CHAPTER 6

UNGULATES

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

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MONTANA CHAPTER OF THE WILDLIFE SOCIETY

Written by

Jodie E. Canfield - Management Biologist, Helena National Forest, Townsend
L. Jack Lyon - Research Biologist, U.S. Forest Service Research (retired), Missoula
J. Michael Hillis – Forest Wildlife Biologist, Lolo National Forest, Missoula
Michael J. Thompson – Wildlife Management Biologist, Montana Fish, Wildlife and Parks, Missoula

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ABSTRACT

Ungulates provide a large percentage of the recreational opportunities for wildlife enthusiasts in the State of Montana. Hunting, wildlife viewing, and photography generate economic benefits in excess of $450 million annually. However, recreational activities have the potential not only to displace ungulates to private land where they may cause damage, but also to have negative direct and indirect effects to the populations themselves. During winter, many ungulates are seasonally confined to restricted geographic areas with limited forage resources. In these conditions, physiological adaptations and behavioral adaptations tend to reduce energy requirements. Despite lowered metabolic and activity rates, most wintering ungulates normally lose weight. Responses of ungulates to human recreation during this critical period range from apparent disinterest to flight, but every response has a cost in energy consumption. Snowmobiles have received the most attention compared to other wintertime disturbances, and the majority of reports dwell on negative aspects of snowmobile traffic. However, snowmobiles appear less distressing than cross-country skiers, and for several ungulate species, the greatest negative responses were measured for unpredictable or erratic occurrences. In addition to increasing energy costs for wintering animals, recreational activity can result in displacement to less desirable habitats, or in some situations, to tolerance of urban developments. Tendencies to habituation vary by species, but habituated ungulates are almost always undesirable. Managers can provide an important contribution to energy conservation by reducing or eliminating disturbance of wintering ungulates and restricting recreational use of spring ranges that are important for assuring recovery from winter weight loss. During summer, the biological focus for ungulates includes restoring the winter-depleted body condition and accumulating new fat reserves. In addition, females must support young of the year and males meet the energy demands of horn and antler growth. The potential for impacts increase and options for acquiring high quality nutrition, with the least possible effort, decline as the size of the area affected by recreationists expands to fill an increasing proportion of the summer range. Disturbance of the highly productive seeps and wet sites may cause animals to withdraw to less productive areas. In addition, ungulates may be especially vulnerable to disturbance around special habitat features, such as salt licks. Persistently high levels of recreational use and the proximity to human population centers is predicted to impact reproductive performance of ungulate populations, but little direct research at this level of disturbance has been reported. Recreational traffic on and off roads has been linked with high rates of establishment and spread of noxious weeds in wildlife habitat. The importance of summer range to most ungulate populations has gone unrecognized for many years. It is apparent, however, that managers can contribute substantially to the health, productivity, and survival of these populations by reducing human disturbances to summering animals. Big game hunting has more immediate effects on ungulate population densities and structures than any other recreational activity. Hunting season security and management affects short and long-term hunting opportunities. Managers of public lands control only a few of the potential variables that contribute to security; including retention of important vegetative cover, travel management, and enforcement of travel regulations. There is a strong relationship between adequate security and predicted buck/bull carryover, but excessive hunter numbers will overwhelm any level of security. Hunting also has the potential to negatively affect herd productivity as mature males are lost from populations. Violations of ethical considerations including the concept of "fair chase" and the perception of the "sportsman" in the public mind, can increase ungulate vulnerability as well as influence social acceptance of the sport of hunting. Pursuit of pronghorns with ORVs and killing of trophy animals within game farm exclosures are presented as ethical violations.

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INTRODUCTION

Ungulates, primarily deer and elk, but also pronghorn, moose, bighorn sheep, and mountain goats, provide a large percentage of the recreational opportunities for wildlife enthusiasts in the State of Montana (MFWP 1999:37). According to Montana Fish, Wildlife and Parks (MFWP), deer hunters spend an average of 1.2 million hunter days afield per year; elk hunters spend an average of almost 900,000 hunter days afield. In addition, ungulate populations provide substantial economic benefits. The estimated annual economic value of hunting deer, pronghorn, and elk is about $360 million (Brooks 1988, Duffield and Holliman 1988 [adjusted to 1998]). Nonhunting wildlife viewing and photography generates another $53 million in trip-related expenditures (MFWP 1999:37). People who live in Montana and those who come as visitors value our ungulate populations.

Hunting is the primary tool used by MFWP to manage ungulate populations. The department's current program emphasizes hunting as a traditional use of Montana's game species (MFWP 1999). In addition, hunting is used to control big game numbers on private land at levels that minimize game damage. To increase landowner tolerance for big game animals and to minimize big game damage, it is advantageous for land managers to work with wildlife managers to reduce displacement of animals from public to private lands. In the material presented in this review, we have assumed that successful wildlife management in Montana cannot occur without continuous coordination and cooperation between the public and private agencies and individuals responsible for both the animals and the habitats in which they live.

Recreational activities on public lands have the potential not only to displace ungulates to private land where they may cause damage, but also to have negative direct and indirect effects on the populations themselves (Knight and Cole 1995). Wildlife responses to disturbance are shaped by 6 factors: type of activity; predictability of the activity; frequency and magnitude of the activity; timing (e.g., breeding season); relative location (e.g., above versus below on a slope); and the type of animal including size, specialized versus generalized niche, group size, and sex and age (Knight and Cole 1995).

To discuss potential effects of recreational activities on ungulate populations, we have focused on seasonal biology. Discussion of relevant literature and recommendations for recreation management are given for Winter/Spring, Summer, and Hunting Season. Each of these three seasons has distinct characteristics and biological limitations or considerations that influence the nature of the impact of recreational activities on ungulate populations. Management guidelines are based on our interpretation and synthesis of the available literature.

WINTER/SPRING

For many species of northern ungulates, winter range is traditionally considered the limiting factor of environment. According to Smith and Anderson (1998:1043), winter survival was reported to regulate, in a density-dependent fashion, both red deer on the Isle of Rhum, Scotland (Clutton-Brock et al. 1985), and northern Yellowstone National Park elk (Houston 1982, Singer et al. 1997). Animals that may have occupied thousands of acres of summer/fall range can be seasonally confined to relatively restricted geographic areas on which forage is limited and environmental conditions can cause physiological stress. As defined by Mackie et al. (1998:27) this is "maintenance habitat," environments that provide ". . .all resources necessary for adult survival, but not necessarily recruitment of young." The number of animals that can be successfully maintained in limited geographic areas is further limited by ". . . developments such as reservoir impoundments, subdivisions, access roads, highways, and the cultivation of land for agriculture. . . ." (Skovlin 1982:372).

Typically, winter ranges of elk and deer are south- and southwest-facing, low elevation slopes (Skovlin 1982) and the bottoms of large valleys (Telfer 1978) somewhat removed from areas occupied during the summer. The determining variable, however, is snow depth, and Mackie et al. (1998) have pointed out that deer populations winter where the least snow falls. "Snow impedes movement, increases energy expenditure, and reduces forage availability." (Parker et al. 1984:479). Energy expenditures for locomotion in snow increase curvilinearly as a function of snow depth and density. As an example, Parker et al. (1984) found that a 100-kg elk calf required five times more energy when moving through 58 cm of snow than on bare ground. Snow cover greater than 30 cm can have substantial influence on the ability of elk to meet daily energy requirements (Wickstrom et al. 1984), and ". . . average snow depths beyond 25 cm are sufficient to discourage occupation of a given area by deer" (Parker et al.

1984:483). Leege and Hickey (1977) reported that elk in north Idaho selected winter range with snow depths under 2 feet if possible, and Sweeney and Sweeney (1984) found that elk avoided areas with 70 cm of snow when possible. Goodson et al. (1991) reported that even small amounts of snow had an important negative effect on foraging efficiency and diet quality for bighorn sheep.

For some elk and deer herds, there may be major migratory movements from summer to winter range. Hoskinson and Tester (1980) also reported migration of pronghorn from low-elevation winter ranges to summer ranges near the heads of valleys, and Bruns (1977) observed a southward movement during an exceptionally severe winter. However, pronghorn, moose, mountain sheep, and goats usually occupy the same geographic area year-around, while limiting winter access to specific topographic niches within the area. Rudd et al. (1983) observed that elk in Yellowstone National Park began to migrate when snow depths reached 20 cm, but Sweeney and Sweeney (1984) concluded that 40 cm was required to produce movement in Colorado. Telfer (1978) suggested that moose, being more tolerant of deep snow, simply settle into that part of their habitat with the heaviest browse biomass.

Wickstrom et al. (1984:1299) concluded that net energy intake depends on forage abundance, leaf and bite size, and digestibility of the diet. These considerations become even more important when it is recognized that almost 40% more food is required in winter to generate energy for daily metabolic and activity requirements (Nelson and Leege 1982:327). Few winter ranges are capable of providing forage increases of this magnitude. Among the rare exceptions, Mackie et al. (1998:57) reported on some Montana white-tailed deer that had access to highly nutritional crop residues. On this diet, deer continued to exploit agricultural fields even when wind chill temperatures dropped to -60^{o} C. Normally, winter ranges cannot be described in terms of forage production or quality alone. Instead, it is generally recognized that only under mild conditions will the energy gained from native forage offset energy lost from increased exposure and mobility associated with feeding (Wood 1988).

Natural Physiological and Behavioral Adaptations

Winter ranges have been most often evaluated through food habits studies and surveys of forage production. Indeed, Mackie et al. (1998:1) have pointed out that deer management in Montana has been based on a winter range conceptual model for more than 50 years where ". . . the key elements were winter range, the quantity and quality of forage (i.e., browse) available on primary wintering areas, and deer numbers and distribution relative to these resources." Various studies (Wallmo et al. 1977) have shown that native forages available in winter are mostly too low in nutritional value to meet maintenance needs of deer, which explains the limited fit of the model to observed population performance. Nelson and Leege (1982:347) may have expressed a more appropriate ecological model for many ungulates when they wrote, "Elk move to ranges where snow depth is minimal, and exist there on whatever forage is available." Mackie et al. (1998:30) observed that, "Deer survive primarily by supplementing energy reserves accumulated prior to winter with energy intake from submaintenance winter diets." This requires behavior that emphasizes energy conservation. Skovlin (1982:379) credits Beall (1974) with the observation that cold-climate ungulates ". . . seek habitats with microclimates that furnish the greatest comfort with the least expenditure of energy."

Research describing the energetic requirements and metabolic rates of various ungulates during the winter period demonstrates major physiological adaptations to winter stress. McEwan and Whitehead (1970) reported that caloric intake for caribou was 35-45% lower in winter than during the summer growth period, and similar reductions have been reported for other ungulates. Chappel and Hudson (1978), for example, found that voluntary forage intake by bighorn sheep decreased in mid-February to 0.55 of intake in mid-October. Moen (1978) reported that ecological metabolism for white-tailed deer was lowest in winter and highest in the summer, and Chappel and Hudson (1980) found that metabolic rate decreased with temperature and fasting in bighorn sheep. According to Silver et al. (1969), the fasting metabolic rate of white-tailed deer is 1.5 times greater in summer than in winter. In moose (Regelin et al. 1985), mean heat production in summer exceeded heat production in winter by a factor of 1.4. These examples all demonstrate a general physiological adaptation in ungulates that reduces energy requirements when winter survival is at stake.

In addition, most ungulates demonstrate behavioral adaptations related to energy conservation. The energy cost of standing is 25% greater than the lying posture for elk (Parker et al. 1984), moose (Renecker and Hudson 1986), pronghorn (Wesley et al. 1973), and roe deer (Weiner 1977). "Wherever behavioral patterns have been recorded, elk selection of winter resting and feeding sites has been more critical to maintenance of constant body temperature than selection of forage sites." (Lyon and Ward 1982:472). Such selections might include any of several energy conservation behaviors reported for deer (Moen 1976), including reduced activity levels, selection of areas with lesser snow, and walking slowly. Wood (1988 in Mackie et al. 1998:58) reported that foraging was energetically inefficient for mule deer during severe winter weather conditions. Bedding in protected sites was the favored strategy because it conserved energy.

One of the less desirable behaviors noticed for several ungulate species has been habituation to human habitations. Thompson and Henderson (1998) reported an increasing occurrence of elk not responding to predictable and harmless human activities on winter ranges in the urban fringe. They noted that the habituation response was an adaptive behavioral strategy promoted by the need to conserve energy, avoid bodily damage, out compete other individuals, and find unutilized resources. Human tolerance for some smaller ungulates like deer is fairly high, as evidenced by management planning to maintain an urban population (Shoesmith and Koontz 1977), but it is doubtful there is very much tolerance for larger species like elk and moose.

Finally, the importance of certain physical attributes of winter ranges should not be overlooked. Beall (1974) detected and reported consistent patterns of bedding site selection in which elk regularly utilized the largest available tree in any situation. Ryder and Irwin (1987) reported that larger shrubs, steep slopes, and irregular topography were important determinants of winter habitat use for pronghorn, thus confirming Martinka's (1967) observation of starvation for several hundred pronghorn restricted to a grassland vegetative type while pronghorn on adjacent ranges where sagebrush was present suffered only minor losses. Bruns (1977) reported pronghorn that selected microhabitats with more favorable conditions than the average for the study area enjoyed 63% lower wind velocities, 24% less snow, and 87% softer snow. Similarly, "By use of shelter associated with badlands topography, mule deer reduced conductive heat loss by 47 percent at feeding sites and by 61 percent in bedding sites." (Mackie et al.1998:57).

Energetic contributions of thermal cover have been widely assumed as valuable in winter, but a recent monograph by Cook et al. (1998:5) concluded there was no positive effect of thermal cover on elk. Instead, they found that dense cover provided a ". . . costly energetic environment, resulting in significantly greater overwinter mass loss. . ." These authors also reported that previous studies of winter thermal cover for white-tailed deer (Robinson 1960, Gilbert and Bateman 1983) and mule deer (Freddy 1984*b*, 1985, 1986*b*) had reached similar conclusions. They suggested that habitat managers should give more attention to forage relationships and vulnerability of ungulates to harvest and harassment.

For some large ungulate species, winter separation of sex and age groups has been reported. Geist and Petocz (1977) suggest that bighorn sheep males segregate from females to minimize competition and disturbance for mothers of their prospective offspring. Both sexes occupy a continuous range but concentrate in different areas. Mackie et al. (1998:39) reported a similar separation in both species of deer. Dominant breeding males, ". . . in poor condition following the energy-costly rut . . ." select winter habitats to conserve remaining fat reserves. Unsworth (1993) reported a complete separation of elk in Idaho, with bulls using more open timber habitats and less shrubfield types than cows and calves. Leege and Hickey (1977) described a similar separation, but they also noted there was competition for forage between adult bulls and other elk.

Natural Physiological Manifestations and Ramifications

For all ungulates, winter is a difficult time in which stresses imposed by deep snow, forage shortages, and low temperatures depress the body condition of even healthy animals. One obvious manifestation of severe winter weather is loss of body weight. Weight loss occurs even in normal winters and on the most productive winter ranges. Nelson and Leege (1982:330), quoting Gerstell (1937), report ". . . that white-tailed deer in Pennsylvania were not able to maintain body weight at temperatures below -1 degree Celsius regardless of the quality or quantity of diet." It is generally accepted among biologists that weight loss approaching 15% during the winter is normal for many ungulates. Mautz (1978) wrote that deer frequently lose up to 20-30% of their weight over the winter. Youmans (1992:5) indicated that winter stresses ". . . can result in a 20-25% loss in body weight for an adult.", but Cook et al. (1998:42) reported that weight loss of 18-20% in elk calves sometimes resulted in death.

Weight loss does have a cost, however. Thorne et al. (1976) found that weight lost by elk cows during pregnancy was significantly correlated to calf weights at birth and subsequent growth rates through the fourth week. Captive elk that lost more than 3% of body weight between January and calving produced lighter-weight calves with a reduced probability of survival. Smith and Anderson (1998:1042), on the other hand, wrote, "Contrary to our expectations, we found no correlation between birth mass of individual calves and their survival. However, survival was positively correlated with mean cohort birth mass." The effect of undernutrition on reproduction, birth mass, and survival of calves was also identified as determining population trends in the northern herd of Yellowstone National Park. Houston (1982:44) reported that elk migrating down the Yellowstone River and out of the Park tended to show higher calf/cow ratios in winter than elk that remained within Yellowstone. Whether these differences were due to hunting outside the Park or to less severe snow conditions at lower elevations could not be determined.

Pregnant females are obviously affected by weight loss during winter, although much recent research has suggested that body fat accumulated during the summer is more important than winter weight loss in determining the outcome of pregnancy. In an investigation of embryonic mortality in caribou, Russell et al. (1998:1073) found that maternal fat and body mass determined probability of pregnancy and postulated that ". . . embryonic mortality occurs very close to the breeding season,. . . " rather than late in pregnancy as a result of poor winter diet. Even though winter weight loss may be severe, Nelson and Leege (1982:328) observed that for elk, "Serious demands on the cow do not occur during the first 170 days of gestation." Nearly 70% of weight gain in a developing fetus occurs during the last 80 days of pregnancy (Bubenik 1982:171 [using data from Morrison et al. (1959)]). Thus, spring green-up may be the most important winter forage resource for pregnant elk.

The importance of spring range in assuring recovery from winter weight loss has not been appropriately emphasized in the literature. Even with warming temperatures and reduced snow depths, early spring reveals many ungulates at the absolute lowest physical condition of the year. Until new, green forage restores lost weight and energy, these animals may succumb to stresses that would be considered minor at other times of the year. The development of green vegetation at lower elevations on southerly slopes are also attractive for people following a long winter. A collector looking for dropped antlers, or even an early-season family picnic, can inflict major stress injury on any ungulate at this time of the year.

Physiological Impacts of Human Disturbance

The Montana Department of Fish, Wildlife and Parks has, for many years, prohibited public access to dedicated big game winter ranges between December 1 and May 15. This closure is intended to prevent disturbance and harassment of game animals during a period when physical stress is already relatively high. Managers also recognize the counterintuitive logic of compounding climatic stress with late hunting seasons, but such seasons are sometimes the only available management tool. Very often, road closures can be used as an adjunct method of reducing simultaneous disturbance by hunters and vehicles. Gates and Hudson (1979), found that activity by elk in cold temperatures results in a thermoregulatory penalty, that is, it takes more energy to move in winter than in the fall. Thus, while inactivity provides an energetic advantage for animals exposed to cold, forced activity caused by human disturbance exacts an energetic disadvantage. Geist (1978) further defined effects of human disturbance in terms of increased metabolism, which could result in illness, decreased reproduction, and even death.

The overt expression of this cost can take a number of forms, ranging from an increase in general alertness to a slow retreating movement to outright flight, depending on the ungulate species and the type of disturbance. Denniston (1956) reported that moose were tolerant of close observers when no quick motions or loud noises were made, but LeResche (1966) observed a number of different reactions ranging from flight, to drifting away, to disinterest.

Of the ungulate species for which relationships with humans and disturbance have been reported, the bighorn sheep appears to be most susceptible to detrimental effects. Berwick (1968) suggested that harassment may be debilitating to winter-stressed animals, and several other authors have agreed. Geist (1971) speculated that harassment by recreationists may be fatal to sheep, and Dunaway (1971) considered disturbance caused by human recreation to be a factor limiting populations of bighorn sheep in California. Stemp (1983), who used observations as well as heart rate data to monitor response to harassment, reported that overt behavior was a poor indicator of the stress response of bighorn sheep to human intruders.

Specific investigations of winter disturbance have primarily examined skiers, snowmobiles, and, to a lesser extent, helicopters. Snowmobiles have received far more attention than all other disturbance factors combined, and the reports, not unexpectedly, express the complete range of possible results. Bollinger, et al. (1972) reported that deer activity increased when snowmobiles were present, but deer were not driven out of their normal home range. Lavigne (1976) reported that snowmobile trails enhanced deer mobility during periods of deep snow in Maine. This study was followed by a report (Richens and Lavigne 1978) that white-tailed deer were not driven out by snowmobiles, but were following snowmobile trails because the snow was firmer. In a slightly more negative series of studies, Eckstein and Rongstad (1973), Dorrance et al. (1975), and Eckstein et al. (1979) found that while some deer showed avoidance when snowmobiles were present, there were no significant changes in home range or daily movement patterns. Doyle (1980) summarized two studies reporting negligible impacts by snowmobiles on the environment.

The majority of reports on this subject, however, dwell on negative aspects of snowmobile traffic. Malaher (1967) complained that snow machines were illegally used for hunting, while Neuman and Merriam (1972) reported the loss of insulating quality in snow packed by snowmobiles as well as damage to vegetation. Baldwin (1970) suggested a luxury tax on snowmobiles for the damage they cause. Fancy and White (1985) found that the energy cost for caribou of cratering through snow compacted by a snowmobile was 2-4 times as great as for uncrusted snow. Other authors have reported disturbance of wild animals as disparate as muskoxen (McLaren and Green 1985), caribou (Fancy and White 1985), and white-tailed deer (Kopischke 1972, Moen et al. 1982,). Huff and Savage (1972) reported that the size of home ranges for whitetails was reduced in high-use areas, and snowmobile use appeared to force deer into less preferred habitats. Aasheim (1980) observed that animals accustomed to humans are less affected by snowmobiles than animals in more remote areas.

Apparently, however, snowmobiles are less disturbing than cross-country skiers. Freddy (1986*a*) and Freddy et al. (1986), found that responses by mule deer to persons afoot, when compared to snowmobiles, were longer in duration, more often involved running, and involved greater energy costs. Aune (1981) classified responses of wildlife to winter recreationists in Yellowstone National Park as attention or alarm, flight, or, rarely, aggression. He agreed with Chester (1976) in concluding that winter recreational activities were not a major factor influencing wildlife, although minor displacement was observed. Such displacement might have indicated only movement away from active ski trails, as reported for elk by Ferguson and Keith (1982) in Elk Island National Park, Alberta, but it could also have involved overwinter displacement as reported for Elk Island moose (ibid.). Almost certainly because of increasing recreational pressure in Yellowstone National Park, Cassirer et al. (1992) found that 75% of flight behavior by elk occurred within 650 m of skiers and recommended that restrictions be imposed. Parker et al. (1984:484) observed, “Flight distances decline from early to late winter as the animals become habituated and as body energy reserves are depleted. Greater flight distances occur in response to skiers or individuals on foot than to snowmobiles, suggesting that the most detrimental disturbances to the wintering animal is that which is unanticipated.” This greater response to unpredictable or erratic disturbance was also noted for pronghorn (Segerstrom 1982) and bighorn sheep (Stemp 1983).

Most research testing helicopter disturbance to wildlife has been related to oil exploration activities. However, these data can be applied to some recently popular winter skiing activities. Bleich et al. (1994) recorded negative responses of bighorn sheep to helicopter overflights. Joslin (1986b) reported a decline in mountain goat reproduction and/or recruitment of kids in response to disturbance by helicopters in Montana, and Côté (1996) reported that mountain goats were disturbed by 85% of all flights within 500 m. Foster and Rahs (1985) have even suggested that localized goat mortality and temporary range abandonment is a result of hydroelectric exploration activities. Luz and Smith (1976) found that pronghorn responses to helicopters varied from mild to strong in relation to decibel levels.

The degree of disturbance caused by skiers, snowmobiles, and helicopters has mostly been reported in terms of flight distance or in some observed change in behavior manifested by animals. Based on elk heart rate data, Chabot (1991) showed that even when disturbances do not induce an overt behavioral response, the increased heart rates can result in relatively high energy expenditures. These results have been confirmed and expanded for a variety of ungulates including mule deer (Freddy 1984*a*, Weisenberger et al. 1996, Freddy 1977), caribou and reindeer (Nilssen et al. 1984, Fancy and White 1985, Floyd 1987), white-tailed deer (Moen 1978, Moen et al. 1982), elk (Ward and Cupal 1979, Lieb 1981, Chabot 1991), red deer (Epsmark and Langvatn 1985, Herbold et al. 1992, Price and Sibly 1993) and bighorn sheep (MacArthur et al. 1979, MacArthur et al. 1982, Stemp 1983, Geist et al. 1985, MacArthur and Geist 1986, Hayes et al. 1994). In summary, it has been shown repeatedly, and for virtually every ungulate species, that even minor, seemingly harmless sorts of disturbance cause increased heart rates -- and increased energy expenditure.

Displacement Impacts

In addition to the obvious energy costs, continuing disturbance by humans can result in a variety of insidious effects that are less easy to document. Canfield (1984) noted that effects of increased access associated with a high-voltage powerline were accentuated because of the placement of the powerline corridor in open wintering areas and on the edge of the timber that separated bedding and feeding areas. Vogel (1983) reported that white-tailed deer inhabiting more developed areas became increasingly nocturnal and secretive and made greater use of cover during the day. Canfield (1984), based on 24-hour telemetry work, found that elk utilized the more open, productive habitats in close proximity to human activity nocturnally. Similarly, Morgantini and Hudson (1979) reported that harassment by vehicle activity and the hunting season reduced elk use of open grassland and resulted in overgrazing of marginal areas. Yarmoloy et al. (1988) were able to demonstrate how little disturbance was required to produce such modified behavior. They reported a study in which intentional harassment of three mule deer does for 9 minutes/day for 15 days in October caused the deer to begin feeding at night and using cover more frequently. They also suggested a secondary effect through reduced reproduction.

Another potential result of disturbance or harassment of wintering animals can be movement from historical and accepted winter ranges (usually on public land) to private lands where haystacks and forage for domestic livestock are at risk. Rognrud and Janson (1971) reported damage to private property after natural food plants on the winter range had been eaten by elk.

There are also situations in which flight and/or displacement are not possible, and, for lack of other options, animals become habituated to disturbance. Morrison et al. (1995) reported responses of elk to ski area development in Colorado were negative, but not as great as predicted. In part, this may have been evidence of habituation of the kind reported by Schultz and Bailey (1978) in which elk wintering adjacent to Rocky Mountain National Park often used a residential area at night and were little disturbed by normal visitor traffic on roads. Most species represent some risk to humans, and in many cases the damage to residential landscape vegetation is untenable. Habituation at this level can be far more serious than is usually suggested by complaints about damage to landscape plantings (Thompson and Henderson 1998). Once habituated to urban environments, ungulate populations are very difficult to control. In both Colorado and Montana, habituated white-tailed deer have attracted mountain lions to the edges of housing developments, thus increasing the risk to both humans and their pets.

Conclusions

Based on the available research, wildlife and land managers have little reluctance in recommending that human disturbance of wintering animals be prevented. We propose the following guidelines as minimum acceptable considerations for protecting ungulates on Montana winter ranges. In addition, we believe there should be management flexibility in application depending on the degree of winter severity. Such flexibility could be used to trigger emergency restrictions in specific situations.

Guidelines/Recommendations

Management techniques that reduce human disturbances on ungulate winter range include the following, by priority:

1. Route winter-use facilities, trails, and/or roads away from ungulate wintering areas (this may include high-elevation areas used by some sex and age classes or during mild conditions).
2. Establish designated travel routes within area closures where recreation occurs on or across winter ranges (no off-road/trail use) to make human use of wintering areas as predictable as possible (if needed, use could be restricted to mid-day time frames, dogs could be restricted of excluded, and low speed limits could be imposed on snowmachines). Examine routes to ensure that bedding and feeding areas are not separated, that open ridges are avoided, and that topography serves to buffer noise and disturbance.
3. Monitor ungulate use of areas that receive high-impact winter use by snowmobiles and/or skiers and identify and mitigate any potential conflicts.

4. Actively enforce travel restrictions on ungulate winter ranges.
5. Use interpretive signing to inform users of the importance of ungulate winter range and that they should not approach wildlife closer than 150 m.
6. Restrict antler collection and other recreational activities with potential to displace ungulates during spring green-up until at least May 15th (preferably leaving some flexibility, based on snow conditions, to allow animals to disperse naturally from their traditional winter concentration areas).

Information Needs

Parker et al. (1984:486) concluded that "Unnecessary energy expenditures . . . can be limited by minimizing human disturbances." Standards for preventing disturbance, however, have been variable. Severinghaus and Tullar (1975) concluded that snowmobiles should not be allowed in wintering areas and trails should be kept at least one half mile from such areas. Freddy et al. (1986) concluded that preventing locomotor responses would require persons afoot and snowmobiles to remain >191 m and >133 m, respectively, from mule deer. Côté (1996) recommended restriction of helicopter traffic within 2 km of alpine areas and cliffs that support mountain goat populations. Additional research might establish an absolute minimum disturbance formula for each species, but we recommend an overall conservative approach as more useful to managers.

SUMMER

Ungulate physiology and behavior favor physical development and fat accumulation in both sexes during the biological season after birthing (e.g., early June through October). Adult males must build fat reserves for the fall breeding season while meeting energy demands of horn and antler growth. Males of all ungulate species grow either antlers or horns, and in several species the growth rate is one of the spectacular events in nature. Adult females must obtain forage of adequate quantity and quality to meet energy demands of lactation while simultaneously recovering from weight lost during the previous winter and building fat reserves for the coming winter. It has been more than 30 years since Verme (1967:419) suggested, ". . . that the quality of spring, summer, and fall foods of the whitetail might be more important than many people think in determining the number of future targets for the hunter." A decade later, Mautz (1978:90) observed, "It was at first a logical conclusion that research emphasis should be put on that time of the year where weight loss occurs and mortality is most evident. It appears now, however, that the major emphasis should be shifted from the analysis of the nutritive value of winter foods to studies of summer and fall food availability and digestibility and other factors influencing the accumulation of body fat."

Verme's (1965) research with penned white-tailed does on controlled diets showed that starvation during summer caused a late and irregular rut, yielding 0.95 fawns per doe while well-fed deer had 1.74 fawns per doe. More recently, Hines et al. (1985), in a controlled test of yearling bull breeding efficiency, found that breeding deficiencies were related to the level of fat reserves stored by females. Parker et al. (1999) have concluded that reserves accumulated during summer were critical to winter survival of black-tailed deer, and Cook et al. (1996) reported that forage intake and nutritional quality during August and September can be determinants of winter survival of elk calves.

Prior to restoring their own body condition, many female ungulates must also support young of the year. Moen (1978) estimated energy expenditure of a white-tailed doe with twin fawns at four times baseline metabolism during lactation, and Carl and Robbins (1988) have found that energetic costs in deer were five times greater to the doe than to the neonate.

For virtually all ungulate species, habitats available during summer represent a substantial increase in geographic area as compared to winter range. Some ungulate species access high-quality forage throughout summer by migrating upward in elevation to feed on vegetation in early phenological stages and/or by withdrawing to areas surrounding seeps, springs, and other wet sites within seasonal home ranges where vegetation remains highly digestible. Lieb (1981) reported that elk expanded their home range from spring through midsummer and thereafter reduced areas of use through early fall. A few ungulate species, in particular mountain goats and bighorn sheep, are very much limited in habitat choices by topography. Thus, even though the total extent of summer habitat is usually not limiting, the important features of the habitat may be limiting (Leege 1984).

Natural Physiological and Behavioral Adaptations

During summer, ungulates continue to follow the law of least effort as a strategy for retaining and storing as much energy as possible (Geist 1982). However, recreationists can impact this effort through either direct disturbance of animals or by disrupting access to essential forage resources. Energetic costs of disturbance have been well described for winter conditions, but not nearly as well for the summer period. Costs of locomotion are much less than during periods of deep or crusted snow in winter, but energetic demands of the summer season are relatively higher than generally recognized because most ungulates are more sensitive to heat than to cold. Chappel and Hudson (1978) reported resting metabolic rates of caribou were lowest in February and highest in May. Renecker and Hudson (1986) reported moose are easily heat stressed, and that respiration rate increased above 14^{o} C. Lieb (1981) reported elk activity was reduced after temperatures exceeded 75^{o} F.

Physiological Impacts of Human Disturbance

Several authors (McMillan 1954, Denniston 1956) have reported moose tolerance of observers when no quick motions or loud noises were made. Bansner (1976) has reported a similar observation for mountain goats, and Goodson (1978) found that bighorn sheep were more tolerant in areas where they are accustomed to seeing people. Miller and Smith (1985), however, reported that sheep exhibited stronger reactions to 1 or 2 humans on the ground than to parked vehicles or a light airplane circling overhead. Controlled experiments with elk, pronghorn, and bighorn sheep (Bunch and Workman 1993) resulted in habituation for most disturbance factors tested. The exceptions were people on foot and aircraft at low elevations. In California, black-tailed deer in a vehicular recreation area were reported to avoid active OHV areas during peak use, but returned to established home ranges after traffic levels subsided (Ferris and Kutilek 1989).

Any apparent level of tolerance, however, may be misleading. MacArthur et al. (1982) reported responses to disturbance of bighorn sheep were detected using heart-rate telemetry that were not evident from behavioral cues alone. The appearance of a human within 50 m of sheep resulted in a 20% rise in mean heart rate (MacArthur et al. 1979). Stemp (1983) also reported increased heart rates in bighorn sheep relative to human intruders in their habitat. As an isolated event, such a disturbance is probably not significant, but the energy costs associated with repeated disturbance can be considerable.

Ungulates may be especially vulnerable to disturbance around special habitat features, such as salt licks. For example, female and young mountain goats make daily trips to salt during periods of the summer, sometimes venturing several hundred meters from escape terrain (Thompson 1981). Kids may face increased risk of separation from nannies while fleeing when surprised or distracted by humans on a salt lick as well as higher mortality if not reunited. Although wild ungulates normally do not require supplemental salt, they will use salt placed within their summer home ranges and may be baited into traps with salt placed by researchers. Hamilton et al. (1982) reported that bighorns did not abandon habitat because of recreational use but did avoid an important lick when people were present. Sites where salt is or has been placed for cattle often attract ungulates and are accessible viewing areas for general recreationists and wildlife photographers. Potential impacts on the survival of individual animals are heightened under such circumstances.

Displacement Impacts

Perhaps more important than the short-term energetic effects of human disturbance are the longer-term influences of displacement from selected habitats. Relatively high levels of human disturbance are often confined within a narrow corridor through wildlife habitat, such as a road. These may have little or no measurable impact on ungulates during summer if essential foraging sites are not directly impacted or limited in availability across the summer home range. However, a substantial number of studies have demonstrated that vehicle traffic on forest roads does establish a pattern of habitat use in which the areas nearest the road are not fully available for use by elk (Ward et al. 1973; Rost and Bailey 1974, 1979; Rost 1975; Marcum 1976; Perry and Overly 1976; Thiessen 1976; Ward 1976; Lyon 1979*a*, 1983; Edge 1982; Edge and Marcum 1985,1991; Edge et al. 1987; Marcum and Edge 1991). The extent of reduced habitat use can be very substantial. With only two miles of roads open to vehicular traffic per square mile, the area affected can easily exceed half of available elk habitat (Lyon 1983).

Once the original purpose of a forest road is satisfied (normally a timber sale), management agencies tend to assume that daily traffic is primarily recreational in nature. Accordingly, many roads have been gated under the assumption that limited use by "administrative traffic" will not unduly disturb elk and other wildlife. Unfortunately, this assumption is untrue, and even a limited amount of administrative traffic behind closed gates provides more than adequate reinforcement of the avoidance behavior (Lyon 1979*b*).

As the size of the area affected by recreationists expands to fill an increasing proportion of the animals' summer range, the potential for impact increases because options decline for acquiring high-quality nutrition with the least possible effort. In some cases, there may be no options available. Populations of mountain goats and bighorn sheep, for example, are often confined to relatively narrow bands of suitable habitat associated with very steep and rocky slopes. Population impacts may be expected where summer recreation is concentrated in such areas. Kuck (1986) reported, ". . . that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeastern Idaho, but cannot compensate for disturbance on important seasonal ranges. . . " such as those used for calving and winter migration. Similarly, Lieb and Mossman (1966) found that human disturbance caused Roosevelt elk with young calves to move to secondary forage areas away from the central parts of their home ranges. In Colorado, Phillips (1998) was able to show that repeated displacement during the calving season resulted in major declines in survival of elk calves. He recommended that recreational traffic be routed away from areas in which elk were known to calve. In Montana, summertime occurrences of known human recreational impacts on reproductive performance in ungulate populations have been limited to relatively few situations and circumstances, but managers need to be aware of the potential problems.

Bear and Jones (1973) reported that camping, hiking, and ORVs negatively influence sheep distributions and activities. Many other authors have confirmed these observations and recommended regulating ORV use and human activities where they affect sheep (Tevis 1959; Wilson 1969, 1975; Dunaway 1971a; Geist 1971b; Graham 1971, 1980; Demarchi 1975; DeForge 1976; Douglas 1976; Horejsi 1976, 1986; Elder 1977; Hicks and Elder 1979; Thorne et al. 1979; Leslie and Douglas 1980; Skiba 1981; Hansen 1982; Stevens 1982; Stemp 1983; King 1985; King and Workman 1986; Krausman and Leopold 1986a; Stockwell et al. 1991; and Harris et al. 1995a). Wehausen et al. (1977), however, concluded that human disturbance was not as important as previously assumed.

Areas of intensive summer recreation, where they occur in the urban interface or very near cities, are often crisscrossed by many miles of trails across thousands of acres of summer habitat for deer and elk. Persistently high levels of forest recreational use by hikers, joggers, mountain bikers, and Frisbee golfers are fueled by close proximity to a major human population center. Where summer recreational activities approach high levels, elsewhere or in the future, impacts on reproductive performance of ungulate populations may be expected. However, little direct research describing this level of disturbance has been reported. Bullock et al. (1993) recorded the responses of deer in two English deer parks and reported encounter rates with people, dogs, and vehicles between 6 and 40 per hour. Resulting withdrawal percentages by deer were less than 10%. Areas of potential concern for the future include increasing development of summer recreational facilities at high-elevation ski areas and development of expansive forest trail networks for mountain bikers. Morrison et al. (1991) discovered that ski-area development caused elk to partially abandon the area developed along with a concurrent reduction of timbered-habitat use from 80-95% down to 20%. In a follow-up study, Morrison et al. (1995) compared two ski-area developments and found that physical disturbance caused a 30% reduction in elk use of one area while human activity in another area led to 98% reduction in elk use. Recreational use may also alter migratory movement patterns of ungulates, like deer and elk, using public lands and result in situations where more time is spent on private lands.

Indirect Impacts

Under current conditions in Montana, indirect impacts on ungulates by recreationists may also be of major immediate concern. Vehicular traffic on and off roads has been linked with high rates of establishment and spread of noxious weeds in wildlife habitat. Competition from noxious weeds may reduce quality and quantity of summer forage for ungulates, resulting in poorer reproductive performance during the lifetime of an animal. Observations in western Montana have shown that noxious weeds are capable of influencing ecosystems at the landscape scale, and risks of habitat impacts are high without an aggressive program of prevention and rapid response to first weed establishment. Education and management of recreationists is a fundamental component of any weed prevention program. The potential for spreading noxious weeds across the landscape should also be a factor in the evaluation of road-closure decisions.

Conclusions

For many years, winter ranges were considered the most limiting component of ungulate environments. However, as our knowledge of ungulate physiology and behavior has increased, it has become apparent that weight gains and nutritional contributions of high quality summer range may be of equal or greater importance in determining winter survival and reproductive success. Based on our interpretation and synthesis of available literature, we propose the following guidelines for management of recreation on summer range.

Guidelines/Recommendations

Management techniques that reduce human disturbances on ungulate summer range include the following by priority:

1. Route summer recreation facilities away from key foraging areas (drainage heads, mesic areas) and consider restrictions on existing roads or trails to minimize disruption of these important areas.
2. Establish designated routes within area closures to make human use of summer range as predictable as possible.
3. Reduce human intrusions (through road or trail restrictions and/or education) into areas where ungulates are limited to easily identified habitat areas (such as areas used by bighorn sheep or mountain goats) or where limited areas of habitat are either desirable or exceptionally productive.
4. Limit open road densities to zero in scattered key areas and less than 1 mile per section elsewhere; reclaim roads that are closed and re-establish native vegetation to help keep travel violations to a minimum.
5. Minimize administrative uses of and the granting of travel variances for closed routes on summer range.

Information Needs

The effects of open roads on summer habitat use is extremely well documented for many ungulates. Our primary deviation from published literature involves the recommendation for scattered areas of zero road density to protect key summer forage sites.

HUNTING SEASON

Hunting is an important tool for managing ungulate populations. Hunting is also an important cultural activity (Posewitz 1994) that annually involves nearly half the adult male population and one-fifth of adult females in Montana (Merrill and Jacobson 1997). Big game hunting is also a major economic activity and an important contributor to the state economy (Brooks 1988, Duffield and Holliman 1988, Loomis and Cooper 1988). Hunting almost certainly has more immediate effects on ungulate population densities and structures than any other recreational activity in this state.

Little attention has been paid to possible short-term effects of the hunting season on animal condition. Because “Elk enter the fall season in near peak body condition.” (Youmans 1992:5), energetic costs of disturbance by hunters appear less important than at other times of the year. Nevertheless, there are costs.
Hurley (1994) reported that distances moved by elk between telemetry relocations in Montana increased significantly during the hunting season. And in Utah, Austin et al. (1989) reported a study in which mule deer bucks killed on the second weekend of the hunting season consistently weighed less than bucks of the same age class killed the first weekend. They blamed (p.35) “. . . hunter harassment, although other factors, including rutting activity and hunter selection, may also be important.” Flook’s (1970) observations of elk in several Canadian National Parks suggest breeding activity is not of secondary importance. He wrote (p.5), "A number of factors contribute to shortening the life span of bulls, probably a major one being the depletion of their fat reserves during the breeding season in the autumn. This leaves bulls less well prepared to survive the winter." In addition, both Irwin and Peek

(1979) and Lyon and Canfield (1991) have reported elk displaced by hunters from preferred areas to areas of larger patches and less diversity.

Longer-term effects of hunting on population structure and productivity are relationships best understood for deer and elk. They involve hunter opportunity, security during the hunting season, and the resulting vulnerability of hunted animals. For many years, management plans for big game have assumed that harvest regulations can maintain populations at near optimal levels as determined by winter range carrying capacity (Leopold 1933) and landowner tolerance. As knowledge has increased, managers have broadened this perspective to recognize that among factors which influence population status, those most influential are weather, habitat condition, predation, and hunter harvest (MFWP 1998:2). Because the interrelationships of these factors are so complex, it is easy to overlook the fact that if not carefully managed, hunting recreation and hunter access can have very negative effects on the sex and age class distribution of hunted animals, on the amount and quality of hunting recreation available, and on net productivity of ungulate herds.

Hunter Opportunity

Hunter opportunity includes "An array of options that allows hunters to choose situations that are personally rewarding." (Lyon and Christensen 1992). For Montana elk hunters, maximum hunter opportunity occurs when the statewide recreation objectives for elk are met. These include a 5-week general season, a harvest in excess of 20,000 elk, about 5.5 hunter days for each of about 123,000 elk hunters, and an annual bull harvest comprised of at least 25% branch-antlered bulls (Youmans 1992:19). Deer management objectives are more complex and include an adaptive harvest management strategy (MDFWP 1995) with a variety of hunting regulation alternatives. The greatest hunter opportunity occurs when seasons are long (the current 5-week general season is considered adequate to meet the definition of long), regulations are minimal (hunters have many choices on where, when, and what they hunt), and there are good opportunities to harvest an animal throughout the season with some chance for harvesting a mature animal.

Logically, any factor that leads to shorter seasons, more regulations, and restricted age structures in populations can be considered detrimental to hunter opportunity. Conversely, conditions that allow for longer seasons, require less regulations, and help maintain desired age structures would be considered beneficial to hunter opportunity. In one way or another, conditions that contribute to increased hunter opportunity involve security during the hunting season.

Security

For elk, security has been defined as "The protection inherent in any situation that allows elk to remain in a defined area despite an increase in stress or disturbance associated with the hunting season or other human activities." (Lyon and Christensen 1992:5). And Youmans (1992:7) has declared, "Emphasis on maintaining fall security areas and secure migration corridors is essential to meeting statewide demands for public hunting opportunity, maintaining a variety of recreational experiences and maintaining a diverse bull age structure." When security is inadequate, elk may become increasingly vulnerable to hunter harvest and, as Lonner and Cada (1982) pointed out, "A lengthy hunting season has little meaning if the majority of the harvest occurs in the first few days." Thus, poor security can lead to a decrease in hunter opportunity and the inability of managers to meet objectives for sex and age structure.

One of the surest methods of increasing elk security has been to close roads and/or areas to motorized vehicles. Lonner and Cada (1982) assumed an inverse relationship between density of open roads and hunter opportunity by using the rationale that high road densities make elk highly vulnerable to hunter harvest. Basile and Lonner (1979) found that vehicle closures generally increased the time hunters spent walking and tended to prolong the time required to achieve the desired harvest. In Idaho, Leptich and Zager (1991) found a strong relationship between restricted road access and bull survival. However, security is more complex than just low road densities and can be influenced by a multitude of factors that may vary from one population or habitat complex to the next. Hurley (1994), for example, concluded that, "Restricting motor vehicle access can reduce elk vulnerability, but road closures must encompass large areas to be effective." In all cases, security is that combination of variables that provide protection for vulnerable animals during the hunting season.

Hillis et al. (1991) described the minimum-sized area providing elk security in habitat types west of the Continental Divide as a nonlinear cover patch greater than 250 acres in size and more than 1/2 mile from an open road. They defined a threshold under which 30% of forested landscapes dedicated to security would presumably provide for adequate bull carryover. They also concluded that other factors, such as topographic ruggedness, hunter-use patterns, animal-use patterns, and adjacent private-land access could significantly alter bull survival somewhat independently of the size of security patches or road density. Lyon and Canfield (1991) tested these relationships with radioed elk and found that elk selected for larger cover patches after the onset of the hunting season.

Hillis et al. (1991) cautioned that security cannot be defined by a "cookbook" recipe, but must be determined and mapped by qualified local biologists in consideration of all potential variables. In support of the concept of locally defined security variables, Weber (1996) examined a large area in western Montana to determine where hunters actually killed elk (by locating gut piles) and compared the locations against a number of security variables. He concluded that cover patch sizes described by Hillis et al. (1991) might be inadequate, and that security areas significantly greater than 250 acres might be needed if a moderate level of bull carryover is desired.

Unfortunately, environmental variables do not provide security in all cases. Unsworth and Kuck (1991) determined that increasing hunter numbers will ultimately overwhelm any level of security and result in rapid and total bull harvest. This confirms what earlier researchers in Oregon found, that road closures did not necessarily result in improved bull carryover, presumably because of the overwhelming number of hunters (Coggins 1976). Similar relationships exist for deer populations. In a management analysis of Montana deer hunting (MDFWP 1995:3), the authors concluded, ". . . although different season types can alter the age structure of a deer population, population fluctuations will still continue due to changing environmental conditions and other factors." Thus, limiting buck harvest will not consistently result in an older age structure.

And finally, Burcham et al. (1998) have described one additional security variable in the mixture managers must consider. Between 1983 and 1993, they reported increased use of private lands by elk in the Chamberlain Creek drainage of western Montana. During a period of timber harvest and a threefold increase in numbers of hunters, posted private lands acted as security for elk despite being near open roads and mostly non-forested, agricultural land. Elk that did not use these private-land refuges selected more traditional security cover of closed-canopy coniferous forest far from open roads.

In summary, the deer and elk literature shows several strong relationships between age and sex structure of ungulate populations resulting from hunting harvest and environmental factors such as roads, topography and cover. These relationships, in turn, affect short- and long-term hunting opportunities. Managers of public lands have control over only a few of the potential variables that contribute to security, including retention of important vegetative cover, travel management, and enforcement of travel regulations.

In terms of security/harvest rate/carryover issues for other species including goats, bighorn sheep, and moose, the literature is less conclusive. For mountain goats (and bighorn sheep in many circumstances), the level of security (measured by roadless, rugged topography) can be extremely high, yet the hunting success rate remains consistently high throughout the state. In this situation, the number of hunting tags issued determines the harvest, not the amount of security on the landscape. High success rates are due to the species' limited trophy-entry status and high demand and vulnerability. In some cases, the issuance of special tags for antlerless elk and deer may also result in high success rates. However, this is not always true, and managers may encounter situations where reducing security will be necessary to achieve management objectives.

Vulnerability and Productivity

"In other western states, reductions in elk security and concurrent increases in elk vulnerability have prompted substantial reductions in public hunting opportunity. . . " (Youmans 1992:9). Experiences in northeast Oregon in the 1970s and 1980s (Leckenby et al. 1991) serve as a good example of the effect that hunting recreation can have on ungulate productivity when the quarry is overly vulnerable. Reports by the Oregon Department of Fish and Wildlife were mostly limited to elk, but their experience should serve as a caution for management of other ungulates relative to disruption of normal breeding dynamics.

Elk hunting opportunity declined drastically in northeast Oregon in the late 1980s as a result of ". . . increased public access and reductions in cover. . . ." (Leckenby et al. 1991:89). In the early 1970s many hunting districts in northeast Oregon had little if any bull carryover. Attempts to improve bull carryover through road management largely failed (Coggins 1976). Because of low bull/cow ratios and declining calf recruitment, the Oregon Department of Fish and Wildlife shortened seasons, split seasons, and limited numbers of hunters. At about this same time, Smith (1980) reported a strong correlation between the presence of older males in the breeding population and significantly higher pregnancy rates in Roosevelt elk of the Olympic Peninsula. In an Oregon study a few years later (Hines et al. 1985) concluded that is it not prudent to depend on yearling breeders, that a few older bulls are needed to ensure maximum herd productivity, but that pregnancy rates are actually determined by nutritional level among the cows. Following studies of breeding by known-age bulls in the captive Starkey elk herd, Noyes et al. (1996) explained the Oregon elk decline with the following rationale:

1. High hunter numbers and limited security results in a long-term total bull kill.
2. Yearling bulls (protected as calves during the preceding hunting season) must do 100% of the breeding.
3. Inexperience and immaturity of those bulls cause most cows to breed at the second estrus, which means that calves are born late.
4. Younger calves have reduced body weight going into their first winter.
5. Consequently, there is lower overwinter survival and overall reduced productivity.

Fortunately, there has been no indication that any Montana elk herd is in decline because of poor bull carryover. In the Gravelly Range, one of the most studied and heavily hunted elk herds in the state has entered the breeding season in recent years with an average 11.5 bulls over 2 years old (per 100 cows) but with only 2.3 bulls > 3 years old. Pregnancy rates have consistently remained above 95% (K. Hamlin, Montana Department of Fish, Wildlife and Parks, personal correspondence). However, to avoid Oregon's experience, Montana has developed hunting-district-specific bull and buck carryover objectives in the Montana elk plan (Youmans 1992) and the Montana deer plan (MFWP 1998), respectively. Officially endorsed by both the U.S. Forest Service and Bureau of Land Management in Montana, the bull carryover objectives outlined in the elk plan are (in theory) cooperatively shared by all land management agencies. In practice, there is quite a bit of variation in how the various agencies work together in meeting these objectives. The Deer Analysis, at this date, lacks any such multi-agency commitment.

Based on the same "interrupted breeding cycle" relationships that resulted in the elk population problems in Oregon, there are some aspects of Montana's hunting season and forest-road-management practices that place deer and elk populations "at risk" for declines in productivity. For example:

1. Youmans (1991) concluded that severe weather contributed to high bull harvest more than most other factors. His results strongly indicated that holding the general hunting season through the Thanksgiving weekend significantly increases bull vulnerability and reduces bull carryover. Consequently, it is concluded that timing of the general season places Montana's deer and elk populations at some risk from a productivity standpoint.
2. While the archery harvest data suggest that a low number of animals are harvested, the level of *unrecovered* elk (Cada 1991) indicated one elk wounded for every elk legally harvested. Specific effects on timing and genetic selection aspects of breeding suggest that the archery season could have adverse effects on elk productivity. Although some of this effect may be mitigated by additional environmental security (e.g., road restrictions) hunting season closures on national forest lands generally take effect October 15 and end December 1. These restrictions do not include the archery season and the potential negative effects of human activity superimposed on the peak period of the elk rut.
3. The general big game season overlaps the peak rut period for deer. An analysis of deer hunting in Montana (MDFWP 1995) points out that large buck availability (and carryover) are at critical stages in some deer herds, and statewide harvest data show large bucks make up a very small percentage of the population. Data also show that buck harvest accelerates during the last week of the season. Therefore, the timing of the general season can place deer populations at risk due to the excessive (or potentially excessive) vulnerability of the few remaining older bucks during the rut.

Ethical Considerations

As we enter the 21st Century, sport-hunting will more often be seen as an anachronism in our modern culture. Even in Montana, where a large proportion of the population participates in hunting, and an even larger proportion regularly consumes game meat, it is difficult to justify hunting as necessary to prevent human starvation. Thus, in Montana as elsewhere, hunters are “. . . a minority; and if we are to continue, we must do it in a way that is acceptable to the majority.” (Posewitz 1994:110). As with many other areas of human behavior, legislation is but a partial answer. In the end, ethical behavior by hunters will be determined by education and peer pressure. We include in this review two examples of hunter behavior regarding ungulates that can only be continued to the detriment of all sport-hunting.

Because pronghorns occupy areas without forest cover, hunting poses a special challenge relative to ORV use. Traditional pronghorn hunting involves observing the pronghorn, usually at extremely long distances; and stalking to within 100-250 yards. At this distance, shooting a standing animal usually assures a clean kill. Pronghorn are moderately easy to stalk, and the terrain is normally relatively gentle. Hunters usually derive a high level of satisfaction from this type of hunting experience, and nonhunters would likely view such a hunt as an ethical experience.

Recently, many pronghorn hunters have reported seeing hunters “herding” fleeing pronghorn with ORVs and taking “flock shots” toward running herds at extremely long ranges, often in excess of 500 yards. Such vehicle-oriented hunting has potentially severe consequences for hunting opportunities, including: (1) significant overharvest due to crippling loss, which can only be compensated for by more restrictive regulations; (2) a total breakdown in recreational opportunities for all the pronghorn hunters afield (i.e., if pronghorn herds are being run continuously throughout the daylight hours by ORVs, *nobody* has a reasonable opportunity to pursue or harvest an animal); and (3) a loss in public credibility because such hunting is likely to be viewed as clearly unethical (Posewitz 1994). Although this unethical hunting behavior is already illegal under Montana statutes (87-3-101), it is certainly true that increased enforcement, along with adequate travel planning and ORV restrictions, could help minimize this kind of activity.

There is an existing “trophy” market and buyers who ". . . will pay $10,000 to $35,000 to kill mature 'shooter' bulls behind fences." (Stalling 1998:72). It requires only minutes on the internet to locate facilities offering a “guaranteed kill” of a record bull elk at prices ranging from $4,000 to $15,000 depending on the Boone and Crockett score. Geist (1985:597) observed, “there is danger in allowing wildlife to become a symbol of the rich, making hunting a frivolous pastime of the wealthy . . . . ” The killing “trophy” big game animals on game farms is clearly a violation of the “fair chase” ethic (Posewitz 1994). In addition to the obvious ethical problems, Lanka and Guenzel (1991) describe other concerns regarding game farms, including escape, diseases and parasites, hybridization, social and habitat competition, control and enforcement, and impacts of public hunting. Game ranching “. . . will mean the end of elk as we know them through genetic pollution, diseases and competition with uncontrollable feral populations of exotics.” (Geist 1991:292).

Posewitz (1994) describes various hunting practices in terms of whether or not they are perceived as being ethical. He labels pursuit of game by vehicle, and hunting of game on game farms as clearly violating the sense of “fair chase.” Because of potential impacts on sport-hunting and negative effects on the animals themselves, vehicular pursuit anywhere and the killing of “trophy animals” in game farms should both be prohibited.

Conclusions

The literature on security and buck/bull carryover is generally adequate and shows a strong relationship between adequate security, including the use of restricted vehicle access, and predicted buck and bull carryover. The literature is somewhat less conclusive on the potential for hunting to negatively affect herd productivity as mature males are lost from populations. The literature is even less conclusive in describing relationships for ungulates other than deer and elk, but our interpretation and synthesis is based on an assumption of strong similarity.

Most of the existing literature deals with conventional vehicles using open roads. The effects of ORVs using closed roads/trails or travelling off-road is not well documented. It can be logically inferred however, that ORVs travelling on trails or closed roads are comparable to conventional vehicles using roads. Additionally, it can be inferred that

ORVs travelling in unroaded landscapes, especially when most main ridges are accessible to ORVs, is comparable to conventional vehicles travelling in unrestricted, high road-density situations.

Even though there has been little research reported on ethical behavior in recreational hunting, the generally accepted definitions of “fair chase” and “sportsman” provide clear evidence that there are acceptable standards in the public mind. Pursuit of game animals with vehicles and killing of trophy animals within game farm exclosures are two examples of hunter behavior that exceeds those standards.

Guidelines/Recommendations

Management techniques that reduce the potential for overharvest of ungulates and help promote ethical behavior by hunters during the big game hunting season include the following, by priority:

1. Establish interagency objectives by hunting district and herd unit for deer and elk security that are consistent with state plans for these species.
2. Maintain and improve security through road restrictions and cover management, recognizing that area closures are far more effective that individual road closures.
3. Limit all motorized users (including ORVs) to designated routes.
4. Enforce hunting season restrictions (including the use of such programs as TIP MONT where hunters can report travel violations).
5. Modify hunting regulations where objectives for populations cannot be met through road and cover management alone (for example, restrict the harvest of mature males, restrict hunting pressure during the ruts, or shorten the length of the season).
6. Evaluate and consider road/trail restrictions during the archery season.
7. Develop ORV and vehicle management strategies that prohibit ORV and/or vehicle use in the pursuit of pronghorn antelope.
8. Promote recognition that the ethical lapse represented by “trophy” hunting under game-farm conditions is contrary to the position of professional wildlife managers and the Montana Chapter of The Wildlife Society.

Information Needs

Since any off-road vehicle travel in pursuit of a game animal is already illegal, we hesitate to suggest research in this area. Nevertheless, there is a lack of information concerning the relative disturbance caused by ORV traffic as compared to vehicles on open roads. We also lack an adequate description of the relationship between security cover and hunter density.

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