewed studies varied considerably, ranging from 2 to 78%(Kufeld et al. 1973).

The most common browse species in mule deer diets throughout their native range were big sagebrush, curlleaf mountain mahogany, true mountain mahogany, quaking aspen, antelope bitterbrush, Gambel oak, and skunkbrush sumac (Kufeld et al. 1973).

Dominate forbs species in mule deer diets varied considerably among referenced studies. Very few forbs were consistently reported as making up a substantial portion of mule deer diets. The forbs most often occurring in mule deer diets were western yarrow, pussytoes, fringed sagebrush, Louisiana sagebrush, aster, milkvetch, arrowleaf balsamroot, thistle, fleabane, buckwheat, geranium, prickly lettuce, lupine, alfalfa, penstemon, phlox, Hoods phlox, knotweed, cinquefoil, common dandelion, yellow salsify, clover, and american vetch (Kufeld et al. 1973).

Kufeld et al. (1973) noted in many of the studies evaluated in their review, the graminoids were not identified by species.

Consequently, the following list of the most common graminoid species in mule deer diets is based on data from only those studies which did report the graminoid species in the diets: wheatgrass, bearded bluebunch wheatgrass, cheatgrass brome, sedges, Idaho fescue, muttongrass, Kentucky bluegrass, and bluegrasses.

Using rumen sample analysis techniques, Willms et al. (1976) evaluated fall, winter, and spring mule deer diets in southern British Columbia. Significant relationships (P<0.1) were found between the consumption of certain species and the season of the year. Big sagebrush, gray rabbitbrush, and fringed sagebrush were primarily eaten during the winter. Pea vine, strawberry, lupine, Oregon grape, myrtle pachistima, and rose were consumed by mule deer on the fall range. Although the consumption of big sagebrush, fringed sagebrush, Oregon grape, pussytoes, and graminoids was not significantly related to the spring season, these species were common in the spring mule deer diet.

Austin and Urness (1985) used bite count analysis procedures to evaluate tame mule deer diets in 4 plant communities of summer mule deer habitat in the Sheeprock mountains of Utah. Dietary diversity was very low in the Utah serviceberry community. Utah serviceberry and sagebrush formed most of the mule deer diets throughout the summer.

In contrast, dietary diversity was high during late spring and early-mid summer in the Gambel oak community. Forb availability was high in late spring and made up the bulk of the mule deer diet in the Gambel oak community during that time. As the season progressed, the availability of succulent forbs in the Gambel oak community generally decreased. However, forbs occurring under shrub canopies tended to remain succulent longer than those occurring in the open. Intake of forbs decreased with availability; occurring as 77% of the may diet, 26% of the July diet, and less than 1% of the September diet. Consumption of Gambel oak browse increased throughout the summer occurring as 16% of the May diet, 60% of the July diet, and 96% of the September mule deer diet (Austin and Urness 1985).

Mule deer diets in the big sagebrush community contained a high proportion of forbs throughout the season. Late spring and early summer diets contained 84% and 81% forbs, respectively. Forbs and 2 browse species; Utah serviceberry, and mountain snowberry, formed most of the mid and late summer diets. Early fall diets were also dominated by forbs, mountain snowberry, and Utah serviceberry with Utah serviceberry forming a larger proportion of the mule diet during this part of the season (Austin and Urness 1985).

The mixed browse community tended to occur at higher elevations than the 3 proceeding plant communities. Forbs formed the bulk of the late spring and early summer mule deer diets with Utah serviceberry, Woods rose, and mountain snowberry contributing to the remainder. Deer use on forbs decreased by mid summer and use increased on Gambel oak, Woods rose, and mountain snowberry. Gambel oak, Woods rose, and forbs dominated the late summer diet. During early fall, forbs lost their prominence in the diet. Gambel oak, Woods rose, and mountain snowberry made up most of the fall mule deer diet in the mixed browse community (Austin and Urness 1985).

BIGHORN DIETS BY SEASON, FORAGE GROUP, AND SPECIES COMPOSITION

California Bighorn Sheep Diets

Blood (1967) reported the fall -winter- spring diet of the Ashnola River California bighorn sheep herd in British Columbia consisted of 72% graminoids, 4% forbs, and 24% browse. He noted fringed sagebrush made up 35% of the winter diet. Also working with the Ashnola herd, Sugden (1961) noted browse from Douglas fir and Englemann spruce was consumed by California bighorns during the winter when the availability of other forage was reduced. Bearded bluebunch wheatgrass was the most prominent graminoid in the bighorn diet (Sugden 1961).

Rocky Mountain Bighorn Sheep Diets

Section Abstract

Food habit research conducted on Rocky Mountain bighorn occurring in Colorado, Idaho, Montana, and Wyoming reveals winter bighorn sheep diets are generally dominated by graminoids with browse being increasingly important from mid to late winter. Spring bighorn sheep diets appear to be dominated by graminoids with browse being of secondary importance. In late spring, on some bighorn ranges, forbs may become the most prominent component of bighorn diets. However, as summer progresses bighorn diets gradually shift back to a diet dominated by graminoids. During the fall, Rocky Mountain bighorn diets are also generally dominated by graminoids with browse playing a secondary role in the diet. There is some indication fringed sagebrush, often classified as a forb, may be a very important bighorn forage plant during the fall.

Winter Rocky Mountain Bighorn Sheep Diets

Using direct observation and rumen analysis techniques to study the diet of the Rock Creek herd in Montana, Cooperrider (1969) noted 30% of the fall-winter diet consisted of the fringed sagebrush. Other authors have also reported Rocky Mountain bighorn heavily depend on fringed sagebrush during the fall and winter (Mills 1937, Honess and Frost 1942, Spencer 1943, Cowan 1947, Schallenberger 1966, and Constan 1967).

Smith (1954) noted, based on direct observational data, winter Rocky Mountain bighorn diets in habitats along the Salmon River of Idaho consist of 56% graminoids-forbs, 39% browse, and 5% moss and lichen. The browse content of winter bighorn diets tended to increase as snow began to bury the herbaceous plants on the winter range. Bearded bluebunch wheatgrass and Idaho fescue were the principal graminoid species in winter bighorn diets. Curlleaf mountain mahogany was the dominate browse component of the winter diet.

Oldemeyer et al. (1971) reported, based on utilization estimates and feeding site evaluations, winter diets of Rocky Mountain bighorn sheep in Yellowstone National Park consisted of 61% grass, 22% browse, and 17% forbs. Bearded bluebunch wheatgrass was the most preferred grass while phlox and winterfat were the most preferred forb and browse, respectively.

In north central Montana, Kasworm et al. (1984) used fecal analysis techniques to examine the winter diet of Rocky Mountain bighorn sheep. They reported graminoids were the most prominent component in the early winter bighorn diet. Graminoids formed 65% of the early winter diet but declined to 47% of the diet by late winter. Wheatgrasses, fescues, and prairie junegrass were the principal graminoids in the winter bighorn diet. Consumption of browse by bighorn sheep increased from 23% of the early winter diet to 42% of the late winter diet. The most important sources of browse were fringed sagebrush (considered a shrub in this study), Douglas fir, and juniper. Douglas fir and juniper were used primarily in March while fringed sagebrush was considered an important browse species throughout the winter. Balsamroot and biscuitroot were the only forb species heavily used by wintering bighorn sheep.

Based on microhistological analysis of fecal samples, Keating et al. (1985) noted wintering Rocky Mountain bighorn sheep on the Everts and Cinnabar winter ranges of Montana fed mainly on grass and browse taxa. The dominate grass taxa in the bighorn diets were wheatgrasses, prairie Junegrass, fescues, needlegrasses, and bromes. Sagebrush and winterfat were the most common browse taxa consumed by wintering bighorn. Phlox species were the only forbs which were regularly found in bighorn winter diets. It should be noted the fecal analysis in this study was done without adjustment for differential digestibility between forages. Consequently, some of the forbs and more digestible browse species may be underrepresented in the bighorn diet presented in this report.

Based on bite count methodology, Dailey et al. (1984) concluded winter diets of tame Rocky mountain bighorn sheep at Niwot Ridge, Colorado were dominated by grasses with browse and forbs being of secondary and tertiary importance, respectively. During early summer, bighorns fed mostly on forbs but increased their grass intake as the season progressed and the succulence and availability of forbs decreased.

Spring Rocky Mountain Bighorn Sheep Diets

Working in central Idaho, Smith (1954) reported, based on direct observation, spring bighorn diets contained 77% graminoids and forbs, 22% browse, and 1% mosses and lichens. Cheatgrass brome and arrowleaf balsamroot were sought out by bighorn during the spring but ignored during other seasons. Idaho fescue was preferred over bearded bluebunch wheatgrass during the spring.

In Saguache County, Colorado, Todd (1975) noted fecal samples collected for analysis of spring Rocky Mountain bighorn diets included 57% graminoids, 33% browse (primarily fringed sagebrush) , and 10% forbs. Summer diets contained 65% graminoids, 29% browse (primarily true mountain mahogany and bush rockspirea) , and 6% forbs. Graminoids represented 54% of the fall bighorn diet while browse made up 44% and forbs only a trace amount of the diet. Winter diets were dominated by browse (66%) rather than graminoids (23%) with forbs (11%) again becoming a more important component of the diet.

Summer Rocky Mountain Bighorn Sheep Diets

In the Salmon River Drainage of central Idaho, Smith (1954) used forage utilization sampling and direct observation techniques to study the summer food habits of Rocky Mountain bighorn sheep. He reported bighorns consumed 86% graminoids-forbs and 14% browse during the summer. Sedges, rushes, and little ricegrass were the most prominent components of the summer bighorn diet.

Fall Rocky Mountain Bighorn Sheep Diets

In the fall, Smith (1954) observed the Rocky Mountain bighorn sheep diet included an increase in the percentage of browse (25%) and a decrease in the percentage of graminoid-forbs (66%) as compared to the summer diet. He noted more than 75% of the bighorn sheep observed during the fall were located on northerly aspects. It was also noted the occurrence of shrubs was generally higher on northerly aspects than on southerly aspects within the study area.

Moser (1962) analyzed the rumen contents of hunter-killed Rocky mountain bighorn rams in Colorado to determine fall diets. Grasses made up 75% of the diet while browse and forbs formed 19% and 6%, respectively.

PRONGHORN DIETS BY SEASON, FORAGE GROUP, AND SPECIES COMPOSITION

Section Abstract

Pronghorn feed primarily on browse during the winter. Sagebrush species tend to be the most common sources of winter browse. Early spring pronghorn diets are generally dominated by browse species but the percentage of forbs in the diet increases as the season progresses. Consumption of significant quantities of graminoids by pronghorns is normally limited to late winter and early spring when this forage group often provides an abundant source of succulent forage. As the availability of forbs increases during late spring, pronghorns tend to shift toward a forb-dominated diet. Summer pronghorn diets usually continue to be dominated by forb species until late summer when the forbs become mature and lose much of their palatability. Late summer and fall pronghorn diets typically contain primarily browse. However, the occurrence of late summer and fall rains may induce a flush of forb growth. Forbs species will then dominate the pronghorn diet until these species lose their succulence again and are replaced by browse.

Winter Pronghorn Diets

Using microhistological analysis of fecal samples to study the diets of pronghorns in southeastern Oregon, McInnis and Vavra (1987) reported browse formed average of 59% of the winter pronghorn diet while forbs and graminoids accounted for 21% and 20% of the diet, respectively. Low sagebrush and Wyoming big sagebrush were the principal browse species in the winter pronghorn diet. Phlox was the most prominent forb consumed by wintering pronghorn. Sandberg bluegrass was the dominate graminoid in the winter diet.

Working in western Utah, Beale and Smith (1970) reported, based on forage utilization and direct observation data, browse constituted 90% of the late fall and winter pronghorn diet. Black sagebrush was the primarily source of winter browse.

In southcentral Idaho, Johnson (1979) used fecal analysis techniques to examine the winter diets of pronghorns. The author observed browse species formed 77% of the forage consumed by wintering pronghorn. Basin big sagebrush and common winterfat were the most prominent browse species in the winter diet representing 65% and 11% of the forage consumed, respectively.

Spring Pronghorn Diets

McInnis and Vavra (1987) reported spring pronghorn diets in southeastern Oregon contained 47% forbs, 37% browse, and 16% graminoids. Daggerpod was the most prominent forb in the spring diet. The browse portion of the spring pronghorn diet was made up almost exclusively of low sagebrush and Wyoming big sagebrush. Both, Sandberg bluegrass and cheatgrass brome were contained in the spring diet .

In western Utah, Beale and Smith (1970) noted early spring pronghorn diets contained mostly black sagebrush and bud sagebrush. Similar to sheep (Hutchings 1954), pronghorn exhibited a preference for bud sagebrush during its early phenological stages (Beale and Smith 1970). Spring was the only season when grasses made up a notable portion of the pronghorn diet. Pronghorn began consuming

Sandberg bluegrass and Indian ricegrass after the young tillers were produced. Forbs became more available in late spring and replaced grasses as a major component of pronghorn diets. In dry years, forb availability decreased rapidly in early summer and browse became the major dietary component. However, if late summer rains provided enough soil moisture to reinitiate the growth of forbs then, pronghorn diets tended to shift to a heavy reliance on forbs. When the flush of late summer and fall forbs lost their succulence, pronghorn diets shifted back to browse with black sage contributing an average of 49% of the diet.

Summer Pronghorn Diets

McInnis and Vavra (1987) observed, in southeastern Oregon, forbs made up an average of 80% of the summer pronghorn diet, while browse and graminoids formed averages of 15% and 6% of the diet, respectively. Munro globemallow, long-leaf phlox, and Hooker balsamroot were the dominate forbs in the diet. Low sagebrush and Wyoming big sagebrush were nearly the only browse species consumed by pronghorn during the summer. No graminoid species formed more than 4% of the summer pronghorn diet.

Smith and Malechek (1974) studied the summer diets of pronghorn in 2 areas of Utah; the Desert Experimental Range in Millard County and the Awapa Plateau in Wayne County. Examination of pronghorn feeding sites indicated the summer diets in both areas were dominated by browse species, followed by forbs, with grasses very rarely being consumed.

Johnson (1979) reported summer pronghorn diets in the cold desert shrub-steppe of south central Idaho contained similar amounts of browse and forbs. Two shrub species, basin big sagebrush and common winterfat, formed 27% and 19% of the summer diet, respectively. Milkvetch (17%), Munro globemallow (9%), plains prickly pear (8%), and fleabane (5%) were important forbs in the summer pronghorn diet.

Fall Pronghorn Diets

Working in southeastern Oregon, McInnis and Vavra (1987) noted fall pronghorn diets contained an average of 56% browse, 31% forbs, and 13% graminoids. Sagebrush species almost completely dominated the browse portion of the fall diet. Munro globemallow and long-leaf phlox were the principal forbs consumed. Sandberg bluegrass and cheatgrass brome formed a small but important portion of the fall pronghorn diet.

Based on feeding site examination and rumen analysis, Beale and Scotter (1968) concluded pronghorn in western Utah sharply decreased their consumption of forbs between July and September while increasing their browse consumption. Forbs formed roughly 85 to 90% of the diet during July but formed only 35 to 40% of the diet by early September. The forb content in the pronghorn diet steadily decreased throughout the fall, finally stabilizing in December at 5% of the diet.

UNGULATE DIET OVERLAP BY FORAGE GROUP AND SEASON OF USE

Section Abstract.

The potential for diet overlap between cattle and big game is greatest where cattle and elk or cattle and bighorn sheep use the same range. The studies examined indicate summer cattle diets and winter elk diets are the most likely to have substantial overlap. However, in areas containing both cattle summer range and elk winter range, cattle summer range is typically higher in elevation and spatially distant from elk winter range. Consequently, it is unlikely that overlaps will occur between both, the diets and the habitats used by cattle during the summer and by elk during the winter. However, as discussed later in this review, the combination of habitat and diet overlap between these two ungulates is more likely to occur on fall cattle range which is often used by elk later in the year as winter range.

The greatest overlap between the diets of elk and domestic sheep occurs during the summer when both species rely heavily on forbs. However, elk tend to be more selective between forb species than are sheep. Elk are also inclined to remain on a forb-dominated diet throughout the summer. Conversely, the amount of forbs in the summer diets of sheep generally decreases as the season progresses while the amount of graminoids and browse generally increases.

The diets of cattle and mule deer are most prone to overlap during the spring when mule deer diets contain a substantial amount of graminoids. However, spring mule deer diets are primarily dominated by forbs and browse while spring cattle diets contain mostly graminoids. Consequently, the degree of diet overlap between cattle and mule deer is relatively small.

Dietary overlap between domestic sheep and mule deer is most likely to occur id the spring and in the fall when the diets of both ungulates contain a considerable amount of browse and forbs. On rangelands where the availability of palatable browse is low, spring mule deer and sheep diets may both contain high percentages of graminoids.

Winter bighorn sheep diets and summer-fall cattle diets have the greatest potential for overlap of any seasonal diet combination between these two ungulates. Under this combination, the diets of both, cattle and bighorn sheep are dominated by graminoids. However, as with elk and cattle, the differences in seasonal habitat use displayed by cattle and bighorn sheep minimizes the potential for dietary competition between these species.

Literature pertaining directly to diet overlap between domestic sheep and bighorn sheep was apparently not available at the time of this writing. However, it seems likely that considerable overlap exists between the diets of domestic sheep and bighorn sheep given the dietary preferences described in the Sheep Diet and Bighorn Sheep Diet sections of this review.

Cattle and pronghorn diets generally exhibit only a small degree of overlap. Cattle and pronghorn diets appear to be most similar during the spring and fall. However, the diets of these two ungulates typically do not overlap more than 25% during any season of the year.

Dietary overlap between sheep and pronghorn is typically the highest during the spring and fall when both species are consuming sizable quantities of browse. However, as with cattle and pronghorn, the degree of similarity between the diets of pronghorn and sheep is generally less than 25%.

Livestock, Elk, Mule Deer

Using fecal analysis to study the diets of cattle, elk and mule deer in the foothills of the Wallowa Mountains in northeastern Oregon, Miller and Vavra (1982) noted Idaho fescue and bearded bluebunch wheatgrass were important winter dietary components of both mule deer and elk. Idaho fescue and bearded bluebunch wheatgrass also formed a major portion of the summer diets of cattle grazing on big game winter and spring range.

Kasworm et al. (1984) reported the summer diets of cattle grazing on a big game winter range in north central Montana exhibited significant ($P<0.05$) positive Spearman's Rank correlations with early winter elk diets ($r, = 0.63$) and with late winter elk diets ($rs = 0.50$). Wheatgrasses and fescues were common forages in both summer cattle diets and in early and late winter elk diets. Early winter and late winter mule deer diets exhibited negative correlations with summer cattle diets.

Also working in Montana, Stevens (1966) noted, based on feeding site examination, forbs made up 76% of the summer elk diet. Graminoids constituted only 17% of the elk diet and were believed to be consumed incidentally while elk foraged on forbs. The remainder of the summer elk diet consisted of browse. Forb use decreased while browse use increased as the season progressed. Summer diets of cattle consisted of 75% graminoids with forbs forming most of the remaining portion of the diet. Summer sheep diets were dominated by forbs (70%) while graminoids were of secondary importance and browse forming only a minor portion of the diets. The percentage of grasses in sheep diets increased between the first and the second visits to individual parks. It appeared the grazing done by sheep during the first visit to a park decreased the availability of forbs forcing the sheep to increase the percentage of grasses in their diets during the next visit to the park.

Working in southern Colorado, Hansen and Reid (1975) reported analysis of fecal samples, collected during the cattle grazing season (June through September) , indicated the overlap between mule deer and cattle diets varied from 12.1 to 37.8%. However, during this time period, mule deer and cattle tended to remain separated, occupying different areas of the range. Forage species most common in both diets were sedge, bluegrass, fescue, and true mountain mahogany. Elk and cattle were inclined to occupy the same areas during the cattle grazing season. Dietary overlap of elk and cattle ranged from 30.4 to 50.9%. Both elk and cattle diets contained substantial amounts of sedge, fescue, and bluegrass.

Working on a degraded rangeland in northeastern Oregon, Pickford and Reid (1943) compared the forage species utilized by sheep during the summer to those utilized by elk after the sheep had been excluded from the rangeland for 2 years. They found diet similarities were evident between elk and sheep. Forbs growing in wet meadows were heavily used by both species. Mesic sedges were also common in both diets. On dry upland sites, elk sedge was also used by both elk and sheep. However, the potential for strong competition between sheep and elk was moderated by the foraging selectivity exhibited by elk within forage groups. Elk tended to be more selective between forb species than sheep.

Cattle and Bighorn Sheep

In Montana, Kasworm et al. (1984) noted the winter diets of Rocky Mountain bighorn sheep indicated a positive but non-significant Spearman's Rank correlation with summer cattle diets.
Forage from wheatgrasses and fescues represented substantial portions of both, summer cattle diets and winter bighorn sheep diets.

Based on examination of feeding sites, Lauer and Peek (1976) observed that the winter and spring diets of Rocky Mountain bighorn sheep living along the East Fork Salmon River in Idaho consisted of 82% graminoids, 11% forbs, and 7% browse. The late spring and early summer diets of cattle grazing in this area contained 97% graminoids, 1% forbs, and 2% browse. Bearded bluebunch wheatgrass was the most common graminoid species in the winter and spring bighorn diets and in the late spring and early summer cattle diets.

Livestock, Elk, and Pronghorn.

In the Red Desert of Wyoming, Olson and Hansen (1977) compared the seasonal diets of wild horses, cattle, sheep, elk, and pronghorn using fecal analysis techniques. They concluded the overall diets of cattle and elk were the most similar of any comparison made between the five species. The spring diets of elk and cattle in this study overlapped by 89%. The diets of elk and sheep overlapped the greatest (53%) during the winter. Dietary overlap between livestock and pronghorn was relatively low. The highest overlap between cattle and pronghorn diets (20%) occurred during the fall. The diets of pronghorn and sheep were most similar (21%) during the fall.

Livestock, Pronghorn, and Mule Deer.

McInnis and Vavra (1987) noted the overlap between winter cattle diets and winter pronghorn diets in southeastern Oregon ranged from 9 to 13%. During the winter, cattle tended to make heavy use of graminoids, especially bottlebrush squirreltail. Sagebrush species were the dominate forage species in winter pronghorn diets. Spring cattle and pronghorn diets overlapped by 25%. Pronghorn and cattle both consumed substantial quantities of Sandberg bluegrass and cheatgrass brome during the spring. However, the spring pronghorn diets were typically browse and forb-dominated while spring cattle diets contained primarily graminoids.

Hanley and Hanley (1982) reported graminoids made up 94% the cattle spring diet in northeastern California and northwestern Nevada. Sheep spring diets contained similar amounts of graminoids (47%) and browse (41%). Pronghorn and mule deer spring diets consisted primarily of browse, 82% and 85%, respectively. Graminoids made up only 2% and 9% of the pronghorn and mule deer spring diets, respectively.

McInnis and Vavra (1987) observed the similarity between summer cattle and pronghorn diets in southeastern Oregon ranged from 11 to 14%. Summer cattle diets consisted primarily of graminoids (91 to 94%) while summer pronghorn diets were made up of predominately forbs (79 to 80%).

In northeastern California and northwestern Nevada, Hanley and Hanley (1982) reported graminoids made up 91% of the summer cattle diet. Sheep summer diets contained 68% graminoids, 22% forbs, and 10% browse. Pronghorn summer diets contained 68% browse and 5% graminoids with the forb content (27%) being similar to sheep summer diets. Browse formed 88% of the mule deer summer diet.

Working in southeastern Oregon, McInnis and Vavra (1987) noted fall pronghorn diets and fall cattle diets overlapped by an average of 12%. Browse was the principal forage group in fall pronghorn diets while graminoids predominated fall cattle diets.

Hanley and Hanley (1982) reported fall cattle diets in northeastern California and northwestern Nevada contained 93% graminoids. Fall sheep diets were similar to spring diets with 47% graminoids, 12% forbs, and 41% browse occurring in the fall diet. Pronghorn fall diets contained 87% browse, 11% forbs, and 2% graminoids. Mule deer consumed 92% browse, 4% forbs, and 4% graminoids during the fall.

POTENTIAL FOR COMPETITION BETWEEN LIVESTOCK AND BIG GAME

BACKGROUND: FORMS OF COMPETITION

Competition, as described by Birch (1957), can occur in two general forms: 1) common use of a limited resource by individuals of the same or different species; 2) common use of an unlimited resource where negative interactions occur between individuals despite the ready availability of the resource. Miller (1967) referred to the competition for a limited resource as "exploitative competition". Nelson (1982) described 2 forms of exploitative competition: 1) "interference competition" where an individual prevents or hinders the access of another individual to spatially-related resources such as in territorial defense of breeding or feeding areas; and 2) "disturbance competition" where passive social interactions such as where the presence of one individual within an area limits or prevents another individual from using that area. Nelson (1985) and several other authors provide a good discussion of the different forms of competition (Smith and Julander 1953, Denniston 1956, Cole 1958, Julander 1958, Schladweiler 1974, and Mackie 1976).

ELK AND CATTLE

Section Abstract

The highest potential for competition between elk and cattle occurs on foothill rangelands which are used by cattle during the fall and used by elk during the winter. The diets of both ungulates overlap considerably while using these rangelands. However, the patterns of habitat use for cattle and elk are different in the foothill rangelands. Cattle tend to use the drainage bottoms and the lower slopes while elk are inclined to use the upper slopes and other areas of steep terrain. Consequently, the natural behavior of these ungulates typically keeps them spatially separated on these foothill rangelands, thus, minimizing the potential for competition. Notably, the use of cattle management techniques (salting, water developments, herding, and ect.) to gain a more even distribution of cattle on fall ranges may, in fact, increase the competition between elk and cattle if the cattle are moved into habitats previously only used by elk.

There is some indication elk may be inclined to avoid areas being grazed by cattle. However, on an area by area basis, the question of whether the presence of cattle in an area or their impact on the forage base of the area causes elk to avoid that area is debatable. Certain areas are not used by elk, despite the presence or absence of cattle, because these areas contain habitats which elk instinctively avoid. However, research conducted in northeastern Oregon, within dual-use and big game-only pastures which contained similar amounts and types of habitat, seems to indicate the presence of cattle, even at light stocking rates, can influence elk distribution. Additionally, the type of cattle grazing management system used and the combination between the stocking rate used and the grazing system used can produce significantly ($P<0.05$) different effects on elk distribution.

Elk and Cattle: Season of Use Influences on Competition

Skovlin et al. (1968) reported temporal differences in elk and cattle use on the Starkey Experimental Forest and Range in northeastern Oregon. Migrating elk used the area primarily in the spring and fall while cattle grazed there during the summer. Indirect competitive interactions may have occurred if spring elk use was heavy enough to decrease the summer forage availability for cattle or if summer cattle grazing limited the amount of forage available to elk in the fall.

Miller and Vavra (1982) studied the diets of cattle, elk and mule deer in the foothills of the Wallowa mountains in northeastern Oregon. The summer diet of cattle and the winter diets of elk and mule deer all contained substantial amounts of Idaho fescue and bearded bluebunch wheatgrass. Although the season of use on the open south slopes within the study area differed between cattle and big game, these areas presented considerable potential for dietary competition between cattle and big game.

Nelson (1982) described two examples of an "unilateral interaction" between cattle and big game: 1) where elk use of early spring foothill grasses in central Washington prior to cattle turn out reduced the amount of spring forage available to cattle; 2) where the cured bunchgrass forage was consumed by cattle during the fall on these foothill ranges resulting in a decrease of available forage for elk during the winter.

In the Elkhorn Mountains of Montana, Stevens (1966) reported that although elk and cattle both used the high elevation, Engelmann-alpine fir zone between July and September, the potential for direct competition between the two species was low due to differences in their diets during that time of year. Elk diets consisted of mostly forbs (72%) while cattle diets were primarily made up of grasses (71%).

However, cattle summer diets and elk spring diets were more similar, with each containing a high percentage of grasses. Elk used the cattle summer range in mid to late spring before the cattle arrived. Given this situation, the potential for competition appeared high. However, interspecific competition was minimized by the substantial regrowth of grasses that occurred following spring elk use (Stevens 1966).

Miller and Krueger (1976) remarked direct competition between cattle and big game (elk and mule deer) did not occur on their study area in the foothills of the Wallowa Mountains of Oregon. It was suggested that differences in the season of use; cattle used the area from mid to late summer and big game in the spring and fall, probably minimized negative interspecific interactions.

Stevens (1966) reported elk used the mid elevation, Douglas fir zone within his Montana study area during the spring and fall while cattle used this vegetation zone during the summer and early fall. The potential for interspecific competition in the Douglas fir zone was greatest in the fall when the grass content of elk diets increased, becoming more similar to summer and fall cattle diets. Open parks appeared to be the most likely sites for potential conflict. However, the difference in the timing of use of these areas apparently limited the amount of competition that occurred.

Steven (1966) also noted elk used the lower elevation, fescue-wheatgrass zone as winter and spring range while cattle used this vegetation zone for summer and early fall range. Both elk and cattle diets contained high percentages of grasses, 74% and 75%, respectively. Four grass species made up a substantial portion of both elk (48%) and cattle (68%) diets. Despite the high diet similarity of these two ungulates, competition did not appear to be serious. Differences in seasonal of use patterns between the two ungulates seemed to limit interspecific competition. Summer cattle use in the fescue-wheatgrass zone occurred primarily on the lower slopes and in the drainage bottoms where water and shade were more available while winter and spring use by elk occurred on the ridges and south slopes which were more likely to be snow-free. Altering cattle distribution to increase the use on ridges and south slopes increase the potential for conflict between elk and cattle in this vegetation zone. Julander and Jeffery (1964) concluded the steepness of slopes and distance to water sharply limited the extent to which cattle used a rangeland. However, elk were only moderately limited by the steepness of slopes and distance to water and deer exhibited almost no response to these factors (Julander and Jeffery 1964). Consequently, on rangelands with moderate to high relief it is likely there would be large areas where cattle habitat and foraging use would only rarely overlap with that of elk and deer.

Working in the Missouri Breaks of Montana, Mackie (1970) reported that the habitat use of cattle and elk strongly overlapped during spring and fall but diverged during the summer. Elk and cattle chose similar habitat (sagebrush-wheatgrass type) during winter but remained spatially separated from each other. Winter diets were similar with western wheatgrass dominating the diets of both ungulates. By late May, elk and cattle diets had diverged. Late spring and summer elk diets were dominated by forbs while cattle diets were dominated by graminoids. During early fall, cattle and elk diets began to converge and by late fall were "almost identical". There was a potential for acute, direct competition between cattle and elk during the spring and fall. However, actual competition was minimized during the fall by differences in habitat use and during the spring by the tendency of elk to make heavy use of early season grasses and less use of western wheatgrass which was a preferred grass of cattle. The high mobility of the elk and their low densities in the study area also minimized interspecific competition.

Sheehy (1987) noticed cattle use of bunchgrass and ponderosa pine-bunchgrass communities within his study area in northeastern Oregon was highest in June, October, and November. Elk and mule deer use on the study area was heaviest between February and April with use peaking in March and April. Interspecific dietary overlap was highest between fall cattle diets and winter elk diets. These results indicate a potential for competition between cattle and elk on elk winter range. Spring elk diets and summer cattle diets overlapped the least indicating that spring elk grazing probably did not significantly effect the carrying capacity of cattle summer range. Diet overlap between mule deer and the 2 other herbivores never exceeded 51%.

Elk and Cattle: Displacement of Elk

Skovlin et al. (1968) reported on ponderosa pine-bunchgrass summer range in northeastern Oregon, elk use in pastures where cattle were excluded was significantly higher than on pastures where both big game and cattle were allowed to graze. Mackie (1970) noted elk selected areas which had not been utilized by cattle during the same forage year. Steep terrain and forested areas were used in favor of open ridges and canyon bottoms where cattle normally grazed.

Working in the Elkhorn Mountains of Montana, Grover and Thompson (1986) reported the choice of spring feeding sites by elk was most strongly influenced by 4 of the 12 environmental factors they studied. The influences of previous cattle use, distance for the nearest visible road, bunchgrass density, and distance to cover explained 65% of the variability in feeding site locations.

In the Medicine Bow National Forest near Laramie, Wyoming, Ward et al. (1973) used radio telemetry and direct observation to monitor the interaction between cattle and elk. Elk and cattle were concluded to be "socially compatible" based on numerous instances where cattle and elk were observed foraging in close proximity (25 to 100 m) of each other.

Elk and Cattle: Stocking Rate Influences on Competition

Skovlin et al. (1968) noted elk exhibited a negative response to increases in cattle stocking rates. Elk use of pastures moderately stocked with cattle (12 ha/A.U.) was significantly less than elk use on lightly stocked (16 ha/A.U.) pastures. However, there was no further significant decreases in elk use between heavily stocked (8 ha/A.U.) pastures and moderately stocked pastures.

Elk and Cattle: Grazing System Influences on Competition

Skovlin et al. (1968) reported elk use on summer range of the Blue Mountains of Oregon was not significantly different between pastures where the grazing system used was the only variable altered. However, comparison of elk use between pastures under different grazing systems and different stocking rates did indicate some highly significant responses. Under light cattle stocking, elk use was greatest on season-long ranges. Cattle tended to graze fewer plants under the season-long system than under the deferredrotation system. It was suggested elk preferred ungrazed plants and the higher availability of ungrazed plants in lightly stocked pastures under the season-long grazing system was a reason for higher elk use in these pastures. Where stocking rates were heavy, elk selected for pastures that were being grazed under a deferredrotation system. Under heavy stocking, cattle on season-long pastures were inclined to repeatedly graze individual plants of certain species. Repeated grazing did not occur as often on heavily stocked, deferred-rotation pastures. Higher forage availability was suggested as the reason for higher elk use on heavily stocked, deferred-rotation pastures.

Working in pastures of a rest-rotation cattle grazing management system in eastcentral Idaho, Yeo et al. (1993) observed elk tended to avoid pastures where cattle were grazing and apparently avoided pastures where cattle had grazed previously that season. Elk use in pastures which had been grazed by cattle tended to be more confined to forested habitats and terrain which was steeper and higher in elevation than was elk use in rested pastures.

Elk and Cattle: Environmental Factors Influencing Competition

Using fecal group counts of evaluate elk-cattle distribution in central Washington, Stark (1973) reported slope, canopy coverage, elk sedge cover, and distance from water all significantly influenced cattle and elk distribution. Slopes of less than 10% exhibited the highest potential for elk-cattle competition of any slope class. The potential for elk-cattle competition was less influenced by canopy closure than slope. Areas having full canopy closure exhibited the greatest potential for competition. Increasing elk sedge cover was significantly related to potential elk-cattle competition. Although cattle tended to remain closer to water than elk, the potential for competition between these ungulates was inversely correlated with distance to water.

ELK AND SHEEP

Section Abstract

The potential for competition between elk and sheep appears to be greatest on lands used concurrently by wintering elk and sheep. The diets of both ungulates contain a considerable amount of graminoids

during the winter. However, throughout much of the West, lands used by ranchers to winter sheep are generally lower in elevation than those used by elk as winter range. Consequently, elk and sheep tend to remain spatially separate throughout most of the winter.

There is also a potential for elk and sheep to compete on high elevation rangelands, where the summer diets of elk and sheep both contain a dominance of forbs. However, the period of time when this competition is likely to occur is relatively short. Additionally, competition is minimized by the tendency for elk to be more selective consumers of forbs than are sheep.

Elk and Sheep: Season of Use Influences on Competition

Olsen and Hansen (1977) noted the diets of elk and sheep in the Red Desert of Wyoming overlapped the greatest (53%) during winter when graminoids and shrubs were common in both diets. However, foraging elk appeared to concentrate on different species than did foraging sheep. Wheatgrasses formed the bulk of winter elk diets while saltbush was dominate in the winter sheep diets. The potential for competition between elk and sheep did not appear to be severe in this study.

On a southcentral Colorado winter range containing primarily shrub steppe and pinyon-juniper vegetation types, MacCracken and Hansen (1981) reported, based fecal analysis, the late spring diets of sheep and elk overlapped by 46%. Graminoids were common in the diets of both ungulates. However, the ranking of importance of each graminoid species was different between elk and sheep diets. Late spring sheep diets were dominated by western wheatgrass while elk diets contained similar amounts of sedges, fescues, western wheatgrass, and sagebrush during the late spring. They concluded that, despite the relatively high diet overlap between the two ungulates, elk and sheep did not seem to be competing for a limited forage resource during the late spring.

On a high elevation rangeland in northeastern Oregon, Pickford and Reid (1943) noted, during the summer, elk and sheep tended to forage in the same habitats and their diets appeared to overlap extensively. However, the potential for severe competition between elk and sheep was apparently limited by differences in the diets at the forage species level. Although, the summer diets of both, elk and sheep contained primarily forbs, elk tended to consume forb species which were different than those consumed by sheep.

Stevens (1966) suggested there was potential for severe competition between elk and sheep in the parks of the spruce-fir zone. However, the time period when this potential for conflict existed was quite short. Because this vegetation zone occurred at high elevation, the resulting delay in phenology of the forage species allowed elk to extend their spring, graminoid-dominated diet until mid June. Between mid June and the end of July, the diets of elk and sheep feeding in the parks of the spruce-fir zone contained predominately forbs, 72% and 70% of the diet, respectively. However, after the end of July, the forb content in the elk diets decreased while the graminoid and browse content increased. Sheep diets in the spruce- fir zone continued to be dominated by forbs until late summer. Consequently, the potential for severe competition between elk and sheep only existed from mid- June until the end of July

Elk and Sheep: Displacement of Elk

In Montana, Stevens (1966) reported elk used park habitats in the high elevation spruce-fir zone in the early summer but moved off to adjacent areas after sheep began using the parks. Shortly, after the sheep arrived in the parks the elk habitually moved to higher elevation foraging areas, apparently following phenological ques from the forage species. In the Gravelly Mountains of Montana, Rouse (1957) also observed an apparent displacement of elk by sheep.

MULE DEER AND CATTLE

Section Abstract

Competition between mule deer and cattle is typically not serious. The highest potential for competition between these two ungulates occurs during the spring when the diets of both, mule deer and cattle contain substantial quantities of graminoids. On mule deer winter ranges, similar to those of northeastern Oregon, where palatable browse is lacking, graminoids form much of the winter mule deer diet. Fall cattle grazing on these winter ranges could significantly reduce the amount of forage available for wintering mule deer. On degraded rangelands, where the perennial grass component has been considerably reduced but an ample shrub component remains, spring and fall cattle browsing may seriously reduce the amount of browse available to mule deer during the winter and spring. Differences in cattle stocking rate do not seem to influence deer distribution between pastures stocked with cattle and unstocked pastures. However, deer tend to make heavier use of open habitats as the cattle stocking rate increases. Under heavy stocking rates, mule deer prefer to use the early season pastures of deferred-rotation cattle grazing systems. Overall deer use tends to be higher in pastures under a deferred-rotation system than in pastures under a season-long system. Cattle apparently do not displace mule deer from large areas such as mountain pastures. However, cattle may cause changes in mule deer habitat selection. Mule deer appear to prefer forage that has not been previously grazed by cattle. Consequently, mule deer may spend more time foraging in areas that have not been used by cattle.

Mule Deer and Cattle: Season of Use Influences on Competition

In lodgepole pine-antelope bitterbrush-western needlegrass communities in south central Oregon, Stuth and Winward (1977) reported antelope bitterbrush was the most important summer forage species for both cattle and mule deer. Cattle and deer use of individual antelope bitterbrush plants overlapped by 25%. Cattle and deer did not directly compete for the current year's growth of antelope bitterbrush until late summer.

Mackie (1970) noted mule deer and cattle distributions in the Missouri Breaks of Montana substantially overlapped. However, habitat and diet selection differences between the 2 ungulates minimized the potential for competition. mule deer diets were dominated by forbs and browse while cattle diets contained mostly graminoids. Cattle used the more gentle and open terrain and deer selected the more rugged and forested terrain. Cattle and deer dietary overlap was highest during the early spring in the sagebrush-wheatgrass type. Sandberg bluegrass was used by both species at that time but competition was not intensive.

Julander (1958) reported competition between cattle and mule deer was most acute on portions of deer winter range which cattle grazed in spring and fall. Cattle tended to increase their use of antelope bitterbrush in areas which were in depleted range condition as a result of past over-use. Spring and fall browsing on antelope bitterbrush by cattle decreased the winter forage availability for mule deer. Julander (1958) suggested "maximum sustained grazing use" on dual-use rangelands requires careful management of perennial grasses (livestock forage), palatable shrubs and forbs (mule deer forage), and forage species which are used by both deer and livestock. Improper management of any of these 3 forage aspects will eventually lead to competition.

Mule Deer and Cattle: Stocking Rate Influences on Competition

On a deer summer range in the Blue Mountains of Oregon, Skovlin et al. (1968) noticed no significant differences in mule deer use between pastures which were lightly stocked (16 ha/A.U.),. moderately stocked (12 ha/A.U.) or, heavily stocked (8 ha/A.U.) with cattle. However, mule deer use of grassland openings tended to increase with increased cattle stocking rates.

Mule Deer and Cattle: Grazing System Influences on Competition

Skovlin et al. (1968) reported, under heavy cattle stocking rates, mule deer made twice as much use of early-grazed pastures as they did of late-grazed pastures under a deferredrotation grazing system. Mule deer did not exhibit a significant response between the early or late pastures of a deferred-rotation system under light and moderate stocking rates. Mule deer use of both forested areas and grassland openings appeared to be greater ($P<0.1$) on deferred-rotation pastures than on pastures grazed season-long by cattle. As noted above, Skovlin et al. (1968) found elk preferred the season-long grazing system in lightly stocked pastures. This difference in preference exhibited between mule deer and elk was attributed to different seasons of use.

Under a rest-rotation cattle grazing system in eastcentral Idaho, Yeo et al. (1993) observed mule deer selectively used pastures where cattle had grazed previously that season. Pastures which were being rested or were occupied by cattle were avoided by mule deer.

Mule Deer and Cattle: Displacement of Mule Deer

In northeastern Oregon, Skovlin et al. (1968) reported mule deer use in pastures where cattle were excluded was not significantly different than in pastures where big game and cattle were allowed access. However, deer habitat selection was different ($P<0.05$) in pastures where cattle were present than in the pastures where cattle where absent.

Using tame mule deer in Utah, Austin and Urness (1986) noted during late summer, upon initially entering an area (first 20-40 deerdays/ha), mule deer preferred ($P<0.05$) to feed where the forage had not been grazed by cattle earlier in the summer. However, after a short period of occupation in the area (40-60 deer-days/ha) , mule deer no longer exhibited a significant preference ($P>0.05$) between cattle-grazed and ungrazed portions of the area.

Mule Deer and Cattle: Effects on Mule Deer Population Potential

Skovlin and Vavra (197 9) concluded elk could have a negative effect on mule deer populations on dual use winter ranges if there was substantial overlap of elk and deer diets and if elk populations were large enough to remove a critical amount of the highest quality forages (Skovlin and Vavra 1979). This situation would likely be true for mule deer and cattle interactions. If fall cattle grazing on mule deer winter range decreased the availability of critical, high quality deer forage species then, under stressful winter conditions mule might not be able to meet their maintenance requirements.

MULE DEER AND SHEEP

Stuth and Winward (1977) reported antelope bitterbrush was the most important component of sheep and mule deer summer diets in the lodgepole pine-antelope bitterbrush-western needlegrass plant community of southcentral Oregon. Dual use of individual antelope bitterbrush plants was approximately 50% between deer and sheep. Sheep tended to utilize antelope bitterbrush throughout the summer while mule deer diets did not shift to antelope bitterbrush until mid to late summer. Consequently, sheep indirectly competed with deer for the current year's growth of antelope bitterbrush during early summer and directly competed with deer during late summer.

BIGHORN AND CATTLE

Hudson et al. (1976) evaluated the effect summer cattle grazing had on bighorn distribution on their study area in southeastern British Columbia. There was no significant evidence of competition resulting from summer cattle grazing within bighorn habitat. Kasworm, et al. (1984) found a positive but nonsignificant correlation between bighorn winter diets and cattle summer diets on bighorn winter range in western Montana. Cattle summer diets contained 84% graminoids, 12% forbs, and 4% browse. The winter diets of bighorn sheep consisted of 65% graminoids, 12% forbs, and 23% browse. Competition between cattle and bighorn sheep was not directly discussed. McCollough (1982) reported fecal analysis of samples from cattle and Rocky Mountain bighorn sheep in southcentral Colorado indicated the summer diets of cattle and the winter diets of bighorn sheep overlapped by 73%. Although some definite differences in habitat use were exhibited between cattle and bighorn sheep, McCollough (1982) concluded the diet and habitat overlap between cattle and bighorn sheep was large enough to prevent the bighorn population from substantially increasing.

Literature dealing directly with bighorn sheep and cattle range relationships is apparently quite limited. However, given the dominance of graminoids in bighorn fall and winter diets (Honess and Frost 1942, Smith 1954, Moser 1962, Oldemeyer et al. 1971, Constan 1972, Dailey et al. 1984, Keating et al. 1985) and in cattle summer and fall diets (Mackie 1970, Skovlin 1976, Hanley and Hanley 1982, Holechek et al. 1982a, 1982b) , -the potential for competition on bighorn winter range exists. However, due to differences in habitat selection between bighorn sheep and cattle during the spring, summer, and fall, it is unlikely that these two ungulates would directly compete for forage.

BIGHORN AND SHEEP

Most of the available literature concerning the interactions of bighorn and domestic sheep deals with the potential for disease transmission between the two ungulates. At time of this writing, I was unable to locate any literature reporting the results of a well-designed study dealing with bighorn and sheep range relations. The negative effects of disease transmission between bighorns and domestic sheep probably overshadows any potential negative effects resulting from forage competition between the two species.

PRONGHORN AND CATTLE

Yoakum (1975) explained competition between livestock and pronghorn was usually minimal on good condition rangeland. However, competition increased with deteriorating range condition. Decreases in the relative frequency of graminoids and increases in frequencies forbs and shrubs can result in a shift in livestock diets to forbs and browse which are the principal forages of pronghorn.

In southeastern Oregon, McInnis and Vavra (1987) reported the dietary overlap between pronghorn and cattle peaked during the spring (25%) and was least during the winter (8%). They suggested there was a "wide buffer between noncompetitive coexistence and exploitative competition". Dietary overlap alone does not constitute competition (Cowell and Futuyma 1971). Spatial, temporal, and climatic influences on habitat utilization and forage species availability must be considered when evaluating competitive relations (McInnis and Vavra 1987).

Stephenson et al. (1985) observed there was a great deal of seasonal and yearly variability in competition potential between cattle and pronghorn. In north central New Mexico, competition between cattle and pronghorn was apparently the highest during the spring. Conversely, in northeastern California and northwestern Nevada, Hanley and Hanley (1982) noted there was very little dietary overlap between cattle and pronghorn during the spring. Vavra and Sneva (1978) found cattle-pronghorn diet overlap increased during drought. Stephenson et al. (1985) reported, in New Mexico, droughty springs tended to intensify the competition between livestock (cattle and sheep) and pronghorn because forage availability was reduced at a time when the nutritional demands of lactation were the highest for all 3 herbivores.

Johnson (1979) observed summer cattle diets and summer and winter pronghorn diets on the cold desert shrub community of Idaho overlapped by 24% and 15%, respectively. Common winterfat was the forage species with the highest cattle-pronghorn overlap. In the Red Desert of Wyoming, Olson and Hansen (1977) found little evidence of competition between cattle and pronghorn. The annual cattle-pronghorn dietary overlap was only 8%. Beale and Scotter (1968) suggested cattle and pronghorn competition in western Utah was unlikely since cattle and pronghorn did not use the same range until winter when their diets were distinctly different.

PRONGHORN AND SHEEP

Severson et al. (1968) reported pronghorn and sheep "appeared to be compatible" and evidence of competition between the two ungulates was not apparent on their study in the Red Desert of Wyoming. Hanley and Hanley (1982) noted although pronghorn and sheep consumed similar amounts of forbs during the summer, the potential for dietary competition between the two ungulates was apparently relatively low in northeastern California and northwestern Nevada. In the cold desert shrub habitats of Idaho, Johnson (1979) observed sheep summer diets and winter and summer pronghorn diets overlapped by 33% and 14%, respectively. Common winterfat was the only species exhibiting a potential for sheep-pronghorn competition.

On the Desert Experimental Range, Clary and Beale (1983) reported winter sheep grazing significantly ($P<0.05$) reduced winter pronghorn observations on grazed pastures as compared to pastures where sheep were excluded. They speculated competition between the two ungulates for black sagebrush browse was the most likely cause of decreased pronghorn occupation on sheep-grazed pastures. There was no evidence found indicating the sheep grazing treatment had a carry-over effect on pronghorn distribution during the next year. Sheep-induced changes in pronghorn use patterns were limited to the current year. In Utah, Beale and Scotter (1968) suggested sheep would compete directly with pronghorn for black sagebrush browse if both ungulates were using the same range during winter.

IMPACTS OF LIVESTOCK ON BIG GAME FORAGE AND COVER SPECIES

FORAGE

Section Abstract

Forage species in forested areas appear to be more sensitive to the use of different livestock grazing systems and stocking rates. Forage production by species in forested areas tends to be higher under deferred-rotation grazing systems than under season-long grazing systems. The species diversity of forest graminoids increases under light stocking rates but decreases under moderate and heavy stocking rates. Long-term livestock grazing can shift the species composition of a rangeland towards those species that are less palatable to livestock and more grazing and trampling tolerant.

Northeastern Oregon

As part of the results of an 11 year study, Skovlin et al. (1976) reported the graminoids on grassland range in northeastern Oregon generally increased in production under light (4 ha/AUM), moderate (3 ha/AUM), and heavy (2 ha/AUM) stocking rates. However, the changes in grass production were not statistically significant ($P>0.05$) for any of the stocking rate treatments. Forbs on grassland range generally increased under heavy stocking. Forbs of low palatability such as low gumweed and rush pussytoes decreased under light cattle stocking but increased under heavy stocking. Palatable forbs such as balsamroot and biscuitroot declined under heavy stocking.

On forested range dominated by a ponderosa pine overstory, differences in cattle stocking rates resulted in highly significant (P<O. 01) differences in graminoid production. Herbage production of elk sedge significantly declined by 1/6, 1/3, and 1/2 under light, moderate, and heavy stocking rates, respectively. Significant

(P<0.05) changes also occurred in the species composition on forested range under different stocking rates. The number of graminoid species increased by 10% under light stocking but decreased by 20% and 30% under moderate and heavy stocking, respectively. The response of forest forbs to stocking rate was variable and forest shrubs did not exhibit any definite responses to changes in stocking rate (Skovlin et al. 1976).

On grassland ranges, neither the individual species or the forage groups responded significantly to the differences in grazing management between the season-long system and the deferred rotation system. On forested ranges, the production of graminoids decreased significantly (P<0.05) under the season-long system as compared to the deferred rotation system. Elk sedge production was much less (P<0.05) under the season-long system. The more pronounced response to changes in grazing systems and stocking levels observed in the forest understory species as compared to the species in the grassland openings was apparently due to the natural forest crown closure that placed added stress on the understory species (Skovlin et al. 1976).

Although limitations in experimental design prohibited statistical comparisons between dual-use ranges (cattle and big game) and big game-only ranges, Skovlin et al. (1976) reported on grasslands the production of some of the grass species appeared to increase at a higher rate on dual-use ranges under light and moderate cattle stocking than on big game-only ranges.

Southcentral Washington

Rickard et al. (1975) reported spring cattle grazing within sagebrush-bunchgrass communities in southcentral Washington resulted in a pronounced reduction in the vigor of Cusick bluegrass, while bearded bluebunch wheatgrass and Sandberg bluegrass were not acutely affected by spring grazing. However, several studies (Stoddart 1946, Blaisdel and Pechanec 1949, Wilson et. al. 1966, Mueggler 1972) have found spring defoliation of bearded bluebunch wheatgrass can be detrimental and may have longterm effects (Mueggler 1975) on plant vigor.

Other Areas of the West

In the Elkhorn Mountains of Montana, Stevens (1966) noted forage utilization by cattle and elk was not heavy on most of his study area, however, certain areas did receive concentrated use by both species. He suggested long-term, heavy use in these areas by cattle increased the forb content in the available forage. Elk were then attracted to these areas because of the higher forb availability. An explanation of why the cattle were attracted to these areas was not given.

Bowns and Bagley (1986) compared a high-elevation sheep summer range in southwestern Utah to an adjacent reference area that had been only lightly grazed by cattle and horses and was in near potential. condition. Grasses dominated the sheep summer range with a limited number of unpalatable forbs species also occurring. In the adjacent reference area 88% of the plant species were forbs and only 4% were grasses. The species diversity was much higher on the reference area which contained 33 plant species while the sheep range contained only 18 plant species. Herbage production on the reference area was 190% greater ($P<0.05$) than on the sheep range. The production of desirable forage species in the reference area exceeded total plant production on the sheep summer range.

Studying vegetative differences inside and outside of big game/cattle and cattle exclosures in northwestern Wyoming, Jones (1965) categorized the grazing responses of 18 principal forage species: 1) Prairie junegrass and Hoods phlox appeared to be decreasers on cattle range and elk range; 2) Idaho fescue and Richardson geranium appeared to be decreasers on cattle range but remained static on elk range; 3) tapertip hawksbeard was a significant ($P<0.05$) decreaser on elk range but was unchanged on cattle range; 4) gray rabbitbrush was a significant decreaser ($P<0.05$) and American vetch appeared to be a decreaser on elk range but these 2 species were not evaluated on cattle range; 5) rose pussytoes increased significantly ($P<0.05$) and needleandthread grass, baldhead sandwort, and fleabane appeared to be increasers under elk grazing but all 4 species maintained their status on cattle range; 6) notably, only needleleaf sedge appeared to increase under cattle grazing while remaining static on elk range; and 7) fringed sagebrush appeared to be a decreaser on elk range but increased under cattle grazing (Jones 1965). These data were reported as a technical note publication and were based on a limited sample size. Consequently, caution should be taken when applying these results to land management situations.

COVER

In his review of the impacts of riparian grazing, Skovlin (1984) found livestock and wildlife browsing can seriously impact riparian trees and shrubs (McKell et al. 1972, Glinski 1977) but, has less impact than on upland shrubs (Young and Payne 1948, Garrison 1953, Willard and McKell 1978). Heavy use can prevent successful regeneration in browse species (Glinski 1977, Behnke 1978, Crouch 1978). However, Vogler (1978) found light grazing can actually enhance the vigor of many riparian shrubs. Earlier studies report similar findings for light grazing influences on a variety of riparian species (Aldous 1952, Ellison 1960, Jamison 1964).

Working in the Sierra Nevada Mountains of California, Loft et al. (1987) found mule deer hiding cover was significantly reduced by moderate and heavy cattle grazing treatments. Quaking aspen hiding cover of less than 1 m in height was significantly ($P<0.01$)

impacted by cattle early in the grazing season while the quaking aspen was still actively growing. The rate at which quaking aspen hiding cover declined tended to slow down during the late season. Heavy cattle grazing caused a significant ($P<0.05$) decrease in willow hiding cover of greater than or equal to 1.5 m in height as compared with the willow cover in the moderately grazed and ungrazed pastures. Cattle grazing prior to mid summer at stocking rates of less than or equal to 0.7 AUM/ha had scarcely more impact on hiding cover than did natural weathering. Stocking rates of greater than 1.3 AUM/ha resulted in a greater than 50% reduction in available hiding cover for the cover species studied. Under moderate and heavy cattle stocking, deer browsing on willow was significantly ($P<0.05$) higher than in pastures which were not grazed by cattle (Loft et al. 1987). It should be noted this study was conducted under a pseudoreplicated design and caution should be taken when interpreting these results.

IMPACTS OF BIG GAME ON VEGETATION

Northeastern Oregon

Pickford and Reid (1943) concluded, due to the high degree of dietary overlap between sheep and elk on a degraded northeastern Oregon rangeland and the increasing elk population in the area at that time, even exclusion of sheep grazing would not allow the range to recover from its degraded state unless elk use was curtailed.

Edgerton (1987) reported, after 11 years of big game exclusion, plots within a clearcut grand fir community in northeast Oregon exhibited a 400% increase in shrub cover while the shrub cover remained relatively static in adjacent, unprotected areas which had been subjected to big game use only. Within these same protected plots grass cover did not change significantly but outside the exclosure grass cover increased by 400%.

Based on studies by Korfhage et al. (1980), Edgerton (1987), and ongoing experiments (Irwin et al. 1994), Irwin et al. (1994) suggested selective grazing by wild ungulates, especially elk, has altered the plant composition of the Blue Mountains of Oregon away from shrub dominance. The observed declines in calf production in the Blue Mountains could be a negative feedback response to big game-induced declines in the quality of summer range (Irwin et al. 1994).

Bob Marshall Wilderness Area, Montana

In the Bob Marshall Wilderness Area of Montana, Gaffney (1941) described the impact elk had on certain winter range grass and, browse species. Trampling and heavy grazing of new spring grass growth by elk was quite detrimental to stands of certain grass species. Previously vigorous stands of rough fescue were described as having been grazed to "almost complete destruction" by elk. Damage to stands of Idaho fescue and bearded bluebunch wheatgrass by grazing elk was also reported.

Elk use on willows varied greatly from area to area. Willows on some portions of the winter range received almost no use while willows in other areas suffered 75% mortality due to heavy browsing. In some cases, high willow mortality may have been caused by a combination of winter and summer browsing by elk. However, as evidenced by willow growth inside and outside of elk exclosures, once browsing was excluded willows tended to regain vigor rapidly (Gaffney 1941).

Juvenile quaking aspen in some portions of the study area suffered 50% mortality due to overbrowsing by elk. Mature quaking aspen on these sites had been browsed by elk up to 2.5-3.0 m in height. In one area, quaking aspen trees up to 18 cm in diameter were girdled and killed by elk feeding on the bark. An estimated 90% of the quaking aspen near the girdled, dead trees were damaged by bark chewing. Unlike willows, quaking aspen tended to be slower in regaining vigor once browsing was excluded (Gaffney 1941).

Black cottonwood was less widely distributed on the study area than willows or quaking aspen. However, almost all the available juvenile black cottonwoods in the area under 2 meters in height were damaged by elk browsing. Most of the damaged juvenile black cottonwoods were deformed, taking on a hedged appearance, rather than being killed. The lower limbs of mature black cottonwoods that were within reach of elk were heavily browsed but, due to their height and thick bark, mature black cottonwoods were not severely damaged by elk. However, any mature black cottonwood that was felled by beaver was rapidly stripped of palatable browse (Gaffney 1941).

Rocky Mountain maple, western chokecherry, and serviceberry were common throughout the study area before overbrowsing of certain portions of the winter range took its toll. All 3 species were highly palatable and received similar amounts of heavy browsing. In this area of Montana, these 3 species rarely grow to a height that would put their terminal leaders out of reach of browsing elk. Consequently, these species were browsed by elk until their hedged structure prevented access to live stems, browse production was minimized, or the plants were killed (Gaffney 1941).

The level of browsing use on ponderosa pine, Douglas fir, and lodgepole pine on the study area was similar, indicating a similar degree of preference. However, because lodgepole pine was often present in large, young stands and because the lower branches of mature lodgepole were often low enough to be available to elk, lodgepole pine provided the largest amount of elk browse of the 3 conifer species. Heavy elk use limited or severely damaged conifer reproduction in some portions of the study area (Gaffney 1941).

Yellowstone National Park

In Yellowstone National Park, prior to 1968, much of the vegetation on the northern winter range had been seriously damaged by an excessively large elk population which had formed in the late 1800s and early 1900s after elk hunting had been banned in the park. Recognizing the problem, National Park Service personnel, between 1910 and 1967, periodically harvested or live-trapped and translocated elk in an effort- to reduce the number of elk in the park. However, by 1968, public outcry concerning the "slaughter of Yellowstone elk" forced the Nation Park Service to re-evaluate their elk population control policy. Eventually, the concept of "natural regulation" of elk within Yellowstone Nation Park was adapted by the National Park Service (Kay 1990).

The principle hypothesis behind the natural regulation concept was that "vegetation-ungulate equilibria appropriate to the park" could be reached without using human harvest to control ungulate numbers within the park (Houston 1982:2). Specific hypotheses about the natural regulation concept within the northern range of the park suggested: 1) where an ungulate population is "resource-limited", intraspecific competition will function in a density-dependent manner to limit the population size (Houston 1982:67) ; 2) the northern range of the park functions as an ecologically complete habitat; 3) large numbers of elk have wintered on the northern range of the park for 8 to 10,000 years; 4) Co-evolution has occurred between the large numbers of elk, the vegetation, and the other ungulates on the northern range and these three factors have been operating in equilibrium for thousands of years; and 5) any changes in the species composition of the vegetation on the northern range that have occurred since Yellowstone Nation Park was established (1872) are the result of fire suppression or climatic change and are not the result of grazing by large numbers of ungulates (Houston 1972, Kay 1990)

After critical examination and testing of the natural regulation concept for the northern Yellowstone elk herd (see Kay 1990) and.a review of the literature dealing with ungulate impacts on vegetation in other areas of the West, Kay (1994) concluded: 1) riparian shrub and tree species can be extirpated by concentrations of native ungulates; 2) native ungulates alter the structure of woody riparian vegetation; 3) heavy use by native ungulates can alter the species composition of riparian communities; and 4) native ungulates can have severe negative effects on riparian vegetation in both, winter and summer ranges.

Rocky Mountain National Park

In 1968, as part of the natural regulation policy of the National Park Service, human control of the number of elk within Rocky Mountain National Park was eliminated and the elk population was allowed to increase toward ecological carrying capacity (Stevens 1980). Stevens (1980) reported how the vegetation of the park was affected by the increasing elk population. Three upland habitat types on the low elevation winter range were examined. Within the bitterbrush/mountain muhly type, the cover of the dominate plant species remained relatively stable under the influence of the growing elk population. Sagebrush cover in the sagebrush habitat type significantly ($P<0.05$) decreased with increasing elk numbers. Elk use affected the grassland habitat type less than the other two low elevation upland habitat types. In general, the low elevation upland vegetation and the populations of elk and other native ungulates appeared to be approaching an equilibrium without untolerable range deterioration (Stevens 1980).

In the low elevation bottom or riparian areas, the willow habitat type, exhibited a fairly consistent but nonsignificant ($P>0.05$) decrease in willow cover following winter elk browsing. On optimal sites, willows appeared to be tolerant of elk browsing but willows on marginal sites were prevented from reproducing by even moderate levels of elk use. Browsing of willows on marginal sites by elk was suggested to increase the rate of succession on these sites towards a grass/sedge meadow (Stevens 1980).

Within the low elevation aspen habitat type, the density of aspen trees remained statistically stable despite the influences of the growing elk population. However, on sites where aspen were seral species elk browsing may have functioned to accelerate succession as in willow. On sites where aspen were stable or climax species elk browsing may have substantially altered the direction of succession (Stevens 1980).

No significant changes occurred within the habitat types of the alpine tundra winter range or the subalpine summer range. However, the willow habitat types in both the alpine tundra winter range and subalpine summer range appeared to be the most susceptible habitat types to losses in cover in response to increasing elk use (Stevens 1980).

IMPACTS OF BIG GAME ON PRIVATE PROPERTY

Vavra (1980) provided a table of the results of an Oregon Cattlemen's Association elk and deer damage survey conducted on the landowners within 21 Oregon counties. In four northeastern Oregon counties; Wallowa, Umatilla, Baker, and Union, the annual cost of elk and deer damage to livestock grazing lands was 421,998 and 217,993 dollars, respectively. He suggested an important big game damage cost to livestock owners occurred when spring big game use postponed the range readiness of spring livestock range delaying the turn-on date and increasing the hay feeding costs incurred by the livestock owner. Increased labor and material costs associated with big game damage to fences and physical structures was also important.

Big game damage to grain crops within the 4 Oregon counties mentioned above totaled 129,832 dollars annually. Hay crop damage totalled 146,832 dollars annually in those 4 counties (Vavra 1980).

Carpenter (1989) discussed the liability incurred by Colorado Division of Wildlife as a result of big game damage to hay crops and storage, seeded range, and seasonally deferred livestock forage in private lands. Calculation of big game damage to private property is a complex issue in which such factors as: big game species, current and historical population sizes, animal unit equivalencies, diet overlap, duration and season of overlap, and dollar value of the property damaged must be taken into account.

Using economic data. from 1983, Carter and Radtke (1986) compared the amount of revenue that could potentially have been generated in Baker County, Oregon by forage used in the production of cattle, elk, and deer. They reported each AUM of forage utilized by cattle could have produced $13.71 of local personal income. Each AUM of forage utilized by elk could have produced $7.11 to $10.67 of local personal income depending on the nutritional requirement assumption used. Each AUM of forage utilized by deer could have produced $7.36 to $12.22 of local personal income.

On a state-wide basis, each AUM of forage utilized by cattle in Baker County could have produced $17.52 of state-wide personal income in 1983. Each AUM of forage utilized by elk could have produced $29.46 to $44.20 of state-wide personal income. Each AUM consumed by deer in Baker County had the potential to produce $30.48 to $50.80 of state-wide personal income (Carter and Radtke 1986).

It appeared the production of cattle was more lucrative than the production of elk or deer for the Baker County economy and the reverse was apparently true for the state-wide economy. However, these results can easily be misinterpreted if certain factors are not considered. Those people who bore most of the costs of elk and deer production were not the same people who received most of the benefits of elk and deer production. Livestock operators and their supporting businesses in Baker County lost personal income due to big game damage while businesses throughout the state who provided goods and services to hunters received gains in income (Carter and Radtke 1986).

POTENTIAL FOR COMPLEMENTARY RELATIONSHIP BETWEEN LIVESTOCK AND BIG GAME

CONDITIONING OF LIVESTOCK FORAGE BY BIG GAME

Stoddart et al. (1975) suggested winter elk grazing potentially can prevent wolfiness in forage species by removal of standing litter thus providing better forage availability for summer livestock and big game use. Elk use of shrub species during the winter may regulate or limit the encroachment of these species into grasslands used by livestock during the summer (Nelson 1982).

CONDITIONING OF BIG GAME FORAGE AND COVER BY LIVESTOCK

Urness (1990) cites several sources which indicated that attempting to increase winter big-game forage by terminating summer livestock grazing was ineffective or actually reduced big game carrying capacity (U.S. Forest Service 1970, Salwasser 1976, Leckenby et al. 1982, Neal 1982).

Urness (1990) reviewed several studies conducted on the Hardware Ranch in northern Utah, which reported cattle (Smith and Doell 1968), horse (Reiner and Urness 1982), and sheep (Jensen et al. 1972) grazing reduced the herbaceous competition allowing decadent shrubs which were important big game browse species to regain vigor. Smith et al. (1979) and Fulgham, et al. (1982), also working on the Hardware Ranch found sheep grazing made herbaceous forage more available to wintering mule deer.

SPRING CONDITIONING

Anderson and Scherzinger (1975) discussed a case history of the livestock grazing management and winter elk population on the Bridge Creek Wildlife Management Area in northeastern Oregon. Prior to its establishment in 1961, the land making up the Bridge Creek Wildlife Management Area (BCWMA), was grazed by cattle without a definite management plan. Livestock grazing was eliminated when the BCWMA was established. The number of elk wintering on BCWMA initially increased from approximately 120 to 320 head following the elimination of livestock grazing. However, after 3 years, winter elk numbers began to decline. Anderson and Scherzinger (1975) suggested winter elk use declined because the availability of quality forage on the BCWMA began to steadily decrease just 2 years after the elimination of livestock grazing. Apparently, standing dead material began to accumulate in the ungrazed perennial bunchgrasses, hence, limiting the availability of palatable forage for wintering elk.

To help alleviate the forage availability problem and its effect on elk use, a rest-rotational cattle grazing system was instituted under which the pastures grazed early in the season during the boot to seed formation phenological stages for 2 consecutive years and then rested for 1 year. Under this grazing system winter elk numbers increased to 1,190 (Anderson and Scherzinger 1975). Anderson and Scherzinger (1975) speculated the large and rapid increase in wintering elk numbers was due not only to elk being attracted to the BCWMA because of the reduction of "wolf” plants as a result of cattle grazing but also because the forage quality of the bunchgrass plants was enhanced by late spring-early summer cattle grazing. Apparently, the winter range forage quality was increased if cattle were allowed to graze in the early season and then removed while there was still enough of the growing season left that the plants could regrow a substantial amount before temperature and soil moisture conditions forced the plants into dormancy, halting the translocation of plant carbohydrates from the vegetative portions to the roots.

Anderson and Scherzinger (1975) stressed 3 grazing management requirements were critical for successfully manipulating quality and availability of winter elk forage on bunchgrass-dominated winter ranges similar to the BCWMA. First, grazing of the bunchgrass plants must be closely monitored so defoliation of the plants occurs between the boot and seed formation stage of phenology. Second, climatic and soil moisture conditions must also be closely monitored so grazing is halted at a point when enough growing season remains the plants can put on sufficient regrowth to meet the forage quantity needs of wintering elk. Finally, treated pastures should be rested every third or fourth year to prevent substantial reductions in forage plant vigor.

On a bunchgrass-dominated elk winter range in southeastern Washington, Skovlin et al. (1983) used pellet group count methodology to evaluate winter elk use of plots grazed by cattle from mid April to early June. The spring cattle grazing treatment had no significant effect on winter elk use when averaged over the 3 winters of the study. However, elk use was significantly ($P<0.01$) less on the grazed plots as compared to the ungrazed plots during the second winter of the study.

In mixed shrub-forb communities in northern Utah, Smith et al (1979) reported early winter diets of mule deer feeding in pastures that had been grazed by sheep during the previous spring contained more grasses, forbs, and low-growing shrubs than the early winter diets of mule deer feeding in an adjacent pasture with similar species composition and density and where only deer had been allowed access. Smith et al. (1979) referred to the findings of McLean and Willms (1977) when speculating that the increased herbaceous composition of early winter mule deer diets in the sheep grazed pasture was the result of a grazing-induced reduction in standing dead herbaceous material which allowed mule deer better access to more palatable herbaceous material. Comparison of the nutritional quality of the early winter deer diets in the sheepdeer and deer-only pastures indicated crude protein was an average of 2% higher in the deer-only pasture while digestible energy and invitro digestibility were not significantly different between the pastures. Smith et al. (1979) suggested an important consequence of the increased use of herbaceous forage in the sheep-deer pasture was the availability of unbrowsed, current year's growth on palatable shrubs such as antelope bitterbrush which was extended later into the winter.

The late winter mule deer diet composition was similar between the sheep-deer and the deer-only pastures. However, the crude protein, digestible energy, and invitro digestibility of deer feeding in the sheep-deer pasture during late winter was somewhat higher than in the diets of deer feeding in the deer-only pasture. Smith et al. (1979) suggested the quality of the deer diets in the sheep-deer pasture were higher than in the deer-only pasture because deer in the sheep-deer pasture deferred use on the current year's growth of the more palatable, nutritious shrubs until late winter while deer in the deer only pasture consumed much of the available shrub current year's growth during early winter and were using less nutritious forage during late winter.

Smith et al. (1979) used tame deer which, admittedly, were not acclimated to the study area prior to data collection. Additionally, the experimental design of this study lacked replication of the treatment and control plots. Consequently, application of these reported results is limited and should be considered cautiously, especially, if these results are to be used as part of a knowledge base for making land management decisions.

SUMMER CONDITIONING

On the Hardware Ranch in northern Utah, Reiner and Urness (1982) reported summer horse grazing benefited the production of palatable browse on mule deer winter range. Under moderate and heavy stocking rates, horses consumed primarily grasses with some forbs showing up in the diet during the later portion of the grazing period under a heavy stocking treatment. Antelope bitterbrush was not browsed by horses even under heavy stocking. Antelope bitterbrush browse production increased significantly ($P<0.05$) under heavy horse stocking as compared to unstocked pastures.

Austin and Urness (1983) concluded green regrowth of crested wheatgrass produced following spring and summer cattle grazing provided a valuable forage source for wintering mule deer on a winter range in northern Utah.

Austin and Urness (1986) studied the influence summer cattle grazing had on tame mule diet and habitat selection in the Sheeprock Mountains of Utah. Late summer mule deer diets contained significantly more ($P<0.05$) forbs in enclosures where cattle had not grazed. Succulent grasses and browse dominated the late summer diets of mule deer in the cattle-grazed enclosures. Crude protein appeared to be consistently higher in the diets of mule deer foraging in the cattle-grazed enclosures. Invitro dry matter digestibility was similar in the diets of deer in the ungrazed and grazed enclosures.

In the Elkhorn Mountains of Montana, Dragt and Havstad (1987) reported summer cattle grazing under a deferred- rotation grazing management system was not detrimental to the quality of winter elk forage. Neither bearded bluebunch wheatgrass or rough fescue exhibited a significant ($P<0.05$) winter forage quality response relative to the phenological stage in which it was grazed during the summer. Although the overall winter forage quality of Idaho fescue was not *significantly altered* by summer cattle grazing, there were significant ($P<0.05$) decreases in neutral, detergent fiber (NDF) and acid detergent fiber (ADF) percentages in plants that were grazed during the seed shatter stage as compared to plants that were grazed during the boot and vegetative stage of phenology. It was concluded the quantity rather than the quality of winter elk forage was more critically related to summer cattle grazing management.

Riggs et al. (1990) investigated the responses of wintering mule deer to goat browsing treatments of Gambel oak-dominated communities in northern Utah. Intensive goat browsing during the summer reduced the availability of gambel oak and other deciduous browse while increasing the herbage production in the understory. In situations where snow prevented use of understory species, mule deer in goat-browsed pastures consumed significantly more Wyoming big sagebrush and green rabbitbrush and less Gambel oak and antelope bitterbrush -than mule deer in control pastures. In the absence of snow, mule deer diets in the treatment and control pastures did not differ significantly. Mule diets in both the treatment and control plots contained substantial amounts of herbaceous species.

During the spring, Grover and Thompson (1986) reported elk in the Elkhorn Mountains of Montana preferred to feed in areas previously grazed by cattle. These findings appear to support Willms and McLean (1978) who suggested cattle grazing removed the less palatable old growth from spring forage plants making the succulent new growth more available to wild ungulates. Grover and Thompson (1986) stressed manipulation of cattle grazing to improve the quality of spring elk forage should take into account the effect this manipulation would have on the forage supply of wintering elk.

FALL CONDITIONING

Jourdonnais and Bedunah (1990) used fall cattle grazing to enhance the quality and availability of winter elk forage on a rough fescue dominated winter range in the Sun River Wildlife Management Area, Montana. Winter elk use on rough fescue and Idaho fescue in the cattle grazed plots was higher ($P<0.10$) than on ungrazed plots.

Laycock (1967) studied the differences in sagebrush and vegetative response between spring and fall sheep grazing on the Upper Snake River Plains of Idaho. Spring grazing caused further degeneration on range already in poor condition. On range initially in good condition, spring grazing caused three-tip sagebrush cover to increase significantly ($P<0.01$) and the production of understory plants to decrease significantly ($P<0.01$) . Spring grazing also tended to increase the percentage of unpalatable and undesirable species in herbaceous species composition. On degraded range, fall grazing appeared to reduce the sagebrush cover and increase the total production of the remaining, desirable grasses and forbs. On good condition range, under 39 years of fall grazing, the range condition was maintained. Notably, total production of grasses and forbs increased significantly ($P<0.05$) under long-term fall grazing as compared to the production within an adjacent exclosure which contained range which was in good condition at the time the exclosure was built. He advocated fall grazing could be used to improve and maintain the condition of similar ranges for the benefit of livestock production. These results also may have application for improving the condition of degraded elk winter range.

Working in big sagebrush-bunchgrass, and Douglas fir-bunchgrass communities of southern British Columbia, Willms et al. (1981) reported during late winter and spring mule deer preferred ($P<O. 05$) bearded bluebunch wheatgrass plants which had been grazed by cattle during the previous fall over plants that were not grazed by cattle.

LITERATURE CITED

ALDOUS, S. E. 1952. Deer browse clipping study in the Lake States Region. J. Wildl. Manage. 16:401-409.

ALLEN, A. W., and M. J. ARMBRUSTER. 1982. Preliminary evaluation of habitat suitability model for the pronghorn. Proc. Biennial Pronghorn Antelope Workshop 19:93-105.

ANDERSON, E. W., and R. J. SCHERZINGER. 1975. Improving quality of winter forage for elk by cattle grazing. J. Range Manage. 28:120-125.

AUSTIN, D. D., and P. J. URNESS. 1983. Overwinter forage selection by mule deer on seeded big sagebrush-grass range. J. Wildl. Manage. 47:1203-1207.

_____ , and ____. 1985. Values of four communities for mule deer on ranges with limited summer habitat. J. Range Manage. 38:167-171.

_____ , and ____1986. Effects of cattle grazing on mule deer diet and area selection. J. Range Manage. 39:18-21.

BAKER, D. L., and N. T. HOBBS. 1982. Composition and quality of elk summer diets in Colorado. J. Wildl. Manage. 46:694-703.

_____ , and D. R. HANSEN. 1985. Comparative digestion of grass in mule deer and elk. J. Wildl. Manage. 49:77-79.

BAILEY, V. 1936. The mammals and life zones of Oregon. North American Fauna 55. Washington, D.C.: USDA. Bureau of Biol. Surv. 416 pp.

BARKER, E. S. 1948. Antelope comeback. Field and Stream 53:26-27, 1.21-123.

_____ .1958. The future of wildlife in northern Mexico -- a problem in conservation education. Trans. N. Am. Wildl. Conf. 23:567-575.

BEALE, D. M., and G. W. SCOTTER. 1968. Seasonal forage use by pronghorn antelope in western Utah. Utah Sci. 29 (1):

_____ , and A. D. SMITH. 1970. Forage use, water consumption, and productivity of pronghorn antelope in western Utah. J. Wildl. Manage. 34:570-582.

BEHNKE, R. J. 1979. Values and protection of riparia ecosystems. Pages 164-167 *in* The mitigation symposium. USDA For. Ser. Gen. Tech. Rep. RM-65. Rocky Mt. For. and Range Exp. Sta., Fort Collins, Colorado.

BENSON, W. A. 1956. A general view of the antelope in Saskatchewan. Federal -Provincial Wildl. Conf., Ottawa 20:23-34.

BINFORD, L. R. 1978. Nunamiut ethnoarchaeology. Academic Press, New York, New York. 320 pp.

BIRCH, L. C. 1957. The meaning of competition. Am. Nat. 91:5-18.

BLAISDELL, J. P., and J. F. PECHANEC. 1949. Effects of herbage removal at various dates on vigor of bluebunch wheatgrass and arrowleaf balsamroot. Ecology 30:298-305.

BLOOD, D. A. 1963. Some aspects of behavior of a bighorn herd. Can. Field-Natur. 77:77-94.

_____.1966. Range relationships of elk and cattle in Riding Mountain National Park, Manitoba. Canadian Wildl. Serv. Wildl. Manage. Bull. Series 1, No. 19. 62 pp.

_____ .1967. Food habits of the Ashnola bighorn sheep herd. Can. Field Nat. 81:23-29.

BOWNS, J. E., and C. F. BAGLEY. 1986. Vegetation responses to long-term. sheep grazing on mountain ranges. J. Range Manage. 39:431-434.

BOYD, R. J. 1970. Elk of the White River Plateau, Colorado. Colo. Div. Game, Fish, and Parks., Tech. Bull. No. 25. 126 pp.

BROWN, C. L. 1977. An examination and evaluation of the archaeological occurrence of the American pronghorn antelope in the Columbia Plateau. M.S. Thesis. Washington State Univ. Pullman. 23 pp.

BRYANT, L. D. 1982. Response of livestock to riparian zone exclusion. J. Range Manage. 35:780-785.

_____ , and C. MASER. 1982. Classification and distribution. Pages 1-59 in J. W. Thomas and Dale E. Toweill (eds.) Elk of North America: ecology and management. Stackpole Books. Harrisburg, Pennsylvania. 697 pp.

BUECHNER, H. K. 1960a. Regulation of numbers of pronghorn antelope in relation to land use. Trans. Internl. Antelope Conf. 11:105-129.

_____ . 1960b. The bighorn sheep in the United States, its past, present, and future. Wildl. Monog. No. 4. Wildl. Soc. 174 pp

BURT, T. Jr., and G. H. GATES. 1959. Pecos elk reproductive and food habits studies. New Mex. Dept. Game and Fish. Fed. Aid Compl. Rep. Proj. W-93-R-1, Wp-3, J-6. 19 pp.

CARPENTER, L. H. 1989. Colorado's liability for big game damage to livestock forage. Pages 96-100 in A. J. Bjugstad, D. W. Uresk, and R. H. Hamre, tech. coords. 9th Great Plains Wildl. Damage Control Workshop Proc. USDA For. Serv. Gen. Tech. Rep. RM-171. Rocky Mt. For. and Range. Exp. Sta. Fort Collins, Colorado.

CARTER, C. N., and H. D. RADTKE. 1986. An economic comparison of the income aspects of livestock ranching and big game hunting. Oregon Dept. Fish and Wildl. Staff Rep. On file: Oregon Dept. Fish and Wildl. Headquarters. Portland, Oregon. 23 pp.

CASGRANDA, L., and R. G. JANSON. 1957. Wildlife investigations (Dist. 4): big game surveys and investigations. Montana Dept. of Fish and Game. Fed. Aid Compl. Rep. Proj. W-74-R-2, J-Al, Pt. 3. 19 pp.

CHAPMAN. J. A., and G. A. FELDHAMMER. 1982. Wild mammals of North America: biology, management and economics. John Hopkins Univ. Press. Baltimore, Maryland. 1,147 pp.

CLARY, W. P., and F. R. LARSON. 1971. Elk and deer use are related to food sources in Arizona ponderosa pine. USDA For. Serv. Res. Note RM-202. Rocky Mt. For. and Range Exp. Sta. Fort Collins, Colorado. 4 pp.

_____ , P. F. FFOLLIOTT, and F. R. LARSON. 1978. Factors affecting forage consumption by cattle in Arizona ponderosa pine forests. J. Range Manage. 31:9-10.

____, and D. M. BEALE. 1983. Pronghorn reactions to winter sheep grazing, plant communities, and topography in the Great Basin. J. Range Manage. 36:749-752.

COLE, G. F. 1958. Big game-livestock competition on Montana's mountain rangelands. Mont. Wildl. 1958:24-30.

COLLINS, W. B., P. J. URNESS, and D. D. AUSTIN. 1978. Elk diets and activities on different lodgepole pine habitat segments. J. Wildl. Manage. 42:799-810.

_____ , and ____1983. Feeding behavior and habitat selection of mule deer and elk on northern Utah summer range. J. Wildl. Manage. 47:646-663.

CONSTAN, K. J. 1967. Bighorn sheep range use, food habits and relationships to mule deer and elk in Gallatin Canyon. M.S. Thesis. Montane State Univ., Bozeman. 43 pp.

_____ . 1972. Winter foods and range use of three species of ungulates. J. Wildl. Manage. 36:1068-1076.

COOK, C. W. 1966. Factors affecting utilization of mountain slopes by cattle. J. Range Manage. 19:200-204.

COOK, J. G., and L. L. IRWIN. 1985. Validation and modification of a habitat suitability model for pronghorns. Wildl. Soc. Bull. 13:440-448.

COOPERRIDER, A. Y. 1969. The biology and management of the bighorn sheep of Rock Creek, Montana. Montan Fish and Game Dept., Fed. Aid Rep. W-98-R-8,9. 92 pp.

COUCH, L. K. 1953. Chronological data on elk introductions in Oregon and Washington. Murrelet 16:3-6.

COUES, E. 1893. History of the expedition under the command of Lewis and Clark. Vol. I. Francis P. Harper. New York, New York. 820 pp.

COWAN, I. McT. 1940. Distribution and variation in the native sheep of North America. Amer. Midl. Nat. 24:505-580.

_____ . 1947. Range competition between mule deer, bighorn sheep, and elk in Jasper Park, Alberta. Trans. N. Amer. Wildl. Conf. 12:223-227.

CROUCH, G. L. 1978. Effects of protection from livestock grazing on a bottomland wildlife habitat in northeastern Colorado. Pages 118-125 in Lowland river and stream habitat: a symposium. Colo. Chap. Wildl. Soc. and Colo. Audubon Counc., Greenly.

DAILEY, T. V., N. T. HOBBS, and T. N. WOODARD. 1984. Experimental comparisons of diet selection by mountain goats and mountain sheep in Colorado. J. Wildl. Manage. 48:799-806.

De NIO. R. M. 1938. Elk and deer foods and feeding habits. Trans. N. Am., Wildl. Conf. 3:421-427.

DENNISTON, R. H. 1956. Ecology, behavior, and population dynamics of the Wyoming or Rocky Mountain moose, *Alces alces shirasi*. Zoologica 41:105-118

DIETZ, D. R., and J. G. NAGY. 1976. Mule deer nutrition and plant utilization. Pages 71-78 *in* J. B. Low (ed.) Mule deer decline in the West. Utah State Univ. Agric. Exp. Sta. Logan.

DOUGLAS, D. 1829. Observations on two undescribed species of North American Mammalia. Zool. J. 4:330-332.

DRAGT, W. J., and K. M. HAVSTAD. 1987. Effects of cattle grazing upon chemical constituents within important forages for elk. Northwest Sci. 61:70-73.

EDGERTON, P. J., and J. G. Smith. 1971. Seasonal forage use by deer and elk on the Starkey Experimental Forest and Range, Oregon. USDA For. Ser. Res. Pap. PNW.-112. Pac. Northwest For. and Range Exp. Sta. Portland, Oregon. 12 pp.

_____ . 1987. Influence of ungulates on the development of the shrub understory of an upper slope mixed conifer forest. Pages 162-167 *in* F. D. Provenza, J. T. Flinders, and E. D. McArthur (comp.) Proc. of sympo. on plant-herbivore interactions. USDA For. Ser. Gen. Tech. Rep. INT-222. Intermt. For. and Range Exp. Sta. Ogden, Utah.

EDWARDS, D. 1992. Draft elk management plan. Oregon Dept. of Fish and Wildlife. Portland, Oregon. 79 pp.

ELLIOTT, D. G. 1909. The Peter Skene Ogden journals. Oregon Historical Quarterly. 10:331-365. Oregon Historical Soc.

ELLISON, L. 1960. Influence of grazing on plant succession on rangelands. Bot. Rev. 26:1-78.

ERICKSON, G. L. 1972. The ecology of Rocky Mountain bighorn sheep in the Sun River area of Montana with special reference to summer food habits and range movements. Montana Fish and Game Dept. P-R Proj. Rep. W-120-R-2. 50 pp.

EUSTACE, C. D. 1967. Food habits, range use and relationships between elk and livestock in the Gravelly Mountains, Montana. M.S. Thesis. Montana State Univ. Bozeman. 55 pp.

FORSYTH, E. S. 1942. Our stocking experience in the Province of Saskatchewan. Trans. N. Am. Wildl. Conf. 7:152-161.

FRISINA, M. R. 1974. Ecology of bighorn sheep in the Sun River area of Montana during fall and spring. Montana Fish and Game Dept. P-R Proj. Rep. W-120-R-4. 68 pp.

FULGHAM, K. 0., M. A. SMITH, AND J. C. MALECHEK. 1982. A compatible grazing relationship can exist between domestic sheep and mule deer. Pages 468-478 in J. M. Peek and P. D. Dalke (eds.) Wildlife-livestock relationships symposium, Proceedings 10. Univ. of Idaho, For., Wildl., and Range Exp. Sta. Moscow.

GAFFNEY, W. S. 1941. The effects of winter elk browsing, South Fork of the Flathead River, Montana. J. Wildl. Manage. 5:427-453.

GALM, J. R., and R. A. MASTEN. (eds). 1985. Avey's Orchard: archaeological investigation of a late prehistoric Columbia River community. Eastern Washington Univ. Reports in Archaeology and History 100-42. 522 pp.

GANSKOPP, D., and M. VAVRA. 1987. Slope use by cattle, feral horses, deer, and bighorn sheep. Northwest Sci. 61:74-81.

GARRISON, G. A. 1953. Effects of clipping on some range shrubs. J. Range Manage. 6:309-317.

_____ , J. M. SKOVLIN, C. E. POULTON, and A. H. WINWARD. 1976. Northwest plant names and symbols for ecosystem inventory analysis. 4th ed. USDA For. Serv. Gen. Tech. Rep. PNW-46. Pac. Northwest For. and Range Exp. Sta. Portland, Oregon. 263 pp.

GEIST, V. 1971. Bighorn sheep, a study in behavior and evolution. Univ. Chicago Press. Chicago, Illinois. 383 pp.

GILLEN, R. L., W. C. KRUEGER, and R. F. MILLER. 1984. Cattle distribution on mountain rangeland in northeastern Oregon. J. Range Manage. 37:549-553.

_____ , and ____.1985. Cattle use of riparian meadows in the Blue Mountains of northeastern Oregon. J. Range Manage.38:205-209.

GLINSKI, R. L. 1977. Regeneration and distribution of sycamore and cottonwood trees along Sonoita Creek, Santa Cruz County, Arizona. Pages 116-123 *in* Importance, preservation, and management of riparian habitat: a symposium. USDA For. Ser. Gen. Tech. Rep. RM-43. Rocky Mt. For. and Range Exp. Sta., Fort Collins, Colorado.

GORDON, F. A. 1968. Range relationships of elk and cattle on elk winter range, Crow Creek, Montana. M.S. Thesis. Montana State Univ. Bozeman. 52 pp.

GREER, K. R. 1959. Analysis of 68 samples from the 1956. Gallatin Canyon elk "hunter kill". Pages 5-6 in Wildlife Investigations--State: Wildlife Investigations Laboratory. Montana Dept. Fish and Game. Fed. Aid Compl. Rep. Proj. W83-R2. All Jobs.

_____ . 1960. Analysis of twenty-one elk rumens collected from the 1956 hunter-kill at Boyd Ranch, Missoula County. Wildlife Investigations--State: Wildlife Investigations Laboratory. Montana Dept. Fish and Game. Fed. Aid Compl. Rep. Proj. W83-R-3. All Jobs. 14 pp.

_____ , J. B. KIRSCH, and H. W. YEAGHER. 1970. Seasonal food habits of the northern Yellowstone elk (Wapiti) herds during 1957 and 1962-1967 as determined from 793 rumen samples. Montana Dept. Fish and Game. Fed. Aid Final Rep. Proj. W-83R-12, J-B-1. 76 pp.

GRINNELL, G. B. 1928. Mountain sheep. J. Mammal. 9:1-9.

GROVER, K. E., and M. J. THOMPSON. 1986. Factors influencing spring feeding site selection by elk in the Elkhorn Mountains, Montana. J. Wildl. Manage. 50:466-470.

HAMLIN, K. L., and R. J. MACKIE. 1989. Mule deer in the Missouri River Breaks, Montana: a study of population dynamics in a fluctuating environment. Montana Dept. Fish, Wildl. and Parks Final Rep. Res. Proj. W-120-R-7-18. 401 pp.

HANLEY, T. A., and K. A. HANLEY. 1982. Food resource partitioning by sympatric ungulates on Great Basin rangeland. J. Range Manage. 35:152-158.

HANSEN, R. M., and L. D. REID. 1975. Diet overlap of deer, elk, and cattle in southern Colorado. J. Range Manage. 28:43-47.

HART, R. H., K. W. HEPWORTH, M. A. SMITH, and J. W. WAGGONER Jr. 1991. Cattle grazing behavior on a foothill elk winter range in southeastern Wyoming. J. Range Manage. 44:262-265.

HITCHCOCK, C. L., and A. CRONQUIST. 1973. Flora of the Pacific Northwest. Univ. Washington Press. London. 730 pp.

HOLECHEK, J. L., M. VAVRA, J. SKOVLIN, and W. C. KRUEGER. 1982a. Cattle diets in the Blue Mountains of Oregon, I. Grasslands. J. Range Manage. 35:109-112.

_____ , _____ ,_____ , and ____1982b. Cattle diets in the Blue mountains of Oregon II. Forests. J. Range Manage. 35:239-242.

HONESS, R. F., and N. M. FROST. 1942. A Wyoming bighorn sheep study. Wyoming Game and Fish Dept. Bull. No. 1. 126 pp.

HOUSTON, D. B. 1982. The northern Yellowstone elk: ecology and management. MacMillan Publishing Co., Inc. New York, New York. 474 pp.

HUDSON, R. J., D. M. HEBERT, and V. C. BRINK. 1976. occupational patterns of wildlife on a major East Kootenay winter-spring range. J. Range. Manage 29:38-43.

HUMBIRD, J. 1975. Modern day elk more plentiful. Idaho Wildl. Rev. (Jan./Feb.):16-17.

IRVINE, C. A. 1969. The desert bighorn of southeastern Utah. Utah State Div. of Fish and Game Publ. No. 69-12. 99 pp.

IRVING, W. 1885. The adventures of Captain -Bonneville, USA, in the Rocky Mountains and the Far West; digested from his journals, and illustrated from various other sources. New York. G.P. Putman Co. 503 pp.

IRWIN, L. L., and J. M. PEEK. 1983. Elk habitat use relative to forest succession in Idaho. J. Wildl. Manage. 47:664-672.

J.G. COOK, R.A. RIGGS, and J. M. SKOVLIN. 1994. Effects of .long-term grazing by big game and livestock in the Blue Mountains forest ecosystems. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-325. Pac. Northwest For. and Range Exp. Sta. Portland, Oregon. 49 pp.

JAHN, L. R., and J. B. TREFETHAN. 1978. Funding wildlife conservation programs. Pages 456-470 *in* H. P. Brokaw (ed.) Wildlife and America--contributions to an understanding of American Wildlife and its conservation. Council Environ. Qual. Washington D.C.

JAMISON, D. A. 1964. Effects of defoliation on forage plant pathology. Am. Soc. Agron. Spec. Pub. 5:67-80.

JENSEN, C. H., A. D. SMITH, and G. W. SCOTTER. 1972. Guidelines for grazing sheep on rangelands used by big game in winter. J. Range Manage. 25:346-352.

JOHNSON, M. K. 1979. Foods of primary consumers on cold desert shrub-steppe of southcentral Idaho. J. Range Manage. 32:365-368.

JONES, W. B. 1965. Response of major plant species to elk and cattle grazing in northwestern Wyoming. J. Range Manage. 18:218-220.

JOURDONNAIS, C. S., and D. J. BEDUNAH. 1990. Prescribed fire and cattle grazing on an elk winter range in Montana. Wildl. Soc. Bull. 18:232-240.

JULANDER, 0. 1958. Techniques in studying competition between big game and livestock. J. Range Manage. 11:18-21.

_____ . and D. E. JEFFERY. 1964. Deer, elk and cattle range relations on summer range in Utah. Trans. N. Am. Wildl. and Nat. Res. Conf. 29:404-414.

KASWORM, W. F., L. R. IRBY, and H. B. IHSLE PAC. 1984. Diets of ungulates using winter ranges in northcentral Montana. J. Range Manage. 37:67-71.

KAY, C. E. 1990. Yellowstone's northern elk herd: a critical evaluation of the "natural regulation" paradigm. Ph. D. Diss. Utah State Univ. Logan. 490 pp.

_____ . 1994. The impact of native ungulates and beaver on riparian communities in the Intermountain West. Natural Resources and Environ. Issues 1:23-44.

KEATING, K. A., L. R. IRBY, and W. F. KASWORM. 1985. Mountain sheep winter food habits in the upper Yellowstone Valley. J. Wildl. Manage. 49:156-161.

KIRSCH, J. B. 1963. Range use, relationships to logging, and food habits of the elk in the Little Belt Mountains, Montana. M.S. Thesis. Montana State Univ. Bozeman. 44 pp.

KORFRAGE, R. C., J. R. NELSON, and J. M. SKOVLIN. 1980. Summer diets of Rocky Mountain elk in northeastern Oregon. J. Wildl. Manage. 44:747-750.

KORNET . C. A. 1978. Status and habitat use of California bighorn sheep on Hart Mountain, Oregon. M.S. Thesis. Oregon State Univ. Corvallis. 49 pp.

KUFELD, R. C. 1973. Foods eaten by the Rocky Mountain elk. J. Range Manage. 26:106-113.

_____ , 0. C. WALLMO, and C. FEDDEMA. 1973. Foods of the Rocky Mountain mule deer. USDA For. Serv. Res. Pap. RM-111. Rocky Mt. For. and Range Exp. Sta. Fort Collins, Colorado. 31 pp.

_____ , D. C. BOWDEN, and D. J. SCHRUPP. 1988. Habitat selection and activity patterns of female mule deer in the Front Range, Colorado. J. Range Manage. 41:515-522.

LANG, E. M. 1958. Elk of New Mexico. New Mexico Dept. Game and Fish. Bull. No. 8. 33 pp.

LAUER, J. L., and J. M. PEEK. 1976. Big game-livestock relationships on the bighorn sheep winter range East Fork Salmon River, Idaho. Report submitted to the USDI Bureau of Land Manage. 44 pp.

LAUVER, C. L. 1983. Factors influencing distribution patterns of cattle and deer on forested ranges in east-central Washington. M.S. Thesis. Washington State Univ. Pullman.

LAYCOCK, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. J. Range Manage. 20:206-213.

LECKENBY, D. A. 1978. mule deer occupancy of plant communities on a south-central Oregon winter range. Oregon Dept. Fish and Wildl. Job Final Rep. Proj. No. W-70-R. Subproj. B. Oregon Dept. Fish and Wildl. Portland, Oregon. 58 pp.

_______, D. P. SHEEHY, C. H. NELLIS, R. J. SCHERZINGER, I. D. LUMAN, W. ELMORE, J. C. LEMOS, L. DOUGHTY, and C. E. TRAINER. 1982. Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon: Mule Deer. USDA For. Ser. Gen. Tech. Rep. PNW-139. Pac. Northwest For. and Range Exp. Sta. Portland, Oregon. 40 pp.

_______. 1984. Elk use and availability of cover and forage habitat components in the Blue Mountains, northeast Oregon, 1976-1982. Oregon Dept. Fish and Wildl., Wildl. Res. Rep. No. 14. 40 pp.

LEISTER, C. W. 1932. The pronghorn of North America. New York Zool. Soc. Bull. 35:182-205.

LEONHARDY, F. 1985. Archaeological research in the Big Creek Ranger District, Payette National Forest, Idaho. Unpub. Rep., Dept. of Anthropology, Univ. of Idaho, Moscow. 64 pp.

LOFT, E. R., J. W. MENKE, J. G. KIE, and R. C. BERTRAM. 1987. Influence of cattle stocking rate on the structural profile of deer hiding cover. J. Wildl. Manage. 51:655-664.

MACE, R. U. 1971. Oregon's elk. Oregon State Game Commission Bull. 4. Portland, Oregon. 29 pp.

MACKIE, R. J. 1970. Range ecology and relationships of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildl. Monog. No. 20. 79 pp.

_______. 1976. Interspecific competition between mule deer, other game animals, and livestock. Pages 49-54 in J. B. Low (ed.) Mule deer decline in the West. Utah State Univ-. Agric. Exp. Sta. Logan.

MARLOW, C. B., and T. M. POGACNIK. 1986. Cattle feeding and resting patterns in a foothills riparian zone. J. Range Manage. 39:212-217.

MacCRACKEN, J. G., and R. M. HANSEN. 1981. Diets of domestic sheep and other large herbivores in southcentral Colorado. J. Range Manage. 34:242-243.

McCOLLOUGH, S. A. 1982. Impact of cattle grazing on bighorn sheep, Trickle Mountain Colorado. M.S. Thesis. Colorado State Univ. Fort Collins, Colorado. 119 pp.

McCORQUODALE, S. M. 1985. Archaeological evidence of elk in the Columbia Basin. Northwest Sci. 59:192-197.

_______, K. J. RAEDEKE, and R. D. TABER. 1986. Elk habitat use patterns in the shrub-steppe of Washington. J. Wildl. Manage. 50:664-669.

McDANIEL, K. C., and J. A. TIEDEMAN. Sheep use on mountain winter range in New Mexico. J. Range Manage. 34:102-104.

McINNIS, M. I., and M. VAVRA. 1987. Dietary relationships among feral horses, cattle, and pronghorn in southeastern Oregon. J. Range Manage. 40:60-66.

McKELL, C. M., J. P. BLAISDELL, and J. R. GOODIN. 1972 Wildland shrubs--their biology and utilization. USDA For. Ser. Gen. Tech. Rep. INT-1. Intermt. For. and Range Exp. Sta. Ogden, Utah. 494 pp.

McLEAN, A., and W. WILLMS. 1977. Cattle and deer feeding habits on winter range in southern British Columbia. Proc. 30th Annual Meeting, Soc. Range Manage. Portland, Oregon. 56 pp.

MERRIAM, C. H. 1891. Results of a biological reconnaissance of south-central Idaho. N. Amer. Fauna No. 5. US Government Printing Off. Washington D.C. 179 pp.

MILLER, R. S. 1967. Pattern and process in competition. Adv. Ecol. Res. 4:1-74.

MILLER, R. F., and W. C. KRUEGER. 1976. Cattle use on summer foothill rangelands in northeastern Oregon. J. Range Manage. 29:367-371.

_______, _______,and M. VAVRA. 1981. Deer and elk use on foothill rangelands in northeastern Oregon. J. Range Manage. 34:201-204.

_______,, and M. VAVRA. 1982. Deer, elk and cattle diets on northeastern Oregon rangelands. Pages 500-508 *in* J.M. Peek and P. D. Dalke, (eds). Proc. Wildlife-Livestock Relationships Sympos. Univ. Idaho. Moscow.

MILLS, H. B. 1937. A preliminary study of the bighorn of Yellowstone National Park. J. Mammal. 18:205-212

MINOR, R., and K. A. TOPPEL. 1984. Lava Island Rockshelter: an early hunting camp in central Oregon. Occ. Papers Idaho Mus. Natur. Hist. 34:1-52.

MORRIS, M. S., and J. E. SCHWARTZ. 1957. Mule deer and elk food habits on the National Bison Range. J. Wildl. Manage. 21:189-193.

MOSER, C. A. 1962. The bighorn sheep of Colorado. Colo. Game and Fish Dept., Tech. Bull. No. 10. 49 pp.

MUEGGLER, W. F. 1965. Cattle distribution on steep slopes. J. Range manage. 18:255-257.

_______. 1972. Influence of competition on the response of bluebunch wheatgrass to clipping. J. Range Manage. 25:88-92.

_______. 1975. Rate and pattern of vigor recovery in Idaho fescue and bluebunch wheatgrass. J. Range Manage. 28:198-204.

NEAL, D. L. 1982. Improvement of Great Basin deer winter range with livestock grazing. Pages 61-73 *in* J. M. Peek and P. D. Dalke (eds.) Wildlife-livestock relationships symposium, Proceedings 10. Univ. of Idaho, For., Wildl., and Range Exp. Sta. Moscow.

NELSON, E. W. 1925. Status of the pronghorned antelope, 1922-24. USDA Bull. No. 1346. Washington D.C. 64 pp.

NELSON, J. R. 1982. Relationships of elk and other large herbivores. Pages 415-441 *in* J. W. Thomas and D. E. Toweill, eds. Elk of North America--ecology and management. Stackpole Books. Harrisburg, Pennsylvania.

NICHOLS, L. Jr. 1957. Forage utilization by elk and domestic sheep in the White River National Forest. M.S. Thesis. Colo. State Univ. Fort Collins. 92 pp.

OLDEMEYER, J. L., W. J. BARMORE, and D. L. GILBERT. 1971. Winter ecology of bighorn sheep in Yellowstone National Park. J. Wildl. Manage. 35:257-269.

OLSEN, D. L. 1983. A descriptive. analysis of the faunal remains from the Miller site, Franklin County, Washington. M.A. Thesis, Washington State Univ., Pullman. 147 pp.

OLSEN, F. W., and R. M. HANSEN. 1977. Food relations of wild free-roaming horses to livestock and big game, Red Desert, Wyoming. J. Range Manage. 30:17-20.

OREGON HISTORICAL SOCIETY. 1902. Across the continent seventy years ago. Oregon Historical Quarterly, 3.

PECHANEC, J. F., and G. D. REID. 1937. A weight estimate method for determination of range or pasture production. J. Am. Soc. Agron. 29:894-904.

PEEK, J. M. 1963. Wildlife investigatin (Dist. 3): big game survey and investigation-summer of 1956-1960, Gravelly-Snowcrest rumen collections. Montana Dept. Fish and Game. Fed. Aid Compl. Rep. Proj. W-73-R-8, J-A-1. 11 pp.

PEDERSEN, R. J., A. W. ADAMS, and J. M. SKOVLIN. 19 80. Elk habitat uses in an unlogged and logged forest environment. Wildl. Res. Rep. No. 9. Oregon Dept. Fish and Wildl. 121 pp.

PETTIGREW, R. M., and C. G. LEBOW. 1987. Data recovery at sites 35JA27, 35JA59, and 35JA100, Elk Creek Lake project, Jackson County, Oregon. Infotech Research, Eugene, Oregon. Report to U.S. Army Corps of Engineers, Portland, Oregon. IRI Report No. PNW87-7. Vol. I and 11. 847 pp.

PICKFORD, G. D., and E. H. REID. 1943. Competition of elk and domestic livestock for summer range forage. J. Wildl. Manage. 7:328-332.

_______, and _______,1948. Forage utilization on summer cattle ranges in eastern Oregon. USDA Circ. No. 796. US Government Printing office, Washington D.C. 27 pp.

REID, K. C. 1988. Downey Gulch archaeology and the Hill 5230 Game Drive. Center for Northwest Anthro., Washington State Univ. Contrib. *in* Culture Resource Manage. 22. 146 pp.

REINER, R. J., and P. J. URNESS. 1982. Effect of grazing horses managed as manipulators of big game winter range. J. Range Manage. 35:567-571.

RICKARD, W. H., D. W. URESK, and J. F. CLINE. 1975. Impact of cattle grazing on three perennial grasses in south-central Washington. J. Range Manage. 28:108-112.

RIGGS, R. A., P. J. URNESS, and K. A. GONZALEZ. 1990. Effects of domestic goats on deer wintering in Utah oakbrush. J. Range manage. 43:229-234.

ROLLINS, P. A. (ed.). 1935. The discovery of the Oregon Trail: Robert Stuart's narratives of his overland trip eastward from Astoria in 1812-1813. New York.

RISENHOOVER, K. L., and J. A. BAILEY. 1985. Foraging ecology of mountain sheep: implications for habitat management. J. Wildl. Manage. 49:797-804.

ROATH, L. R., and W. C. KRUEGER. 1982. Cattle grazing and behavior on a forested range. J. Range manage. 35:332-338.

ROUSE, R. A. 1957. Elk food habits, range use and movements Gravelly Mountains, Montana. M.S. Thesis. Montana State Univ. Bozeman. 29 pp.

RUSH, W. M. 1932. Northern Yellowstone elk study. Montana Fish and Game Comm., Helena. 131 pp.

_______. 1944. American pronghorn. Natural History 53:321-323.

SALWASSER, H. 1976. Man, deer, and time on the Devil's Garden. Pages 295-318 *in* Proc. of the Western Assoc. of the State Game and Fish Commission.

SCHALLENBERGER, A. D. 1966. Food habits, range use and interspecific relationships of bighorn sheep in the Sun River area, westcentral Montana. M.S. Thesis. Montana State Univ. Bozeman. 44 pp.

SCHLADWEILER, P. 1974. Ecology of Shiras moose in Montana. Big game Res. Proj. W-98-R and W-120-R. Final Rep. Montana Dept.. Fish and Game. Helena. 100 pp.

SCHMITT, D. N. 1986. Zooarchaeological and taphonomic investigations of site 35JA42, upper Applegate River, southwestern Oregon. M.A. Thesis. Oregon State Univ., Corvallis. 163 pp.

SETON, E. T. 1927. Lives of game animals. Vol. III. Doubleday, Doran & Co., Inc. New York, New York. 780 pp.

_______ . 1929. Lives of game animals. Vol. III. Doubleday, Page, & Co. New York, New York. 780 pp.

SEVERSON, E., M. MAY, and W. HEPWORTH. 1968. Food preference, carrying capacities, and forage competition between antelope and domestic sheep in Wyoming's Red Desert. Univ. Wyo. Agr. Exp. Sta. Sci. Monog. 10. 51 pp.

SHAY, R. 1954. Immigrant elk: the story of two early-day elk transplants to Wallowa and Clackamas Counties. Oregon State Game Commission Bull. 1954:3-8.

SHEEHY, D. P. 1987. Grazing relationships of elk, deer, and cattle on seasonal rangelands in northeastern Oregon. PhD. Diss. Oregon State University, Corvallis. 269 pp.

SKOVLIN, J. M., P. J. EDGERTON, and R. W. HARRIS. 1968. The influence of cattle management on deer and elk. Trans. 33rd N. Am. Wildl. and Nat. Res. Conf. 33:169-181.

_______, R. W. HARRIS, G. S. STRICKLER, and. G. A. GARRISON. 1976. Effects of cattle grazing methods on ponderosa pinebunchgrass range in the Pacific Northwest. USDA For. Serv. Tech. Bull. 1531. 40 pp.

_______, and M. VAVRA. 1979. Winter diets of elk and deer in the Blue Mountains, Oregon. USDA For. Serv. Res. Pap. PNW-260. Pac. Northwest For. and Range Exp. Sta. Portland, Oregon. 21 pp

_______, J. M., P. J. EDGERTON, and B. R. McCONNELL. 1983. Elk use of winter range as affected by cattle grazing, fertilizing, and burning in southeastern Washington. J. Range Manage. 36:184-189.

_______,1984. Impacts of grazing on wetlands and riparian habitat: a review of our knowledge. Pages 1001-1104 *in* Developing strategies for rangeland management. National Research Council. National Academy of Science. Westview Press. Boulder, Colorado.

_______, L. D. BRYANT, and R. J. EDGERTON. 1989. Timber harvest affects on elk distribution in the Blue Mountains of Oregon. USDA For. Ser. Res. Paper. PNW-RP 415. PNW For. and Range Exp. Sta. Portland, Oregon. 10 pp.

SMITH, A. D., and D. DOELL. 1968. Guides to allocating forage between cattle and big game winter range. Utah Division of Fish and Game Publication. 68-11.

_______, and J. C. MALECHEK. 1974. Nutritional quality of summer diets of pronghorn antelopes in Utah. J. Wildl. Manage. 38:792-798.

SMITH, D. R. 1954. The bighorn sheep in Idaho, its status, life history, and management. Wildl. Bull. No. 1. Idaho Dept. Fish and Game. 154 pp.

SMITH, J. G., and 0. JULANDER. 1953. Deer and sheep competition in Utah. J. Wildl. Manage. 16:148-155.

SMITH, M. A., J. C. MALECHEK, and K. 0. FULGHAM. 1979. Forage selection by mule deer on winter range grazed by sheep in spring. J. Range Manage. 32:40-45.

SPALDING, D. J., and H. B. MITCHELL. 1970. Abundance and distribution of California bighorn sheep in North America. J. Wildl. Manage. 34:473-475.

SPARKS, D. R., and J. C. MALECHEK. 1968. Estimating percentage dry weight in diets using a microscopic technique. J. Range Manage. 21:264-265.

SPENCER, C. C. 1943. Notes on the life history of Rocky Mountain bighorn sheep in the Tarryall Mountians of Colorado. J. Mammal. 24:1-11.

STARK, R. H. 1973. Elk-cattle interrelations on the Colockum Creek Watershed. M.S. Thesis. Washington - State Univ. Pullman. 87 pp.

STEPHENSON, T. E., J. L. HOLECHEK, and C. B. KUYKENDALL. 1985. Drought effect on pronghorn and other ungulate diets. J. Wildl. Manage. 49:146-151.

STEVENS, D. R. 1966. Range relationships of elk and livestock, Crow Creek Drainage, Montana. J. Wildl. Manage. 30:349-363.

_______. 1980. Effect of elk on vegetation in Rocky Mountain National Park. Proc. Second Conf. Sci. Res. Natl. Parks. 12:394-410.

STODDART, L. A. 1946. Some physical and chemical responses of Agropyron spicatum to herbage removal at various seasons. Utah State Agricultural College Agr. Exp. Sta. Bull. 324. Logan. 24 pp.

_______, A. D. SMITH, and T. W. BOX. 1975. Range Management. McGrawHill Book Co. New York, New York. 532 pp.

STUTH, J. W., and A. H. WINWARD. 1977. Livestock-deer relations in the lodgepole pine-pumice region of central Oregon. J. Range Manage. 30:110-116.

SUGDEN, C. G. 1961. The California bighorn in British Columbia with particular reference to the Churn Creek herd. British Columbia Dept. of Recreat. and Conserv. 58 pp.

THOMAS, J. W., H. Jr. BLACK, R. J. SCHERZINGER, and R. J. PEDERSEN. 1979. Deer and elk. Pages 104-127 *in* J. W. Thomas (ed.) Wildlife habitats in managed forests-- the Blue Mountains of Oregon and Washington. USDA For. Ser. Agric. Handbook No. 553.

THWAITES, R. G. (ed.) . 1969. Origin journals of the Lewis and Clark Expedition. Vol. III. Arno Press. New York. 363 pp.

TILTON, M. E., and E. E. WILLARD. 1982. Winter habitat selection by mountain sheep. J. Wildl. Manage. 46:359-366.

TODD, J. W. 1975. Foods of Rocky Mountain bighorn sheep in southern Colorado. J. Wildl. Manage. 39:108-111.

TROUT, L. C., and T. A. LEEGE. 1971. Are the northern Idaho elk herds doomed? Idaho Wildl. Rev. 24:3-6.

URNESS, P. J. 1990. Livestock as manipulators of mule deer winter habitats in northern Utah. Pages 25-42 *in* Can livestock be used as a tool to enhance wildlife habitat? USDA For. Ser. Gen. Tech. Rep. RM-194. Rocky Mt. For. and Range Exp. Sta. Fort Collins, Colorado.

U.S. FOREST SERVICE. 1970. Research Progress, 1969. Pac. Southwest For. and Range Exp. Sta. Berkeley, California.

VAN DYKE, W. A. 1978. Population characteristics and habitat utilization of bighorn sheep, Steens Mountain, Oregon. M. S. Thesis. Oregon State University, Corvallis. 87 pp.

VAVRA, M. 1980. Problem analysis --forage allocation for big game and livestock in northeastern Oregon. Unpub. On file at USDA For. Serv., For. and Range Sci. Lab. La Grande, Oregon. 99 pp.

_______, and J. L. HOLECHEK. 1980. Factors influencing microhistological analysis of herbivore diets. J. Range Manage. 33:371-374.

_______, and F. A. SNEVA. 1978. Seasonal diets of 5 ungulates grazing in the cold desert biome. Pages 435-437 *in* D. N. Hyder (ed.) Proc. First Intern. Rangel. Cong., Soc. Range Manage.

VOGLER, J. P. 1978. Effects of grazing, clearing, and stream channelization or riparian and associated vegetation of Guthrie County, Iowa. M.S. Thesis. Iowa State Univ., Ames. 79 pp

WALLACE, M. C., and P. R. KRAUSMAN. 1987. Elk, mule deer, and cattle habitats in central Arizona. J. Range Manage. 40:80-83.

WARD, A. L., J - J. CUPAL, A. L. LEA, C. A. OAKLEY, and R. W. WEEKS. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. Trans. 38th N. Am. Wildl. Conf. 38:327-337.

WARREN, J. T., and I. MYSTERUD. Sumner habitat use and activity patterns of domestic sheep on coniferous forest range in southern Norway. J. Range Manage. 44:1-6.

WASHINGTON DEPT. OF GAME. 1979. Big game status report. Olympia: Washington Game Dept. 293 pp.

WILCOX, T. 1963. Prairie dog race. Outdoor life 131:40-43.

WILLARD, E. E., and C. M. McKELL. 1978. Response of shrubs to simulated browsing. J. Wildl. Manage. 42:514-519.

WILLIAMS, R. E. 1954. Modern methods of getting uniform use of ranges. J. Range Manage. 7:77-81.

WILLMS, W., A. McLEAN, and R. RITCEY. 1976. Feeding habits of mule deer on fall, winter, and spring ranges near Kamloops, British Columbia. Can. J. Anim. Sci. 56:531-542.

_______, and ______. 1978. Spring forage selection by tame mule deer on big sagebrush range, British Columbia. J. Range Manage. 31:192-199

A. W. BAILEY, A. McLEAN, and R. TUCKER. 1981. The effects of fall defoliation on the utilization of bluebunch wheatgrass and its influence on the distribution of deer in spring. J. Range Manage. 34:16-18.

WILSON, A. M., G. A. HARRIS, and D. H. GATES. 1966. Cumulative effects of clipping on yield of bluebunch wheatgrass. J. Range Manage. 19:90-91

WOOLF, A. 1968. Summer ecology of bighorn sheep in Yellowstone National Park. M.S. Thesis. Univ. Colorado, Boulder. 112 pp.

WORKMAN, J. P., and J. F. HOOPER. 1968. Preliminary economic evaluation of cattle distribution practices on mountain rangelands. J. Range Manage. 21:301-304.

WYETH, N. J. 1899. The correspondence and journals of Nathaniel J. Wyeth, 1831-36 in Sources of the history of Oregon. Vol. I. Eugene, Oregon.

YOAKUM, J. 1968. A review of the distribution and abundance of American pronghorn antelope. Antelope States Workshop 1968 Proceedings 3:4-14.

_______. 1974. Pronghorn habitat requirements for sagebrushgrasslands. Antelope States Workshop 1974 Proc. 6:1-10.

_______. 1975. Antelope and Livestock on rangelands. J. Anim. Sci. 40:985-992.

YEO, J. J., J. M. PEEK, W. T. WITTINGER, and C. T. KVALE. 1993. Influence of rest-rotation cattle grazing on mule deer and elk habitat use in east-central Idaho. J. Range Manage. 46:245-250.

YOUNG, V. A., and W. L. ROBINETTE. 1939. A study of the range habits of elk on the Selway Game Preserve. Univ. Idaho, School of Forest Bull. No. 9. 47 pp.

_______, and G. F. PAYNE. 1948. Utilization of key browse species in relation to proper grazing practices in cutover western white pine lands in northern Idaho. J. For. 46:35-40.

APPENDIX A

Common and Scientific Names[1]

Common name	Scientific name
MAMMALS	
Bighorn sheep, California	*Ovis canadensis californiana*
Bighorn sheep, Rocky Mountain	*Ovis canadensis canadensis*
Cow, domestic	*Bos taurus*
Elk, Rocky Mountain	*Cervus elaphus nelsoni*
Horse	*Equus caballus*
Mule deer, Rocky Mountain	*Odocoileus hemionus hemionus*
Pronghorn	*Antilocapra americana*
Sheep, domestic	O*vis aries*
PLANTS	
GRAMINOIDS	
Bluegrass	*Poa spp.*
Bluegrass, Cusick	*Poa cusickii*
Bluegrass, Kentucky	*Poa pratensis*
Bluegrass, Leiburg	*Poa leiburgii*
Bluegrass, Sandberg	*Poa secunda.*
Brome	*Bromus spp.*
Brome, mountain	*Bromus marginatus*
Brome, cheatgrass	*Bromus tectorum*
Danthonia	*Danthonia spp.*
Fescue	*Festuca spp.*
Fescue, Idaho	*Festuca idahoensis*
Fescue, rough	*Festuca scabrella*
Fescue, sheep	*Festuca ovina*
Hairgrass, tuffed	*Deschampsia caespitosa*
Junegrass, prairie	*Koelaria cristata*
Muttongrass	*Poa fendleriana*
Needleandthread	*Stipa comata*
Needlegrass	*Stipa spp.*
Needlegrass, subalpine	*Stipa columbiana*
Needlegrass, western	*Stipa occidentalis*
Orchard grass	*Dactylis glomerata*
Ricegrass, Indian	*Oryzopsis hymenoides*
Ricegrass, little	*Oryzopsis exigua*
Rush, Baltic	*Juncus balticus*
Rye, winter	*Secale cereale*
Pinegrass	*Calamagrostis rubescens*
Sedge	*Carex spp.*

---

[1] Mammal scientific names follow Chapman and Feldhammer *(1982);* Plant scientific names follow Hitchcock and Cronquist *(1973)* and Garrison et al. *(1976)*

Sedge, elk	*Carex geyeri*
Squirreltail, bottlebrush	*Sitanion hystrix*
Timothy	*Phleum pratense*
Wheat	*Trisetum spp.*
Wheatgrass	*Agropyron spp.*
Wheatgrass, bluebunch, bearded	*Agropyron spicatum*
Wheatgrass, crested	*Agropyron desertorum*
Wheatgrass, western	*Agropyron smithii*
Wildrye, giant	*Elymus cinereus*

FORBS

Agoseris, pale	*Agoseris glauca*
Alfalfa	*Medicago sativa*
Arnica, heartleaf	*Arnica cordifolia*
Aster	*Aster spp.*
Avens, alpine	*Geum rossii*
Balsamroot	*Balsamorhiza spp.*
Balsamroot, arrowleaf	*Balsamorhiza sagittata*
Balsamroot, Hooker	*Balsamorhiza hookeri*
Biscuitroot	*Lomatium spp.*
Buckwheat	*Eriogonum spp.*
Camas, common	*Camassia quamash*
Cinquefoil	*Potentilla spp.*
Cinquefoil, Newberry	*Potentilla newberryi*
Clover	*Trifolium spp.*
Daggerpod	*Phoenicaulis cheiranthoides*
Dandelion, common	*Taraxicum officinale*
Falsebugbane, Oregon	*Trautvetteria grandis*
Fleabane	*Erigeron spp.*
Geranium	*Geranium spp.*
Geranium, Richardson	*Geranium richardsonii*
Geranium, sticky	*Geranium viscosissimum*
Globemallow, Munro	*Sphaeralcea munroana*
Gumweed, low	*Grindelia nana*
Hawkweed	*Hieracium chapacanum*
Hawksbeard, tapertip	*Crepis acuminata*
Knotweed	*Polygonum spp.*
Kobresia	*Kobresia myosuroides*
Lettuce, prickly	*Lactuca serriola*
Ligusticum, Gray	*Ligusticum grayi*
Lupine	*Lupinus spp.*
Lupine, broadleaf	*Lupinus latifolia*
Marshmarigold, elkslip	*Caltha. leptosepala*
Milkvetch	*Astragalus spp.*
Monkshood, Columbia	*Aconitum columbianum*
onion, Kellogg	*Allium anceps*
Penstemon	*Penstemon spp.*
Penstemon, littleflower	*Penstemon procerus*
Phlox	*Phlox spp.*
Phlox, Hoods	*Phlox hoodii*
Phlox, longleaf	*Phlox longifolia*

Pussytoes	*Antennaria spp.*
Pussytoes, rose	*Antennaria rosea*
Pussytoes, rush	*Antennaria luzuloides*
Sagebrush, Louisiana	*Artemisia ludoviciana*
Salsify, yellow	*Tragopogon dubius*
Sandwort, ballhead	*Arenaria congesta*
Strawberry	*Fragaria glauca*
Sunflower, common	*Helianthus annuus*
Thistle	*Cirsium spp.*
Trail plant, American	*Adenocaulon bicolor*
Vetch, American	*Vicia americana*
Yarrow, western	*Achillea millefolium*

SHRUBS

Blueberry	*Vaccinium spp.*
Bitterbrush, antelope	*Purshia tridentata*
Ceanothus, redstem.	*Ceanothus sanguineus*
Ceanothus, snowbrush	*Ceanothus velutinus*
Currant, wax	*Ribes cereum*
Grape, Oregon	*Berberis ssp.*
Greasewood	*Sarcobatus spp.*
Hawthorne	*Crataequs spp.*
Heather	*Calhuna spp.*
Mahogany, mountain	*Cerocarpus spp.*
Mahogany, mountain, curlleaf	*Cercocarpus ledifolius*
Mahogany, mountain, true	*Cercocarpus montanus*
Ninebark, mallow	*Physocarpus malvaceus*
Oceanspray	*Holodiscus discolor*
Pachistma, Myrtle	*Pachistma myrsinites*
Rabbitbrush, gray	*Chrysothamnus nauseosus*
Rockspirea, bush	*Holodiscus dumosus*
Rose	*Rosa spp.*
Rose, Woods	*Rosa woodsii*
Sagebrush	*Artemisia spp.*
Sagebrush, black	*Artemisia nova*
Sagebrush, big	*Artemisia tridentata spp.*
Sagebrush, big, basin	*Artemisia tridentata tridentata*
Sagebrush, big, Wyoming	*Artemisia tridentata wyomingensis*
Sagebrush, bud	*Artemisia spinescens*
Sagebrush, fringed	*Artemisia frigida*
Sagebrush, low	*Artemisia arbuscula*
Sagebrush, silver	*Artemisia cana*
Sagebrush, threetip	*Artemisia tripartita*
Serviceberry	*Amelanchier spp.*
Serviceberry, Utah	*Amelanchier utahensis*
Snowberry, common	*Symphoriocaipus albus*
Snowberry, mountain	*Symphoriocarpus oreophilus*
Spirea	*Spiraea betulifolia lucida*
Sumac	*Rhus spp.*

Sumac, skunkbrush	*Rhus trilobata*
Winterfat, common	*Eurotia lanata*

TREES

Aspen, quaking	*Populus tremuloides*
Cherry	*Prunus spp.*
Chokecherry, common	*Prunus virginiana*
Chokecherry, western	*Prunus virginiana demissa*
Cottonwood, black	*Populus trichocarpa*
Fir	*Abies spp.*
Fir, Douglas	*Psuedotsuga menziesii*
Fir, grand	*Abies grandis*
Fir, subalpine	*Abies lasiocarpa*
Hemlock, western	*Tsuga heterophylla*
Juniper	*Juniperus sp.*
Maple, Rockymountain	*Acer glabrum*
Oak, Gambel	*Quercus gambelli*
Pine	*Pinus spp.*
Pine, lodgepole	*Pinus contorta*
Pine, ponderosa	*Pinus ponderosa*
Spruce	*Picea spp.*
Spruce, Engelmann	*Picea engelmannii*
willow	*Salix spp.*
Willow, short-fruited	*Salix brachycarpa*
Willow, tea-leaved	*Salix planifolia*
Yew, Pacific	*Taxus brevifolia*

Lower Plants-

Lichen	*Cladonia spp*