Implications of Back-country Travel on Key Big Game Summer Range in the Bighorn-Weitas Roadless Area, Clearwater National Forest

Terry Hershey, Wildlife Biologist, Salmon, Idaho
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Introduction

Travel management is a highly influential factor affecting elk behavior and habitat effectiveness on summer range. The appropriateness of both non-motorized and motorized back-country travel is a contentious issue among different user groups because the potential to disturb elk and degrade their habitat frequently limits recreational activities. This document is a summary of the available science on elk biology and ecology in relation to back-country recreational travel. The review provides some guidance toward coordination and integration of travel management planning/implementation with summer elk habitat requirements on designated key ranges on the Clearwater National Forest.

Peer reviewed scientific publications, research study progress and completion reports, conference proceedings, and theses and dissertations on field studies and captive elk research; and book chapters, literature reviews and modeling/theoretical literature were searched for information on elk responses to human disturbances, primarily back-country travels on linear routes and off-route wanderings. More science is available describing the interactions between elk and roads than between elk and recreation trails (motorized or non-motorized) or off-road travel. The review reports on the effects of traditional foot and horse travel, conventional 4WD vehicles, and more recent mountain bike, motorized dirt bike and ATV(UTV) vehicles to elk and their habitat. Many effects on elk are similar for all means of travel, although there can be differences in severity and duration. The intuitive link among human disturbances, elk energy expenditure, nutrition and individual and population performance is explored.

The findings of these studies and their general application across a broad spectrum of environmental conditions common to elk summer ranges in the western states have been questioned by different user groups and conservation organizations as to their management need, effectiveness and validity in protection of elk and their habitats and limiting recreational opportunities. Given this skepticism and controversy, it is important to assess what is, and is not known, about the potential effects and impacts of back-country recreation on elk and their habitats. This information would include what types of effects and impacts have been documented, their severity, if there are activity specific effects and/or impacts, and what management options are recommended to minimize or mitigate recreation effects and impacts on elk and their habitat needs. Understanding how recreational activities influence elk and their seasonal habitat use is necessary to evaluate management options, and make informed decisions.

This review focuses primarily on the responses of Rocky Mountain elk on summer range in the

Northern, Inter-mountain and Rocky Mountain regions of the western states to back-country travel off-road and along linear routes, with particular attention to forested environments and key habitat components such as calving/nursery areas. I review more recent literature on the effects of mining and energy exploration/development in forested and nonforested environments on elk calving to provide a better understanding of elk behavioral responses across a broader spectrum of human actions, environmental conditions, and geographic ranges. Where appropriate, I also include some reviews of studies on Roosevelt elk in Oregon, Washington and California.

The objectives of the literature review are:

- Describe the management goals, objectives, and prescriptions of designated Management Areas within the Bighorn-Weitas Roadless Area as key elk summer range.
- Provide a brief overview of the population trend and current status of the Lolo Zone elk herds.
- Present information on the rapidly growing off-road motorized recreation demand
- Review the potential effects and impacts of spring/summer back-country recreational travel on elk behavior, physiology and population performance.
- Discuss the literature on the elk calving/nursery period, cow/calf nutrition, and responses of cow/calf pairs to human disturbance in forested and non-forested habitats
- Summarize existing recommendations on travel management in elk summer range.
- Recommend management actions to minimize potential effects of back-country travel on elk calving and nursery areas, and displacement of elk from key summer habitats

Reactions of elk to all forms of back-country recreational activities are already well described in numerous observational and comparative studies and several previous literature reviews. This review provides a summary and some conclusions about the behavioral effects, potential physiologic effects, and population performance impacts of human disturbance stimuli on elk. The information should be of value to land managers at the site and landscape-level of travel management planning on roads, trails and off-road areas.

Key Big Game Summer Range Designation

When the Clearwater National Forest implemented its Forest Plan in 1987, an area of key big game summer range (Management Area C1) was designated for protection and management south of Kelly Forks in the upper North Fork of the Clearwater River. The area is at the heart of the Bighorn-Weitas roadless area as identified in the Idaho Roadless Rule. The three principal drainages include: Fourth of July, Junction and Barnard Creeks. The area is bounded by the

North Fork and Kelly Creek to the north, Bear Butte and Cook Mountain to the east, Lookout Peak, Star Point, Paradise Meadows and Switchback Hill to the south and Scurvy Saddle and Mountain to the west. The Management Area (MA) is 45,110 acres (19% of the Bighorn-Weitas area) of forest, shrubfield and meadow elk summer, spring/fall transition and winter range. The elk population at the time was an estimated 16,119 in the Lolo Elk Management Zone (Game Management Units 10 and 12) which falls mainly in the Clearwater National Forest (Zager and Lonneker 2008). The roadless area occurs in GMU 10. Schlegel (1986) reported that the North Fork Clearwater elk herd was probably the largest and most important in Idaho at the time. Unit 10 had the highest elk harvest in the state. The population trend appeared to be upward based on annual aerial elk herd composition and trend flights between 1978 and 1984 (Schlegel 1986) in comparison to counts in earlier years (1956, ‘72 and ‘76).

The MA includes the northern half of the largest, contiguous core of elk calving habitat on the Forest. In 1978, Schlegel (1986) captured and radio-collared 26 calf elk in the Fourth of July Creek-Cook Mountain area as part of a calf elk mortality study on the Lochsa/North Fork elk herds. The MA prescription is “to maximize big-game summer habitat potential. Manage without roads to provide minimum disturbance to big-game animals. Provide for high quality dispersed recreation (mostly hunting) in a semi-primitive motorized setting.” The management standard for elk habitat potential is 100%. The area is traversed and bounded by several miles of system trails. All trails are presently open year-long to motorcycle and mountain bike (USDA 2005). Trail 524 to Scurvy Mountain Lookout also is open year-long to ATVs. A MA Standard permits trail bike use on trails to the extent that use does not damage trails, . . . , or prevent achievement of fish and wildlife management goals.

Almost half of the Bighorn-Weitas roadless area of 235,510 acres was designated to management without roads under MAC1 and MAC6 because of overwhelming public opposition to prior development plans (USDA, ROD, 1987). The management emphasis in MAC6 is:

- Key fishery habitat/semi-primitive recreation- Cayuse, Toboggan, and Monroe Creeks (59,740 acres) adjoining MAC1 to the east. Considered key big game summer range to be managed to a standard of 100% elk habitat potential. A MA standard permits trail bike use on trails to the extent use does not damage trails, ..., or prevent achievement of fish and wildlife management goals.

Another MA, C8S, was designated in most of the Weitas Creek drainage in the Bighorn-Weitas roadless area to the west of MAC1. Management emphasis in C8S is:

• Big game summer range/timber management - a compromise for harvesting timber while providing protection for big-game habitat. Timber and big game resources were to be managed equally, and motorized use was to be excluded from this area. The Weitas Creek drainage is recognized as key big game summer range and includes the southern portions of the large core elk calving habitat that adjoins the calving area in Fourth of July Creek. The management standard for elk habitat potential is a minimum of 75%. A MA Standard permits trail bike use on trails suitable for trail bikes until the area is roaded, at which time the entire area will be closed to public use of motor vehicles.

The ROD (USDA 1987) for the Forest Plan FEIS in summarizing responses to issues and concerns on elk summer habitat and road management stated: "The Clearwater National Forest contains excellent elk summer range. Most of it was burned early in the century resulting in forbs, grasses and brush fields which provide the elk with ample forage. This area also is, for the most part, roadless which means the elk are relatively undisturbed by man's activities. Most respondents to the Proposed Forest Plan were concerned that the development of many of these areas for timber would have significant adverse impacts on this habitat."

Likewise, a Forest Plan Overview (USDA 1987) of Response to Critical Issues noted: "Elk summer range in the Clearwater Forest is considered the best in the State of Idaho. Many respondents to the draft Plan expressed concern that constructing roads into key summer range would have significant adverse impact on this habitat. We have lessened these impacts by establishing areas which will remain undeveloped and will maintain 100 percent of the potential habitat." The Forest Plan ROD (USDA 1987) requires that elk summer range be managed to achieve a specified level of habitat potential depending on individual management area goals. The management standard required and expected for key elk summer habitat potential is 100%. Potential elk habitat refers to habitat quality; 100 percent potential means that a site has the optimum amount of habitat factors, including security, to permit elk use at the maximum potential for that site.

Habitat potential and effectiveness are two primary considerations of elk habitat assessment and management. Habitat potential is defined as the combination of ecological factors (e.g., existing vegetation, climate, landform) that influence the inherent ability of a landscape to produce and sustain elk in the absence of human disturbance. Habitat effectiveness is defined as the spatial use of potential habitats in the context of human disturbance. Knowledge of both components is necessary for resource planners to address three general questions: 1) can the planning landscape inherently support elk, 2) is elk use of potential habitat being limited, and 3) if elk use of potential habitat is being limited, what environmental factors are limiting (Roloff 1998)?

The Forest Plan Overview noted that "the major adverse impact on elk use of summer habitat is open roads. Research has consistently shown that elk will avoid areas adjacent to open roads if the roads are used frequently. Approximately 663,000 acres are planned to remain roadless and will provide near natural levels of elk use (See Chapter IV in the EIS)."

Although winter is a time of obvious stress to elk and other ungulates, the importance of high quality summer habitats has received growing recognition from biologists in recent years. The summer season is when elk must have access to adequate forage to build fat stores sufficient to allow them to survive the next winter. Summer nutrition also plays an important role in the ability of cows to produce healthy calves (Canfield et al. 1999:6.9). Disturbance from human activities has the potential to displace elk from preferred habitats during these critical periods, thus compromising their ability to survive and reproduce, potentially affecting populations (Canfield et al. 1999:6.11).

The Forest incorporated concerns about elk and motorized travel on roads and trails into the Forest Plan (USDA 1987) through the application of several Forest-wide and specific Management Area goals, objectives and management standards. These management prescriptions were designed to maintain and/or enhance wildlife and their habitat during commodity resource extraction and recreational activities that have the potential to disturb or otherwise impact wildlife and habitats. They include:

Forest-wide Wildlife Goals

- Rehabilitate big-game habitats for thermal cover, security, and forage as needed to provide optimum habitat conditions.
- Maintain and, where appropriate, improve the winter and summer habitat over time to support increased populations of big-game wildlife species.
- Limit motorized use on selected big-game range to minimize effects on big game

Forest-wide Management Standard

<u>Recreation and Visuals</u>

Regulate use of roads, trails, and specified areas along with designating areas for ORV (Off-road Vehicle) use as per Executive Order (E.O.) 11644, through the Clearwater National Forest Travel Planning Direction (Appendix F), and in conformance with the ROS designations for specific areas.

✓ **E.O. Sec. 3.** *Zones of Use.* Areas and trails shall be located to minimize harassment of wildlife or significant disruption of wildlife habitats.

✓**E.O. Sec. 9.** *Special Protection of the Public Lands.* (a) Notwithstanding the provisions of Section 3 of this Order, the respective agency head shall, whenever he determines that the use of off-road vehicles will cause or is causing considerable adverse effects on the . . . wildlife, wildlife habitat or . . . of particular areas or trails of the public lands, immediately close such areas or trails to the type of off-road vehicle causing such effects, until such time as he determines that such adverse effects have been eliminated and that measures have been implemented to prevent future recurrence.

Wildlife
Provide the proper mix of hiding and thermal cover, forage, and protection from harassment during critical periods on big-game summer range (primarily elk) in accordance with criteria contained in the "Guidelines for Evaluating and Managing Summer Elk Habitat in Northern Idaho."

- Manage use of motorized vehicles off roads, on roads, and on trails in areas of key wildlife habitat features such as elk licks, wallows, and calving areas to accomplish habitat objectives.

Facilities
Restrict use of roads as needed to prevent resource damage and close roads and restrict the use of ORV's to protect road beds and to protect wildlife from undue harassment. Closures may be seasonal or year-long to accomplish resource management objectives.

Forest Travel Plan
Appendix F in of the Forest Plan (USDA1987) on supplemental direction on Forest Travel Planning states that:

Off-road Use

- Normally motor vehicles will be restricted when . . . wildlife, . . . may be damaged through such use. Use will be restricted for that season when damage would occur and permitted when no damage would be expected. . . .
- All motor vehicles would normally be prohibited by area closures in those areas being managed as a primitive or semi-primitive setting for non-motorized recreation.
- Use of motor vehicles with not more than two wheels on Forest development trails will be permitted except where:

    ✓ Trails are located in areas designated to provide non-motorized recreational settings
    ✓ Motorized use is or is expected to occur at levels which result in harassment of wildlife or key wildlife habitats.

On-road Use

- Motor vehicle use on Forest Development roads will be permitted except where restriction of use is necessary for protection of Forest resources, . . . , or to accomplish Forest Plan goals and standards stated in Chapters II and III of the plan.
- Periods of restriction will be limited to those times necessary to accomplish objectives and will be standardized Forest-wide to make regulations easily understood by the public. Standard restriction periods are as follows: Key wildlife habitats - YEAR-LONG TO ALL VEHICLES. Where a habitat is of seasonal importance, use will be constrained for only that period of time. For example, elk winter ranges: December 1 through May 15;

elk calving; until July 15.

The sum of Forest Plan direction clearly establishes that planners and managers intended for resource values and human uses in the three MA designations in the Bighorn-Weitas Roadless Area be managed to maintain and benefit key elk summer habitats and retain high elk use.

Elk Population Status and Trend

Elk numbers in the Lolo Zone increased following creation of vast brush-fields from wildfires in the early twentieth century, and the population apparently peaked around 1950 (Compton, ed. 2009). Elk herds declined into the 1970s when the population probably reached some equilibrium with declining habitat conditions as forest succession advanced (White et al. 2010). The population peaked again in the late 1980s under more restrictive hunting seasons and moderate, but positive calf recruitment rates (25-40 calves: 100 cows).

Annual aerial surveys since the mid-1980s have revealed that the population in the Lolo Zone has steadily and dramatically declined since the early 1990s (Zager and Gratson 2001, White and Zager 2007, Zager and Lonneker 2008). Catastrophic winter losses (48% and 30% population declines in GMUs 10 and 12, respectively) occurred in the Lolo Zone in 1996-97 from severe deep snow conditions when snowfall exceeded 200% of the long-term average in some areas of north-central Idaho. Calf productivity and/or recruitment also have declined substantially since the late 1980s, from 30+ calves:100cows to calf numbers in the teens in more recent herd composition surveys in the last decade (Kuck and Toweill 2001). Elk herds in north-central Idaho generally have the lowest calf:cow ratios statewide (Compton, ed. 2009). Survival rates of adult cow elk in the Lolo Zone also are below the threshold necessary for population stability or growth given existing calf recruitment rates. Declines in elk populations in north-central Idaho likely are influenced by the complex and confounding interactions of habitat limitations (primarily forage availability and quality), predator systems and temporal changes in weather patterns (White et al. 2010).

The current population is well below management objectives and continues to decline. White et al. (2010) reported that calf recruitment on their Lochsa study area (GMUs 10 and 12) from 1997 to 2004 was low and declining. Groen (2010) recently reported that the Lolo elk herd is in trouble. The latest aerial surveys (2010) estimated a population of 2178 elk, with poor cow and calf survival. This number represents 87% fewer elk than were present in the Lolo Elk Management Zone when the Forest Plan was signed in 1987.

Off-road Vehicle Recreation Trend

At the time the Forest Plan was implemented, the travel planning focus was almost completely on roads and conventional highway vehicles. Four wheel drive pickups were the predominant vehicles for transportation on the more primitive Forest roads and two-track trails. Off-road vehicles were virtually unknown as a common means of travel on public lands. A few motorized toad goats, low horsepower dirt bikes and three-wheel ATVs might occasionally leave tracks on Forest roads and trails, but their presence on the landscape was minimal and without noticeable effect on wildland resource values. Ten years later (1997), even an update (Servheen et al.1997) of Leege's (1984) "Guidelines for Evaluating and Managing Summer Elk Habitat in Northern Idaho" by an interagency/tribal team of wildlife biologists made only casual reference to motorized use on trails, but no mention of the potential escalating effects of an increasing trend in ORV use and off-road travel on elk summer range. Since that time, motorized off-road vehicle travel on public lands has become one of the fastest growing forms of outdoor recreation in the United States (Cordell et al. 2005) and Idaho (Idaho OHV Outreach Project 2007). OHV recreation has increased substantially in the last two decades (Bowker et al. 1999 and Cordell et al. 2005), a trend that appears to be continuing in Idaho (IDPR 2007a). The number of ATVs and motorbikes registered in Idaho has been growing recently by more than 10,000 each year (IDPR 2007b). Idaho now ranks third in the nation in survey estimates of the number of people participating in OHV recreation. The 2004 Idaho Outdoor Recreation Survey found that just over one-third of all Idaho residents participate in four-wheel driving and ATV riding, and 14% participate in dual sport or dirt bike motorcycling (IDPR 2007a). Another statewide motor vehicle travel survey found that 17% of nonresident visitors participated in four-wheel driving, 11% in ATV riding, and 9% in motorbiking. Of the eight National Forests in Idaho, the Clearwater forest ranked first in estimates of annual OHV participation as a percent (20%) of total recreation visits in survey data collected from 2000-2003 (English et al. 2004).

In addition to greater numbers and types of ORVs, modern ATV's, UTVs and motorcycles have capabilities that could not have been envisioned in 1987 when the Forest Plan was implemented. Technological advances in ORV power and control now allow even more novice operators to easily get to remote areas that were previously inaccessible to motor vehicles. Travel off linear routes like roads, primitive two-tracks and trails is common place on many public land areas. Miles of trails that once provided only foot and stock access are now accessible by motorized bikes and their tread is progressively being widened as some ATV users create their own routes along these linear corridors. Motorized users are rapidly advancing into wildland habitats where such noise and recreational disturbance were unknown just two decades ago. ORV users can cover much more terrain per day or visit than a hiker or equestrian and potentially have a disproportionate impact on resource values when compared to more traditional forms of travel on public lands.

Likewise, technologic changes in bicycles have spurred a growing industry and increasingly popular recreational sport in mountain biking on public lands. Mountain biking is one of the fastest-growing outdoor activities, with 43.3 million persons participating at least once in 2000 (USDA Forest Service and National Oceanic and Atmospheric Administration 2000). Like hiking and horse riding, mountain biking can occur on multi-use, single use, informal trails or cross country in areas with no existing trails.

The potential impacts of this recent explosion of ORV use on National Forest lands lead Forest Service Chief Dale Bosworth to name unmanaged recreation as one of the four "great issues" facing the Forest Service today (Bosworth 2003). Off-highway vehicle participants on National Forest lands increased from 36 million to 51 million in the four-year period that ended in 2004 (USFS 2004). The Forest Service adopted new rules for OHV management on national forests in

2005 (70 Fed. Reg. 68264, 36CFR 212) in part to help address the growing threat of increasing OHV use in regard to recreational conflicts, public safety and resource damage/impacts to forest natural and cultural resources. National Forests nationwide are in the process of updating their travel management plans and internal directives (manuals and handbooks) to conform with the new rules (72 Fed. Reg. 10632). The Clearwater National Forest released their Travel Planning DEIS in 2009 and is now working on an FEIS to release a ROD in 2011.

Key big game summer range(MA C1, C6 and C8S) is a focal point of public comment on the Clearwater National Forest Travel Planning DEIS. The effect of motorized recreation on wildlife habitats, more specifically elk habitat security, was a significant issue in the DEIS. Both advocates of off/on-road motorized recreation and those opposing off-road motorized recreation because of potential impacts to wildlife, their habitats and other natural resource values provided numerous comments on the alternative actions presented in the DEIS. Thus, effects of motorized travel on wildlife habitat security were a primary consideration in crafting alternative actions.

Back-country Travel Effects on Wildlife

Specific criteria that Forest Service travel management planners and managers must address in designation of roads, trails and areas open to motor vehicle use when updating management plans include minimizing harassment of wildlife and significant disruption of wildlife habitats.

Geist (1978) summarized the three primary consequences of harassment of wildlife. He defined harassment as actions which may only cause arousal in one situation, but may lead to panic, exertion or death in another situation. The consequences of harassment include:

✓ Elevates metabolism at the cost of energy resources and reserves needed for the animal’s normal growth and reproductive potential
✓ Can cause death, illness or reduced reproduction due to secondary effects from physical exertion and temporary confusion
✓ Can lead to avoidance or abandonment of areas and to reduction in a population’s range and, ultimately, to reduction of the populations due to loss of access to resources, increased predation or increased energy cost for existence

He suggested that harassment was most damaging when animals were in poor condition (Geist 1970) and when disturbance was frequent and unpredictable.

Wildlife responses to disturbance are shaped by six factors: type of activity, predictability of the activity, frequency and magnitude of the activity; timing (e. g., breeding seasons); 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). For several ungulate species, the greatest negative responses to recreational activities (either motorized or non-motorized) were measured for unpredictable or erratic occurrences (Canfield et. al. 1999). Wildlife behavior may take the form of avoidance, habituation or attraction (Knight and Temple 1995). Disturbance may modify an animal's behavior either positively or negatively through five mechanisms: home range changes, altered movement patterns, altered reproductive success, altered escape response and altered physiological state (Tromulak and Frissell 2000). Behavioral responses may be of short duration (temporary displacement) or long-term, such as abandonment of preferred foraging areas (Geist 1978). Mammals may respond to disturbances by humans by reducing activity to areas, habitats, and times of day where encounters with humans are minimal (Geist 1971). Avoidance or abandonment of harassment-prone areas may subsequently reduce range of the population (Geist 1978).

Disturbance from recreation may have both immediate and long-term effects on wildlife. The immediate response of many animals to disturbance is a change in behavior, such as cessation of foraging, fleeing, or altering reproductive behavior (Knight and Cole 1991). Over time, energetic losses from flight, decreased foraging time, or increased stress levels come at the cost of energy resources needed for an individual's survival, growth, and reproduction (Geist 1978). Physiological responses that affect an individual's energy budget may result in death. At the population level, physiological response may result in reduced productivity (Yarmoloy et al. 1988).

Elk Response to Motorized Recreation

Lieb (1981) suggested that elk appear to be highly attuned to their environment and its energy demands, a refined behavioral and physiologic balance that can be readily disrupted by human actions. Elk may view human recreational activities as a form of predation risk even without direct mortality because of innate indirect behavioral mechanisms (Frid and Dill 2002, Gesit 2002).

A review of the literature indicates that elk respond to all forms of human activity: energy development, exploration activities, logging and mining, road traffic and recreation. At least some individuals appear plastic in their behavior in that they resume pre-disturbance behavior once human activity levels subside or cease.

Behavioral Response

The most obvious of the responses an animal makes to a threatening stimulus are behavioral responses. Behavioral reactions can be used directly to measure the relative degree to which stressors affect individuals. Reactions of animals to disturbance stimuli cost calories of energy and grams of nutrients (Moen 1973) which also may have a physiologic effect on individuals. Certainly human activities (disturbance and noise) affect animal behavior, but this does not necessarily mean human disturbance has a negative impact on animal conservation and welfare.

Behavioral responses of elk to human activity demonstrate a high degree of variation and are influenced by several factors in different habitat conditions. Elk respond differently to different recreational disturbances (Wisdom et al. 2004). Responses of elk to human disturbance included greater use of cover (Irwin and Peek 1983), increased movements (Cole et al. 1997) and avoidance of roads (Rowland et al. 2000). A single disturbance event /day can elicit a flight response by elk (Wisdom et al. 2004).

Elk have been the most extensively studied animal in relation to motorized access. Hunted populations of elk on summer range in all habitat conditions (forest, nonforest and mixed) subjected to motorized and non-motorized travel are impacted by human disturbance that is unpredictable and erratic in terms of numbers, frequency, duration, time of day, type of travel, and noise level. Several studies demonstrate that elk tend to select areas with lower road densities, farther from roads, and with less human disturbance in hunted environments (Basile and Lonner 1979, Rost and Bailey 1979, Irwin and Peek 1983, Witmer and deCalesta 1985, Lyon and Canfield 1991, Rowland et al. 2000, Rumble et al. 2007). Rowland et al. (2005) cited numerous studies that demonstrate elk avoid areas near open roads and that this response varies in relation to multiple factors, including: traffic rates, extent of escape/security cover adjacent to roads, topographic barriers to disturbance and type of road (improved versus primitive) (Frair et al. 2008, Sawyer et al. 2007, Rowland et al. 2005, Christensen et al. 1993, Lyon 1983, Lyon and Jensen 1980, Thomas 1979). Peer reviewed research also has demonstrated that elk consistently avoid roads open to motorized vehicles across a variety of environmental conditions and seasonal ranges throughout their geographic range, Perry and Overly (1977) and Cole et al. (1997) in Washington, Lyon (1979) and Edge and Marcum (1985) in Montana, Hershey and Leege (1982) in Idaho, Rowland et al. (2000) in Oregon, Rost and Bailey (1979) in Colorado, Stubblefield et al. (2006) in South Dakota, and Sawyer et al. (2007) and Ward et al. (1973) in Wyoming.

Elk select areas farther from roads with increasing rates of motorized traffic (Wisdom et al. 2004 and 2005b). Johnson et al. (2000) showed that as the volume of traffic increased on roads, the mean distance that elk were located from roads also increased. Perry and Overly (1977) and Witmer and deCalesta (1985) also found less elk use of areas near primary roads than use observed near secondary or primitive roads, presumably due to a higher rate of traffic and associated human activity along primary roads. Elk showed increasingly strong selection toward areas with increasing distance from roads open to motorized traffic at the Starkey Experimental Forest and Range in northeast Oregon (Rowland et al. 2000, 2004). Lieb (1981) found elk preferred areas with low noise levels, and Edge (1982), Hershey and Leege (1982) and Marcum (1975) reported that elk significantly avoided the human activity (the greatest traffic), not the roads. Elk in northwestern Wyoming were not significantly influenced by pioneered four-wheel drive roads when the roads were not frequently traveled during summer, but elk avoided these same primitive roads when used frequently during hunting seasons (Gruell and Roby 1976). Altmann (1956) observed moves of three to eight miles by many “spooked” elk out of a hunting area into Yellowstone National Park by hunter activities prior to opening of hunting seasons.

Where human activity is both non-lethal and predictable, such as in Yellowstone, Banff, and Rocky Mountain National Parks, and urban fringe areas where elk find refuge from hunting pressure (Thompson & Henderson 1998), elk have become habituated to human disturbances associated with roads (Frair et al. 2008, Cassirer et al. 1992, Schultz and Bailey 1978, McKenzie 2001). In some cases, human activities may create predation refugia for elk (Hebblewhite et al. 2005, Hebblewhite & Merrill 2007), with roads potentially becoming an attractant rather than a repulsive force. Elk also may become more tolerant of areas adjacent to roads should their impact be reduced by managing human use of the road network (Gratson & Whitman 2000; Cole, Pope and Anthony 2004, Basile and Lonner 1979).

Habitat Effectiveness

Rowland et al. (2005) provide a thorough summary of the direct impacts of roads and associated traffic on elk and their habitat. Their review concluded that a temporary or permanent reduction in effective habitat for elk is the ultimate effect of elk displacement by motorized traffic or other disturbances. Habitat effectiveness being defined as the "percent of available habitat that is usable by elk outside the hunting season (Lyon and Christensen 1992)." Forman et al. (2003) indicated that loss of effective habitat can lead to reduced local and regional populations.

A substantial number of studies have demonstrated that motorized traffic on forest roads does establish a pattern of habitat use in which the areas nearest the roads are not fully available for use by elk (Ward et al. 1973; Rost and Bailey 1979; Rost 1975; Marcum 1976; Perry and Overly 1976; Thiessen 1976; Ward 1976; Lyon 1979a, 1983; Edge 1982; Edge and Marcum 1985, 1991; Edge et al. 1987; Marcum and Edge 1991). Even a limited amount of traffic behind closed gates provides more than enough reinforcement of the avoidance behavior (Lyon 1979b) to affect elk use of habitats along road corridors. The ecological footprint of a road prism can extend up to several kilometers from the road proper because of a road's influence on habitat quality (Forman 2000). Approximately, 1.1 miles is the distance at which elk response to open roads diminished markedly at Starkey (Rowland et al. 2000). Declines in habitat use have been reported within 0.25-1.8 miles of open roads (Lyon and Christensen 2002:567), but substantial reductions in habitat use are normally confined to <0.5 miles from an open road. Many variables influence elk habitat use relative to open roads. Avoidance of open roads was greatest when less cover was present, during the hunting season when use of forest roads peaks, and on high-standard primary roads (Lyon et al. 1985:6). Topography also influences elk habitat use near roads (Frederick 1991:22, Edge and Marcum 1991).

The extent of reduced habitat use can be very substantial. Lyon (1983) reported that "habitat effectiveness can be expected to decline by at least 25 percent with a density of 1 mile of road per square mile and by at least 50 percent with two miles of road per square mile . . . As road densities increased to five to six miles per square mile, elk use declined to less than 25 percent of potential." Road effects can saturate a landscape even at relatively low road density (Forman et al. 2003). Road effects saturated a simulated modeled landscape (i.e., no refuges >0.62 miles from a road) given a road density of approximately 2.58 miles/sq. mile (Frair et al. 2008) in elk range in Alberta, Canada.

Home Range Use

Habitats used by elk during the summer represent a substantial increase in geographic area as compared to winter range. Even though the total extent of summer habitats is usually not limiting elk fitness or performance, important features of the habitat like elk calving areas with highly digestible forages may be limiting (Leege 1984). As the size of the area affected by recreational activities expands to fill an increasing proportion of an animal's summer range, the potential for impact increases because options decline for acquiring high-quality nutrition with the least possible effort. If human disturbance results in elk inhabiting habitats not previously used or causes elk to avoid habitats that would otherwise be beneficial, the health or reproductive success of elk could be compromised (Geist 1982, Skovlin 1982, Hutchins 2006). Morgantini and Hudson (1979) reported heavy elk use of marginal sectors of potentially available grassland on largely snow free winter/spring range in western Alberta foothills to be a direct result of human activity, particularly vehicle activity. Peek et al. (1982) even suggested that high levels of human disturbance may result in the abandonment of home ranges by elk. Ward et al. (1980) also demonstrated that even productive habitats may be abandoned by elk if human disturbance was excessive.

Grigg (2007) evaluated the effects of human disturbance in the forms of motorized and total combined access networks on elk (Cervus elaphus) summer home range size, and movement rates of adult female elk in southwestern Montana over two-years. He found evidence that elk responded to motorized access during the summer by increasing summer home range sizes. A general trend indicated summer home ranges two times as large in areas with relatively high levels of motorized access compared to home ranges with little or no motorized access. Home ranges were three times larger in areas with relatively high total access compared to areas with lower amounts of total access. The larger summer home ranges associated with motorized access indicate that elk require larger areas to acquire necessary food reserves while avoiding human disturbance (Nicholson et al. 1997). Elk exposed to the highest disturbance levels in Grigg's study had larger summer home ranges, but generally did not abandon the general summer range area. Lieb (1981) suggested that the energetic costs to an elk population will increase as animals put more effort into locating increasingly scarce, preferred forage, or energy intake will decline as less nutritious forage must be utilized. He indicated this would be reflected in a declining home range carrying capacity and herd productivity.

Larger summer home ranges of cow elk also were correlated with greater density of improved surface roads and with all roads in the Black Hill National Forest (BHNF) in Wyoming and South Dakota (Benkobi et al. 2005). Inherent in the concept of a home range (Burt 1943) is that less energy is expended traversing a smaller home range to meet the needs of the animal. Thus, when comparisons are made within a species or among populations, smaller is better. Elk appear to need more space where there are more roads. High road densities reduce the effectiveness of habitat for elk (Lyon 1979, Rowland et al. 2004) because elk preferentially select areas away from roads (Rowland et al. 2000). Larger summer home ranges in the Black Hills were associated with total road density (although not significantly), but the strongest correlation was between improved surface roads and summer home range area. Benkobi et al.(2005) compared elk home ranges from their study to those in Custer State Park, South Dakota, approximately 19 miles southeast of their study area. Total road density appeared to influence home range size of elk between the two areas. Summer home ranges of elk in the Black Hills were 2.8 to 4.5 times larger than home ranges of elk in Custer State Park (CSP) (Millspaugh 1999). While the density of improved surface roads was similar between the two areas, the Black Hills study area had on average more than two times (3.7 miles/sq. mile) the total road density that occurred in CSP (1.45 miles/sq. mile, Millspaugh 1999). Also, travel off improved surface roads in CSP is restricted, whereas in the BHNF, travel was permissible on and off roads in the study area. There also were many unmapped roads in the Black Hills.

Habitat Fragmentation

Rowland et al. (2005) noted that the primary indirect effect of roads may be habitat fragmentation; heavily roaded areas may contain few patches of forest cover large enough to function effectively as habitat for elk (Leege 1984 and Rowland et al. 2000). In the central Black Hills of western South Dakota, elk were concentrated on more intact landscapes that had a minimum proportion of 0.65 of continuous open space greater than 0.62 miles distant from the nearest improved (gravel and paved) road (Stubblefield et al. 2006). Ninety percent of 87 cow elk home ranges in a hunted population in Alberta, Canada occurred in areas where road density was <0.80 miles/sq. mile, and none occupied areas where road densities exceeded 1.74 miles/sq. mile despite road densities exceeding 4.02 miles/sq. miles in the region (Frair et al 2008). In north-central Wyoming, elk selected areas with half the average road density (0.43 mi./sq mi.) that occurred on the study area (0.88mi/sq. mi.) (Sawyer et al. 1997), and rarely used areas where densities exceeded 0.5mi. /sq. mi. Elk will avoid areas with increased access, selecting areas with little or no access (Wisdom and Cook 2000).

Special Habitat Components

Geist (1982) suggested that female ungulates differentially used habitats that maximized offspring survival. In the case of limited key habitats such as elk calving areas, there may be no other options available. Kuck (1986) reported, "... that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeast Idaho, but cannot compensate for disturbance on important seasonal ranges ... " such as those used for calving. Areas near high-traffic roads consistently had lower probabilities of cow elk use than areas near low-traffic roads during calving season in western Montana (Edge and Marcum 1991). Elk on spring calving range and alpine summer range in forested habitats in northwestern Wyoming were displaced from open habitats into secluded areas of dense forest cover (>70% canopy) an average of 0.75 miles from roads and seismic exploration activity (Gillin and Irwin 1985, Gillin 1989). Elk detected and moved away from seismic activity up to 2.00 miles away, did not abandon home range areas, but did abandon spring calving sites (Irwin and Gillin 1984).

Three Wyoming studies in sagebrush steppe grassland demonstrated that well site activity influenced the movements and distribution of cow elk during this critical biologic period. Although conducted in much more open habitats than found in the Bighorn-Weitas Roadless Area, oil and gas field development activities in southwest and western Wyoming caused elk to move calves at an earlier age, move calves away from drilling activity and abandon calving sites during intense drilling activity (Johnson and Wolrab 1987, Johnson 1980, Johnson and Lockman 1981, Hayden-Wing Associates 1990). Hayden-Wing Associates (1990) surveyed elk calving areas over 11 years of pre, during and past energy development activities and found elk avoided active construction and drilling development on calving areas, but re occupied these areas once intense development ceased. Vegetation types included sage-steppe grassland, pine breaks and mixed communities. Similarly, during calving (15 May - 30 June) elk avoided areas <0.62 miles from roads and well sites in the sage-steppe ecosystem of Jack Marrow Hills, Wyoming (Powell 2003). Elk continued to show avoidance of well-sites long after the construction phase ended. Johnson and Lockman (1981) also reported early elk migration from calving areas exposed to ongoing energy operations. Sawyer et al. (2007) reiterated that elk avoidance of roads and human activity was greatest during summer in more open, shrub-steppe habitats in southwestern Wyoming, but current levels of disturbance or displacement had not reduced population performance.

On elk calving and summer ranges of central Colorado in a treatment/control experimental design, Phillips and Alldredge (2000), repeatedly, displaced radio collared elk by an observer directly (without consideration of trails or roads) approaching each marked cow with a calf on foot. They were able to show that repeated displacement following direct human disturbance during the calving season resulted in declines in elk calf survival. Vertebrates can track the direction of movement and typically respond more strongly to direct approaches than to tangential passes (Knight and Gutzweiler 1995:114, 133). A declining trend in the cow/calf ratio over a two-year period appeared to be inversely related to escalated disturbance levels in year two. Average production from displaced elk was 0.225 calves/cow, or 23 calves: 100cows, lower than that of undisturbed elk. Their population modeling indicated those disturbance levels cow elk were exposed to (8.3 disturbance events/cow) were high enough to curtail annual population growth to 1%. Modeling also revealed that this reduction in calf survival could reduce population growth rates from 7% to 0%/year with an average of 10 disturbances/cow above existing human activity levels, and > 10 disturbances caused population decline. They suggested predation as the primary proximate factor in reducing calf/cow ratios. Disturbance may have increased vulnerability to predation through either increased calf movement (Kuck et al. 1985), nutritional stress, desertion, or a combination of these factors. Predation accounted for 47% of neonatal and juvenile elk calf mortality on Coolwater Ridge in the Lochsa drainage of north-central Idaho (Schlegel 1986). Zager et al. (2007) later found that predators killed 55% of all marked elk calves during the summer period on the Lochsa and 39% of elk calves during the same period on the South Fork of the Clearwater River in Idaho.

Shively et al. (2005) did a follow-up investigation of the reproductive response of cow elk for two years after cessation of the disturbance treatments on the same study areas used by Phillips and Alldredge (2000). They found that calf productivity rebounded following release from this targeted and repeated human disturbance, and achieved full recovery to pre-disturbance levels by the second post-disturbance year. They considered the observed response to support direct human harassment as a causal mechanism for reduced reproductive success on their study area over a two-year period. Twelve percent and 39% fewer calves/cow were observed in successive years of disturbance, respectively, with an average reduction in productivity of 26% (Shively et al. 2005). Average calf production was lower for disturbed than undisturbed marked cows. Shively et al. (2005) inferred that a reduction in calf productivity from human disturbance has the potential to overshadow the effects of winter mortality on elk calf recruitment based on a 4-year average winter mortality of 11% for elk calves in western Colorado reported by Freddy (1997).

Intentional harassment of mule deer by all-terrain vehicles also resulted in reduced reproduction the following year (Yarmaloy et al. 1988). Radio collared female mule deer were habituated to an all-terrain vehicle (ATV) traveling the same truck trail for 12 weeks. Three of the females were then followed by an ATV for nine minutes per day for 15 days between one and 24 October for a total of 135 minutes. The harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distance from the ATV. The following year, the three harassed females collectively raised one fawn, having had normal reproduction the year before and the year after. Neither the unmarked females in the study area nor the two radio-collared control females suffered decreases in reproduction during the study.

Kuck et al. (1985) found that elk cow/calf pairs in southeast Idaho were sensitive to direct and persistent human and recorded surface-mining noise during calving and calf rearing. They repeatedly displaced radio collared elk calves by an observer directly approaching each marked calf on foot and indirectly (tangentially) broadcasting recorded mine noise along a transect. Compared to undisturbed calves, disturbed calves moved greater distances, used larger areas, had less fidelity, showed greater use of coniferous forest and used less optimal habitat. An index to nursery group cohesion was relatively low for disturbed calves, but for undisturbed calves was comparable to other elk herds during the same season (Knight 1970). Effects were greater in response to direct human harassment than to indirect recorded mine-noise. They suggested the increased energy costs of movement, escape and stress caused by frequent and unpredictable disturbance may have been detrimental to calf growth. Energy costs of calves should be relatively greater than for adults because of their smaller size (Geist 1978, Robbins et al. 1979). Elk spent from 94 to 99% of the day in the relatively low cost activities of bedding, standing and feeding in Montana (Craighead et al. 1973).

Cow/calf pairs responded to initial disturbance by moving across a ridge or drainage to areas that provided a topographic barrier between the disturbance and the calf, but returned to their traditional areas in several days (Kuck et al. 1985). Vore and Schmidt (2001) found strong fidelity to elk birthing sites in northwest Montana. After repeated disturbance, pairs readily abandoned their traditional calf-rearing sites, presumably withdrawing from favorable areas to more marginal habitats. Geist (1971) suggested that single disturbance episodes may be insignificant, but prolonged, frequent and unpredictable human disturbance could severely alter species behavior and could result in reduced calf survival or aborted fetuses in cows. He recommended that recreational traffic be routed away from elk calving areas. Lieb and Mossman (1966) found in California that human disturbance caused Roosevelt elk with young calves to move to secondary forage areas away from the central parts of their home ranges. Female Roosevelt elk in the central Coast Range of Oregon exhibited the greatest avoidance of roads during the season they bore their calves (Witmer and deCalesta 1985). Elk in Montana prefer spring feeding sites away from visible roads (Grover and Thompson 1986). Conversely, Marcum (1975) found that elk were more tolerant of roads in June and July in the Sapphire Mountains of western Montana. Likewise, Lemkuhl (1981) reported elk did not avoid roads during the calving and summer season in the north Garnet Mountains of western Montana. Low recreational traffic during this period in these Montana study areas was suggested as the reason elk did not avoid habitats near roads.

Physiological Response

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). 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 (Canfield et al. 1999). Weight gains and nutritional contributions of high quality summer range may be of equal or greater value than winter habitat quality in determining winter survival and reproductive success (Hudson et al. 1985). To maximize energy benefits derived from forage individuals must live frugally in a predictable social and physical environment that has a minimum of energy cost surprises. Recreationists can impact this effort through either direct disturbance of animals or by disrupting access to essential forage resources. Energetic costs of disturbance during the summer season are relatively higher than generally recognized because most ungulates are more sensitive to heat than cold. Lieb. (1981) reported elk activity was reduced after temperatures exceeded 75 degrees Fahrenheit. He found undisturbed elk spent very little time engaged in activities involving high heart rates. Parker et al. (1984) concluded that: "Unnecessary energy expenditures . . . can be limited by minimizing human disturbances."

The physiologic effect of harassment from human uses of roads, trails and off-road can be an elevated metabolism, which depletes energy available for production or storage. The typical defense response (fight-or-flight) is characterized by adrenalin-induced increases in heart rates, blood flow to skeletal muscle, increased body temperature, and elevated blood sugar. However, an animal experiencing a deficit energy budget may use another behavioral and physiological response to disturbance that is expressed as the opposite of the active-defense response. The passive-defense response is characterized by the inhibition of activity, reduced blood flow to skeletal muscle, reduced blood flow to the digestive system, lower heart rate, respiratory rate and body temperature (Gabrielsen and Smith 1995). This behavior can be misconstrued as lack of response or habituation.

Energy expended by elk increases significantly as they transition from lying to walking to running. Geist (1978) reported that energy expenditure caused by excitation can temporarily double the expenditure for maintenance. He offered as a rule, excitement increases an animal's metabolism about 25% more than that required for maintenance for long periods. Excited animals frequently also incur the cost of the locomotion if they leave the site of disturbance. Travel costs vary with distance moved, type of locomotion and amount of elevational gain. Hard running can exceed by 20 times the cost of basal metabolism, and climbing requires about 12 times more energy than travel over level terrain (Geist 1978). Energy costs of excitation and locomotion are very high compared to the relatively low daily food (energy) intake by ruminants, and exceedingly expensive if fat stores are used to pay the cost of undue excitement.

Elk utilize fat and protein reserves accumulated during late summer and fall to survive winter and successfully meet the nutritional demands of gestation (Cook 2002, Cook et al. 2004). Depletion rates of fat and muscle mass vary depending on nutrient availability, energy expenditure and winter severity. Human disturbance may therefore negatively impact elk by causing increased energy expenditure and decreased forage availability, which ultimately increases the rate at which nutrient body stores are depleted. This may lead to death, reduced vigor or reduced reproduction (Ward 1977). If disturbances are of sufficient magnitude to reduce newborn calf production and survival, or cause increased overwinter calf mortality, elk populations will decline. However, elk may be likely to move entirely away from disturbed areas, thereby avoiding chronic disturbance effects assuming suitable habitats occur elsewhere. Movements of elk to undisturbed habitats will inevitably have impacts on elk groups in those areas via direct or indirect forage competition (Watkins et al. 2007).

Ward and Cupal (1979) found that intentional harassment of elk in south-central Wyoming by observers on foot elicited increased heart rate and flight responses, particularly if the disturbance was within 984 feet of an elk. An audible car horn or stopped vehicles caused greater reactions than moving traffic, either trail bike or conventional vehicle. Distant noise from humans elicited few heart rate reactions. Since heart rate is strongly correlated with metabolic rate (Gessman 1973), heart rate increases accompanying rapid flight indicate large energy expenditures. Frequent high energy use could adversely affect animals, particularly during warmer weather when heart rates are already high (Ward and Cupal 1979) because of temperature and when cows are nursing calves.

Wisdom (2007) noted that elk avoidance of ATV trails during periods of both use and non-use after repeated exposure to ATVs has two key potential effects on the species:

1. increased movement rates, and thus increased energy expenditures, in elk moving away from ATVs;

2. decreased foraging opportunities in the area of avoidance, and potential overgrazing in areas farther from ATV trails where elk move to as part of the avoidance response.

He indicated that these potential effects can reduce accumulation of fat reserves from spring through fall that elk depend on to survive the subsequent winter. Any movement away from an area in relation to human activity has the potential to disrupt both foraging and resting patterns, and thereby cost energy (Johnson et al. 2004). Cook et al.(2004) found that if percent body fat of captive elk is below 9% as animals enter the winter season, the probability of surviving the winter is reduced. Models comparing fall nutritional condition (body fat measurement) of lactating and dry cow elk from six free-ranging Rocky Mountain elk populations throughout the United States indicated those lactating cows accruing <7.9%BF prior to winter are in a nutritionally stressed condition, which may be limiting population performance (Piasecke and Bender 2009). Elk experienced no negative effects of reproduction on condition when lactating cows were able to accrue >13.7%BF by autumn.

However, Wisdom et al. (2004) found no change in animal or nutritional performance (weight gain) of elk displaced by logging activity in northeast Oregon during and after timber harvest even though elk made longer movements over larger areas to meet their needs. They did caution that their findings were based on relatively small sample sizes that had low statistical power and a higher likelihood of falsely concluding that weight gains did not change in relation to timber harvest disturbance. Their results indicate that studies of animal behavior and distribution in relation to human disturbances may not provide strong inference about demographic or nutritional effects. Garton et al. (2001) noted that changes in animal selection or distribution do not always result in changes in population or animal performance.

Rowland et al. (2005), in summarizing direct impacts of roads and traffic on elk, noted that elk exhibit higher levels of stress and increased movement rates in areas of higher road density. They cited Millspaugh et al. (2001) who reported increased levels of stress hormones (fecal glucocorticoid-FG) in radio collared elk were associated with vehicle use on primary roads and the density of primary roads in Custer State Park, South Dakota, where human activities were pervasive. They suggested displacement from roads during the day, avoidance of trails, and reduced diurnal activity in summer (Millspaugh 1999) may be responses elk are not fully able to compensate for from chronic, intense vehicle use, as evidenced by elevated FG levels in summer. Their findings are significant biologically because behavioral modification may not be fully effective at eliminating physiological effects of high human activity in summer, and behavioral data alone may not fully describe response to human-induced disturbances. Presently, the relationship between stress hormones and population dynamics of elk is not well understood, and these results should be interpreted with caution (Millspaugh et al. 2001). Among other responses to physiological or behavioral stressors, the hypothalamic-pituitary-adrenal axis increases the secretion of glucocorticoids (GCs). Although GC responses are adaptive in the short term, chronically elevated GC levels produce an array of pathologies, including reproductive suppression, ulcers, muscle wasting, and immune suppression (Munck et al. 1984 and Sapolsky 1992 in Creel et al. 2002).

Also, from Cole et al. (1997), Rowland et al. (2005) noted that the energetic costs of moving away from disturbance associated with roads may be substantial. Energetic needs of lactating cow elk in summer are two or three times higher than during gestation (Nelson and Leege 1982 and Robbins 1993); thus, foraging options at that time have implications for elk population productivity (Wisdom and Cook 2000). Increased energy demands and stress resulting from consistent human disturbance may lead to decreased reproductive success or the abandonment of traditional calving areas (Kuck et al. 1985, Vore and Schmidt 2001). Reproduction and survival are fundamental to elk population status. Population changes are driven by several parameters: 1) pregnancy rates, 2) fetal production and survival to birth, 3) neonatal survival, 4) overwinter calf survival, and 5) annual adult female survival. Negative impacts to habitats such as human disturbance could cause pregnancy rates and calf survival to decline in populations that are already habitat-limited (Cook et al. 2004). Poor and declining calf recruitment in recent decades is of concern to wildlife managers and elk advocates in Idaho and many other elk ranges in the western States (White et al. 2010). Recruitment is influenced by many factors, including habitat limitations (forage availability and nutritional quality), female fitness, predation and adverse weather conditions. Human disturbance can influence any of these variables, except weather.

Nutritional Limitations

Seasonal forage quality and quantity are widely recognized as critical determinants of elk reproductive performance (Nelson and Leege 1982, Irwin and Peek 1983, Hobbs and Swift 1985, Marcum and Scott 1985, Merill and Boyce 1991, Cook et al. 1996). Open habitat components in June can be expected to have a higher quantity and quality of forage (Irwin 1976, Lyon and Jensen 1980). June radio locations of cow elk in western Montana (Edge et al.1987) and north-central Colorado (Bear 1989) were in more open habitats. Johnson (1951) reported that sage was the most important calving habitat, accounting for 42% of observations. Elk calves were also found primarily in sagebrush in east-central Idaho (Roberts 1974). Female elk in north-central (Sawyer 1997) and northwestern (Altmann 1952) Wyoming selected vegetation types (herbaceous range, aspen, sagebrush and riparian grass/sedge/rush communities) that offered abundant high-quality forage during the early spring period in June. Roosevelt cow elk in the southern Oregon Coast Range increased use of open foraging habitats (grass/forb and shrub) because of reduced human disturbance from restricted vehicle access by road closure (Cole et al. 2004). Elk movements during spring were associated with sage, but riparian areas were preferred during the calving season in Washington (McCorquodale 1986). Shoen (1977) felt that during the calving period cows with calves used their home ranges more selectively than did cows without calves. Lieb (1981) suggested that pregnant cows satisfy their increased energetic needs by differential selection of more nutritious forage rather than through increased foraging time or greater foraging intensity.

Nutrition is the habitat feature most likely to have predominant influence on reproduction, survival and thus population demographics (Cook et al. 1998). Nutritional limitations from reduced resource capture affect elk in a predictable process, i.e., initially through poor individual condition, followed by declines in juvenile fecundity and survival, adult fecundity, and, last, adult survival (Hanks 1981, Gaillard et al. 2000). Although factors other than nutrition (such as disturbance, disease, weather, etc.) can influence condition of free-ranging ungulates, these factors become more relevant when populations are malnourished (Sinclair 1977, Costner et al. 1982). Consequently, nutrition during the spring–autumn period has a predominant effect on autumn condition of elk and most measures of productivity (pregnancy rates) and survival (Cook et al. 2004, Stewart et al. 2005, Bender et al. 2006, 2008). The role of maternal nutritional condition in determining offspring survival is well documented (Cook 2002 and Thorne et al. 1976).

Relatively early birth dates, large body size at birth and high quality forage in summer and early autumn for rapid growth and development early in life may have important effects on early winter body mass and ultimately juvenile winter survival and net productivity of elk populations (Cook et al. 1996, Merrill and Boyce 1991 and Irwin et al. 1994). Geist (1971) suggested that neonatal ungulates growing at reduced rates may have different behavior, lower long-term survival, and lower adult reproductive rates than well-nourished neonates. Inadequate summer-autumn nutrition can potentially reduce the probability of overwinter calf survival by reducing calf growth rates (Cook et al. 1996, 2004). Smaller calves at the onset of winter survived fewer days through the winter season. Survival of cows over winter also was related to body fat at the onset of winter. Reproductive costs as indexed by lowered accrual of body fat (BF) by fall were greatest when condition of lactating cows dropped below approximately 7.9% BF, indicating that cows were likely experiencing strong nutritional stress (Piasecke and L.C. Bender. 2009). At or below this threshold condition density-dependent or other factors limiting resource quality (i.e., human stressors) would likely be acting on elk populations(Eberhardt 1987) to impact recruitment and growth. Accumulation of BF is a direct result of energy acquisition, and consequently it is extremely sensitive to even slight changes in seasonal and annual changes in habitat quality (Cook et al. 2004 and Hanks 1981). BF is an important index of endogenous reserve and hence its direct link to habitat quality and population performance (Clutton-Brock et al. 1982, Cook et al. 2004, Bender and Cook 2005).

Cook et al. (2004) suggest that the limiting effects of summer-autumn nutrition on populations may be greater that often assumed, and possibly greater than winters' limiting effects on some elk ranges. Based on autumn levels of body fat (below 14%) condition of lactating cow elk from several different populations across the United States, Piasecke and Bender (2009) suggested that present summer habitat conditions on some elk ranges are limiting elk fitness to some degree and are likely related to declining productivity seen in many areas of the West (Gratson and Zager 1999, Noyes et al. 2002, Rearden 2005). In summer, cows with calves must balance habitat selection between areas that provide security from human disturbance and predators for neonates and high-quality forage for milk production and accumulation of sufficient body reserves for future reproduction (Geist 1982). The elk calving/nursery period is a critical time when elk may be most compromised by disturbance.

Maternal Condition

Energy demands on the elk cow during the last trimester of gestation are a very significant expenditure that can become excessive if the cow does not have access to good quality forage (Thorne et al. 1976). Fetal tissue growth, and consequently energy requirements in maternal cow elk, begin rapidly increasing around the beginning of March and continue through birth (Cook 2002). Robbins et al. (1981) reported that food intake of cow elk increases markedly during late gestation and early lactation

Winter-spring nutritional deficiencies increase maternal cow weight loss, depressing calf birth weight and delaying birth date (Sadlier 1987, Thorne et al. 1976, Blaxter and Hamilton 1980, Cook et al. 2004) In turn, low birth weight and growth rate, and late birth decrease neonatal survival (Sadlier 1987, Thorne et al. 1976, Guinness et al. 1978, Kozak et al. 1994, Clutton-Brock et al 1987). Captive cow elk that experienced between 20.6% and 6.6% weight loss during gestation produced calves that averaged 11.8-15.5 kg at birth, with < 50% survival of calves born < 11.4 kg (Thorne et al. 1976). Oldemeyer et al. (1993) identified a 13-kg threshold, below which, calf survival decreased considerably. Low calf birth weight (Blaxter and Hamilton

1980, Clutton-Brock et al. 1987a, Oldemeyer et al. 1993, Singer et al. 1997) and late calf birth date (Clutton-Brock et al. 1987a, Singer et al. 1997, Smith and Anderson 1996) also have been correlated with declines in survival of free-ranging elk. Birth mass and birth date index resource limitations (Thorne et al. 1976 and Singer et al. 1997) potentially influenced by human disturbance on spring calving ranges.

The highest energetic costs to female cervids occur during early lactation (Robbins and Robbins 1979, Spalinger 2000), and growth of calves is closely related to milk yields of mothers (Mitchell et al. 1976, Blaxter and Hamilton 1980). Cow elk energy requirements for the first day of lactation are several times those required for the last day of gestation (Nelson and Leege 1982). Nelson and Leege (1982) reported that energy requirements increase until about day 48 of lactation which is about July 18 if parturition occurred June 1. This places maximum cow energy expenditure for reproduction in midsummer when forage is usually abundant and of high quality. Increased passage rates of highly digestible spring green-up may promote conversion of forage to milk to calf growth (Nelson and Leege 1982). Optimal birth period is synchronous with the peak in forage quality and the peak in nutritional demands of the lactating cow. Nelson and Leege (1982) stated those elk cows calving after 15 June in central Washington would not find sufficient protein in available forage for optimal milk production when lactation demands peak. The effect of nutritional deprivation on milk yields can be rapid, substantial and independent of nutrition prior to the onset of lactation (Oftedal 1985). Less than optimum nutrition in several cervids will adversely affect the female, her milk yield, and hence the growth rate, postnatal survival and weaning weight of neonates (Cook et al. 2004, Cameron et al. 1993, Louden et al. 1983). White et al. (2010) reported that older, less productive shrub-fields (Skovlin et al. 2002 and Lyon and Stickney 1976) of declining nutritional value may have indirectly affected elk calf mortality through lower maternal body condition (Zager et al. 2005) on a Lochsa study area in north-central Idaho. A positive relationship between maternal body condition and calf birth weights and subsequent calf growth rates has been observed in several studies (Thorne et al. 1976, Bear 1989, Singer et al. 1997 and Cook et al. 2004). Calves of below average birth weight, lower growth rate and inferior physiological condition are more vulnerable to predation even when more than a month old (Smith et al. 2006, Smith and Anderson 1996). Healthy calves are typically most vulnerable to predation only during their first month post-partum (Schlegel 1976, Singer et al. 1997, French and French 1990, Mattson 1997, Smith et al. 2006, Smith and Anderson 1996)

Nursing demands and thus nutritional demands on cows diminish starting when calves are about four weeks old (Robbins et al. 1981). Although, healthy cows will nurse calves intensively for the first two and one half months after birth (Bubenki 1982). By September, milk production begins to decline. Because of their small size, relatively high metabolic rate, and absence of fat reserves, selective feeding on readily available high quality, easily digestible forage is essential as calves are weaned from maternal milk (Geist 1982 and Cook et al. 1996). Significant dry feed intake by captive maternally fed calves begins at approximately 40 days of age, increases geometrically, and their growth rates during the third month after birth are at a higher level than during the first month when calves are solely dependent on milk (Robbins et al. 1981 and Cook et al. 2004). Moen (1973) considered cervids to be capable of being weaned at this time because approximately 50% of their nutritional needs are met by forage consumption. Cook et al. (2004) found that captive early born calves consumed appreciable amounts of solid food by late June, but late born calves did not begin consuming solid food until mid-July. Intense grazing by free-ranging calves in Idaho and Montana begins approximately six to eight weeks of age (Johnson 1951, Rush 1932 and Young and Robinette 1939). After mid-August, Young and Robinette (1939) noted that calves grazed as long as their mothers and nursing periods were rarely observed and were very brief when observed after August. Espmarke and Langvatan (1985) reported that the red deer calf activity pattern is approximately the same as its mothers' at eight to 10 weeks of age.

Parturition/Rearing Biology

Elk parturition is time specific, but not necessarily site-specific (Marcum 1975), although calving areas have been described as a specialized kind of habitat (Johnson 1951, Roberts 1974, Thomas et al. 1979, Bear 1989). Habitat selection relative to birth sites can be considered a special behavioral requirement, a subset of general habitat selection. Nonmigratory cow elk showed strong fidelity for birthing sites in northwest Montana (Vore and Schmidt 2001). Skovlin (1982) reported that annual repetition of elk calving areas was due to herds being at the same locality during migrations on successive years. Location of elk calving areas for migratory animals in north-central Idaho (Hershey and Leege 1982) and north-central Colorado (Bear 1989) was dependent on the rate of spring snowmelt and plant development. Harper (1971) found no evidence that Roosevelt elk use the same location each year.

The birth and early neonatal periods are important because neonatal ungulates are more susceptible to predation and other forms of mortality than older juveniles and healthy adults (Adams et al. 1995, Bertram and Vivon 2002, Smith et al. 2006, Smith and Anderson 1996 and 1998). Harris (2007) defined the neonatal and juvenile periods as weeks 1-6 and 7-13, respectively. Dates of the elk calving period (mid-May to mid-June) vary little regardless of longitude, latitude, or subspecies of elk. Calf elk are normally born at peak forage quality in spring when the energetic demands of lactation on cows are rapidly increasing (Robbins et al. 1981). The majority of calves are born in late May and early June (Taber et al. 1982, Sadlier 1987). Births documented outside this period are most likely the result of second estrus conceptions (Morrison 1960).

		Elk Calf Birthing Period		
Location	Source	Peak or Mean	Range	Synchrony
North-central Idaho	Zager et al. 2007	2 June	23 May - 12 June	
North-central Idaho	Schlegel 1986		25 May - 7 June	90% prior to 7 June

		Elk Calf Birthing Period		
Location	Source	Peak or Mean	Range	Synchrony
East-central Idaho	Roberts 1974		25 May - 8 June	
North-central Idaho	Dalke et al. 1965	1st week in June	late May - early June	
North-central Idaho	Young & Robinette 39		15 May - 10 June	
Northern Idaho	Rust 1946	1 June		
West-central Montana	Harris 2007	29 May	20 May - 6 June	
West-central Montana	Raithel 2005	29 May	19 May - 22 June	98% prior to 8 June
Northwest Montana	Vore & Schmidt 2001		25 May - 12 June	
Montana	Brazda 1953	1 June	17 May - 15 June	
Montana	Johnson 1951	1 June	21 May - 12 June	
Western Wyoming	Barbknecht 2008	31 May	17 May - 11 June 22 May - 20 July	
Northern Yellowstone, MT & WY	Barber-Meyer et al. 2008		21 May - 12 June	
Northern Yellowstone	Rush 1932		15 May - 10 June	
Jackson Hole, Wyoming	Smith et al. 1997		20 May - 13 July (seven year period)	80% prior to 15 June
Jackson Hole	Oldemeyer et al. 1993			80% prior to 15 June

		Elk Calf Birthing Period		
Location	Source	Peak or Mean	Range	Synchrony
Estes Valley, Colorado	Bear 1989	12-20 June 1-5,12-16 1-5,11-15	21 May - 24 June, 79 23 May - 30 June, 80 1 June - 17 June, 81 31 May - 27 June, 82	67, 73, 94, 64% prior to 15 June from 1979 through 1982
Western Canada	Flook 1970	1 June		
Oregon (Roosevelt elk)	Hines & Lemos 1979			80% prior to June 15

Calves hide for the first 10-21 days of their lives except for short periods to nurse (Altmann 1956, Knight 1970, Lent 1974). The hider strategy in neonatal calves minimizes energy expenditures and maximizes growth (Geist 1982). Mean daily movements of Roosevelt cow elk in Washington were least during the calving season (Storlie 2006). Harper (1971) reported that Roosevelt elk calves were not prepared to traverse long distances for approximately one month after birth.

Rapid growth rates during the hider period are adaptive. The larger the calf at birth, the better the female's milk supply; and the less the degree and rate of human disturbance (so that the calf can minimize expenditures on maintenance or escape and maximize growth), the earlier it probably will be mobile enough to join the herd (Geist 1982). Calves that grow slowly because they are nutritionally compromised, remain dependent on the hider strategy longer, and may be less able to avoid predation (Smith et al. 200). Most predation on elk calves occurs within one month after birth (White et al. 2010). They reported that limited mobility of calves during this period impeded their negotiating the structure of older shrub-fields in their Locsha study area in north-central Idaho, reducing escapement and increasing vulnerability to predation. Other studies show calf mortality is highest during the first two weeks of age (Barber-Meyers et al. 2008, Singer et al. 1997, Schlegel 1976). Older calves are less vulnerable to predation because they are larger, stronger and more mobile (Smith and Anderson 1996, Singer et al. 1997).

Johnson (1951) and Brazda (1953) reported no movements of calves of more than two to 3 miles during the first three weeks of June. By three to four weeks after parturition calves join nursery herds and remain in cow-calf groups through the summer (Graf 1943, Harper 1971, Altmann 1963, Roberts 1974, Geist 1982). Brazda (1995) observed two cow/calf groups on June 20 in south-central Montana, one of 20 cows and 20 calves, and another of 50 cows and 25 calves. The high point of use in aspen-sagebrush habitats in northwest Wyoming occurred during the last two weeks in June when cows and calves were grouping (Gruell and Roby 1976). Nursery herds reach their maximum size about six weeks after birth (Franklin and Lieg 1979). Martinka (1969) reported that June 16-August 15 was a period of aggregation for elk in Jackson Hole, Wyoming.

Movements of females with calves increased after mid-July (July 16-September 15 period) as larger groups moved over greater areas. Single females, small female-calf groups and female-yearling male groups aggregated into associations that reached maximum size in late July-early August. Cow-calf groups increased their use of more heavily forested habitats at intermediate to higher elevations during July in western Montana (Marcum 1975). By four weeks post calving, cows in Wyoming also selected for forest habitat types (Sawyer 1997), presumably for the cover they offered for nursery herd security. Schlegel (1986) also found that radio-collared calves moved from shrubfield-dominated habitats on primarily south exposures to forested habitats on cooler north aspect in July.

Observations of marked calves in the Gallatin River drainage in south-central Montana during the period June 27 to July 31 indicated a marked movement from the calving grounds (Brazda 1953). The greatest movement occurred from July 1 through July 31, when movements of 6.5 to 18 airline miles to higher elevations were noted for 12 calves. Observations of marked calves in August indicated no movement beyond that observed in July, indicating that cows had arrived on their summer range. Brazda's assessment of plant phenology and animal movement suggested that the period of parturition was more important in governing the upward movements of cows to summer range than plant development. Roberts (1974) also noted that cows with calves dispersed from the Moyer Creek calving area in east-central Idaho in mid-July. Calves were not observed on summer range in the Idaho's Selway country until July 4 (Young and Robinette 1939). The majority of cows in the Sun River elk herd used lower elevation grasslands during calving in June (Picton 1960). Then in late June and early July, elk moved through the forest types and arrived in subalpine barrens along the upper edges of the subalpine forest by mid-July.

Calf Survival

Harris (2007) investigated factors influencing summer survival of radio-marked elk calves in west-central Montana during 2002-2006. Both birth date and birth weight influenced the survival of calves with lighter, early born calves (prior to a median birth date) surviving at lower rates. Calves born during the peak of parturition were heaviest for both male and female. Raithel (2005) also found that calves born prior to the median birth date had lower survival, but he noted an increase in survival across increasingly later birth dates. Early-born calves were highly susceptible to both malnutrition and black bear predation (Raithel 2005, Smith and Anderson1996). Other studies also have found that birth weight (White et al. 2010, Singer et al. 1997), and birth date (Smith and Anderson 1996, Singer et al. 1997, Smith and Anderson 1998, Gregg et al. 2001, Rearden 2005) can impact the survival of young. Zager et al. (2007) did not detect a survival difference due to timing of calf births in the Lolo elk management zone in north-central Idaho.

Harris (2007) noted the effect of birth date on elk calf survival was more prominent during the neonatal period (1-6 weeks), while the effect of birth weight on elk calf survival was more prominent during the juvenile period (7-13 weeks). Calves that died during the juvenile period were on average born 1.1 kg lighter than calves that died during the neonatal period. Calves must compensate for declines in milk consumption and increases in their metabolized energy (ME) requirements as they grow older with high quality forage (Hudson and Haigh 2002, Cook 2002). Smith et al. (2006) observed blood serum values for some enzymes and electrolytes to be lower in calves that died and inferred that it was indicative of poorer nutrition and/or lower intake of milk (Cook et al. 2004). White et al. (2010) also suggested that resource limitations (shrub-field productivity) on their Lochsa study area expressed through lower maternal body condition and lower calf birth mass had substantial effects on calf survival. Low calf birth weight appeared to be related to poor spring foraging conditions in northwest Wyoming (Smith et al. 2006). Barber-Meyer et al. (2008) reported that elk calves in better condition (higher gamma globulin levels) survived better. Similarly, Wyoming calves with lower blood urea nitrogen levels survived better where predation was the primary mortality source (Smith et al. 2006). Energy deficiencies (potentially linked to human disturbance) that cause growth declines in July (Cook 2002), coupled with low birth weight and limited mobility, may result in weaker calves less able to evade predators during the juvenile period.

Low birth weight (below average) predisposes calves to predation and other mortality (Smith et al. 2006, Singer et al. 1997), and prolongs the period during which calves are most vulnerable to predation (White et al.2010). Barber-Meyers et al. (2008) speculated that predators may select neonates in poor condition expressed through neonatal behavior. Neonates in poor condition (malnourished) during the hiding phase may be more likely to cry out for additional feedings or be less still which may expose the hiding neonate to predators. Also, neonates in poor condition may be less apt to follow their mothers to new hiding locations. Stronger scent trails created by the mother's repeated returns to the neonate's location increases the predator's ability to detect the neonate. Espmark and Langvatan (1985) found that captive red deer calves with lower birth weights retained the freezing posture significantly longer than calves with higher birth weights. They indicated that onset of flight response was more dependent on the calf's physical development than on age.

Factors that govern annual calf survival are largely responsible for changes in elk population abundance both within herds over time and across herds (Raithel 2005 and Raithel et al. 2007). Furthermore, factors that influence elk population size (i.e., habitat quality, elk density, predators) are likely predominately acting upon calf survival. Geist (1982) suggested that female ungulates differentially used habitats that maximized offspring survival. Habitat was an important ultimate factor affecting calf mortality on the Lochsa River study area in the Lolo Elk Management Zone (White et al. 2010). Both nutrition and predation are contributing to low calf recruitment levels in the Lolo Zone (Compoton, ed. 2009). Zager et al. (2007) found that elk calf survival on their Lochsa study area in north-central Idaho was inadequate and declining, ranging from 0.06 to 0.46 annually, and between 0.17 and 0.68 during the summer (through August 31). Relatively poor late winter body condition of cow elk (Zager et al. 2005) in less productive habitat on the Lochsa resulted in a lower calf birth mass and presumably lower growth rate which prolonged their vulnerability to predation and increased calf mortality (White et al. 2010). Older shrub-field structure (plant shape and form) also impeded calf mobility and escapement, and increased vulnerability to predation (White et al. 2010). Smith et al. (2006) also found that low birth mass appeared to be related to poor spring foraging conditions. If human disturbance results in elk inhabiting habitats not previously used or causes elk to avoid habitats that would otherwise be beneficial, the health or reproductive success of elk could be compromised (Geist 1982, Skovlin 1982, Hutchins 2006). Elk avoided even highly preferred foraging habitats within 500m of human activity of all types in western Montana (Edge 1982). Witmer and deCalesta (1985) found that Roosevelt cow elk in the Oregon Coast Range were observed farthest from roads during the calving season. They suggested that if managers wish to reduce harassment of elk, their efforts might be most effective during calving . . .

Human disturbances that might be expected to influence summer nutrition and result in variation in calf growth rates and over winter survival (Cook 2004) could affect population growth rates. Although disturbance events would need to produce large changes in calf elk survival to considerably influence population growth, it is possible, given that calf elk survival appears especially sensitive to changes in habitat quality. It is important to recognize that the relationships among habitat quality and quantity, elk density, and productivity and recruitment are complex (Van Horne 1983, Hobbs and Swift 1985, Hobbs and Hanley 1990), and such relationships should more fully and properly be explored.

Juvenile survival is unarguably the most important vital rate affecting recruitment in any wild ungulate population (Gaillard et al. 1998 and 2000). Therefore, a decline in recruitment is of great concern to wildlife managers because recruitment replaces the loss of adults from predators, harvest, and other factors (Gratson and Zager 1999) and may lead to decreases in population size. Many factors can act independently or synergistically to cause variation in the survival of young. Environmental conditions (Adams et al. 1995, Portier et al. 1998, Lubow and Smith 2004), population density (Portier et al. 1998, Lubow and Smith 2004), and individual covariates including sex (Smith and Anderson 1996), birth weight (Clutton-Brock et al. 1987, Singer et al. 1997), and birth date (Clutton-Brock et al. 1987, Singer et al. 1997, Gregg et al. 2001) can all impact the survival of young. Human disturbance from back-country travel is one of several environmental conditions that potentially can directly and/or indirectly impact elk calf survival. As reported earlier in this review, Phillips and Alldredge (2000) and Shively et al. (2005) found direct, repeated human harassment reduced calf survival and population growth rate.

Comparative Studies of Relative Effects of Motorized ORVs and Non-motorized Recreation on Elk

Most studies assessing the effects of motorized uses on elk involve roads with conventional passenger vehicle use rather than motorized trails or off-road where ATVs and/or motorcycles are used. More recent research though has made a direct connection between ORVs and impacts to elk (Vieira 2000, Wisdom et al. 2004, Wisdom 2007, Preisler et al. 2006, Grigg 2007). Canfield et al. (1999:6.16-6.17) and Toweill and Thomas (2002:808) both state that the effects of open motorized trail use are likely similar to those resulting from open roads. Travel route densities incorporating motorized trails cannot be compared to older published habitat effectiveness models that include open road density as a variable, but they can be used to compare effects to elk and their habitats among action alternatives for travel management planning on public lands.

Peer reviewed wildlife research relevant to the effects of off-road ATV, UTV and motorbike disturbance on elk behavior and physiology on summer range is still limited in scope compared to the body of scientific knowledge available on the effects of conventional vehicles using roads. The Precautionary Principle (SEHN 1998) recommends that when there is doubt (such as an absence of adequate scientific study on cause and effect relationships), then the action that would result in the strongest protective measure should be chosen. Management that follows this principle accounts for the threat of uncertainty and the inherently variable nature of ecological systems and processes, and elk populations and individuals, by avoiding results that preclude future options. Travel management planners and managers need to err on the side of caution by taking preventive actions to guard against potentially unacceptable impacts to elk productivity and survival from motorized and non-motorized recreation. Stewart (2002) proposes that an action presenting uncertain potential for harm should be prohibited unless its advocate can show it presents no appreciable risk or harm.

Fundamental uncertainties derive from our fragmentary understanding of species' biology and complex ecosystem dynamics, and abundant stochastic variation in environmental parameters. When we have a reasonable suspicion of harm, and scientific uncertainty about cause and effect, then we have a duty to take action to prevent harm. The Precautionary Principle (PP) does not tell us what action to take. However, proponents of a precautionary approach have suggested a series of actions we can take: (1) Set goals; (2) Examine all reasonable ways of achieving the goals, intending to adopt the least-harmful way; (3) Shift the burden of proof -- when consequences are uncertain, give the benefit of the doubt to nature. Expect responsible parties (not governments or the public) to bear the burden of producing needed information; (4) Throughout the decision-making process, honor the knowledge of those who will be affected by the decisions, and give them a real "say" in the outcome. This approach naturally allows issues of ethics, right-and-wrong, history, cultural appropriateness, and justice to become important in the decision; and (5) Monitor results (pay attention), heed early warnings, and make mid-course corrections as needed; Instead of asking the basic risk-assessment question -- "How much harm is allowable?" -- the precautionary approach asks, "How little harm is possible?" In sum: faced with reasonable suspicion of harm, the precautionary approach urges a full evaluation of available alternatives for the purpose of preventing or minimizing harm.

An extensive review of the effects of recreation on wildlife by professional wildlife biologists (Canfield et al. 1999) concluded, "it can be logically inferred that ORVs traveling on trails or closed roads are comparable to conventional vehicles using roads. Additionally, it can be inferred that ORVs traveling in unroaded landscapes, especially when most main ridges are accessible to ORVs, is comparable to conventional vehicles traveling in unrestricted, high road density situations." Likewise, this review of technical literature on the effects of motorized travel on behavior and physiology of elk on spring and summer seasonal ranges extrapolates the findings on conventional vehicles on roads to ORVs on trails, off-road or on closed roads. Their reasoning, in the absence of more repetitive and controlled field investigations on ORV/wildlife relationships is consistent with the PP approach.

Several papers on recent research in the Starkey Experimental Forest and Range enclosure (3590-

acre) in northeast Oregon report on the effects of four types of off-road recreational disturbances on elk: all-terrain vehicle (ATV) riding, mountain biking, hiking and horseback riding. The facility encompasses spring, summer, and fall ranges typical of those used by mule deer and elk in the western United States. The research was a controlled comparative evaluation of off-road activities as experimental treatments and periods of no human activity as experimental controls. A network of 20 miles of off-road transects were located on flat or moderate terrain typically used by off-road activities. Some primitive two-tracks like those established by off-road vehicles were included in the transects. Disturbance activities along routes (trails, two-tracks, transects) were indirect or tangential to the animals affected by the off-road travel (Taylor and Knight 2003). Tangential disturbance rather than direct harassment is the type of recreational activity elk are more commonly exposed to during the summer season.

Wisdom et al. (2005a) and Wisdom (2007) measured responses of radio marked elk from April to October 2002-2004 in this enclosure to the four types of off-road disturbances. Their controlled study design mimicked daytime patterns of motorized and non-motorized disturbance on National Forests. Starkey is managed for multiple public uses like other National Forest lands in the west. Elk are wild, hunted animals subjected to the same human activities and management as occurs across millions of acres of public land in western North America. Starkey plant communities are a mosaic of bunchgrass meadows and mixed coniferous forest on gently rolling benches dissected by a network of drainages.

Wisdom et al. (2005a) found that movement rates and probabilities of flight response of elk were substantially higher during all four off-road activities compared to periods of no human activity. Their results showed that one pass per day by any of the four off-road activities caused an increased movement rate and flight response by elk. The study also indicated that one pass through an area by a group of two or three ATVs would have greater effect on elk that three passes by groups of horseback riders or hikers. Both movement rates and probabilities of flight responses were higher for ATV and mountain bike riding than for horseback riding and hiking. Conversely, Schultz and Bailey (1978) suggested unhunted elk in Rocky Mountain National Park were more sensitive (longer mean flight distance and faster movement rate) to an approaching person on foot than a vehicle from winter through spring. Probability of elk flight from human disturbance at Starkey was highly dependent on distance. Flight response declined most rapidly during hiking, with little effect when hikers were beyond 550 yards from an elk. Higher probabilities of elk flight continued beyond 820 yards from horseback riders, and 1640 yards from mountain bike and ATV riders. Elk run from ATVs but tend to walk away from hikers unless startled at close range.

Preisler et al. (2006) reporting on the same study, observed that elk responded at relatively long distances (>1094 yards) to ATVs. Their data showed that the estimated probability of flight and movement speed appeared to be higher when elk were closer to the ATV routes (66 feet), even when the distance to an ATV was as far as 1.9 miles. However, response of elk to ATVs appeared to be significantly smaller when the distance to nearest ATV route was large (>546 yards). Their highest probability of response (as high as 80%) occurred when there was an ATV route nearby (66 feet) and the ATV was within 109 yards of the elk. Mean distance of elk was significantly farther from ATV trails during ATV use than during non-use periods (Wisdom 2007). In addition, Wisdom (2007) also reported that repeated exposure to ATVs over three years increased elk avoidance of ATV trails during periods of both ATV use and non-use the last year of the study, in contrast to non-use periods earlier in the study. This mirrors results of elk avoidance of roads open to motorized travel (Rowland et al. 2000) and supports Lyon's et al. (1985) suggestion that elk displacement by roads is likely to be continuous as long as the roads are open to motorized traffic. Wisdom et al. (2005a) noted that about 35% of the time elk did not exhibit a flight response when close to an off-road activity (e.g., 55-109 yards). They speculated and Preisler et al. (2006) repeated that response depends most likely on local topography, cover and possibly other factors not yet analyzed as part of the research.

Naylor et al. (2009) reporting on another phase of this same Starkey study, found elk travel time increased in response to all four disturbances, which reduced time spent feeding and resting. Elk travel time was highest during exposure to ATV riding, followed by exposure to mountain biking, hiking and horseback riding. More noisy ATV disturbance was followed by increased resting time, while quieter biking and hiking disturbance resulted in increased feeding time once elk moved away from travel routes. Reductions in foraging time during disturbances were not compensated for after the disturbance ended, because elk did not increase feeding intensity or duration beyond that of pre-disturbance levels. The authors indicated that a potential disadvantage to elk is the energy expense of traveling during each disturbance, coupled with a loss in forage intake. A movement away from disturbance routes (as noted by Preisler et al. 2006 monitoring the elk) to areas of potentially lesser quality forage could have a cumulative effect on long-term body condition. Elk showed no evidence of habituation to mountain biking, hiking or ATV riding. Preisler et al. (2006) monitoring the same elk, found that elk moved away from and continued to avoid travel routes during ATV riding with repeated ATV disturbance.

Wisdom (2005) suggested that the longer distances motorized vehicles can go in a day compared with distances covered by recreationists on foot or horseback make their potential affects on elk even greater. McCool and Harris (1994) conducted research documenting participation rates and distances traveled for a number of motorized and non-motorized activities in Montana. Participation rates were higher for non-motorized activities, but the number of miles covered per trip was quite a bit less than for trips of motorized activity.

Participation rates and distance traveled for some motorized and non-motorized activities (McCool and Harris 1994).

Activity	Participation Rate: (percent of persons surveyed)	Average mileage of participant/trip
Walking/day hiking	70%	2.5
Jogging	19%	2.5
Bicycling	20%	4
Horseback riding	17%	10
Cross-country skiing	15%	4.5
Backpacking	14%	6
Snowmobiling	15%	27
Off-road 4WD	20%	31
Off-road vehicle riding	12%	15
Off-road motorcycling	9%	25

On public lands in the White River area of Colorado, Vieira (2000) conducted a series of pedestrian and all-terrain vehicle (ATV) disturbance trials on radio-collared cow elk in summer to assess the possibility that motorized hunting access may be causing increased elk movement. Elk were exposed to a randomly assigned treatment of either a single pedestrian or single ATV disturbance by slowly approaching treatment animals and stopping when movement was detected. Individuals from the same group of elk also were randomly selected and treated with three successive daily pedestrian disturbances. Distances moved in 24 hours following each disturbance were compared between treatments. Mean movement distance (1.19 miles) of ATV disturbed elk was more than twice the pedestrian disturbed mean movement distance (0.53 miles). Horejsi (1981) found that caribou react to a moving vehicle based on direction and rate of approach (looming, Gibson 1970), rather than the size, distance from or the movement itself. A rapid and direct approach toward, or at a slight tangent to, an animal is a relatively uncommon occurrence except in situations that pose a threat such as predation. The looming mechanism elicits alertness and/or flight in reaction to any object (predator, vehicle, conspecific) known or unknown, which is approaching rapidly enough to pose a threat.

Engine noise also may alert animals to an ATVs presence at a much greater distance than noises associated with pedestrians.

Elk exposed to three successive daily pedestrian disturbances failed to show any significant increase in movement (Vieira 2000). However, comparison of the three mean distances moved in response to each disturbance event showed an increasing movement trend with increasing disturbance. Average net distance moved in 24 hours after one disturbance was 0.53 miles, after two disturbances 0.56 miles, and following the third disturbance it was 0.82 miles. The gross straight line distance (1.05 miles) moved by disturbed elk between locations taken three days apart was not significantly different from the 3-day distances (0.95 miles) moved during the same time period by undisturbed elk a year earlier. The author concluded that the relative impact of these repeated disturbances was not significant in that elk were moving only temporarily away from disturbance locations and then returning to the same general vicinity.

Management Implications

The following guidelines and recommendations gleaned from this review are intended to provide travel management planners and resource managers a means to minimize and mitigate the potential negative effects and impacts of back-country recreational travel and associated activities on elk and their habitat from spring through fall prior to hunting seasons.

Best Management Practices

Switalski and Jones, eds., (2008) developed Best Management Practices to aid land managers in travel planning and implementation related to off-road vehicle management on forest lands. Their science-based criteria and standards applicable to the potential effects of ORV recreation on elk biology inclu
de:

- If routes are already in important native wildlife habitat, seasonally close during sensitive seasons.
    - ✓ Calving/fawning period for known key ungulate calving/fawning areas (e.g. May 15 through June in the Rocky Mountain West)
- Reduce road/route density to below 1 mile/square mile in important wildlife areas
- Maintain and improve habitat security by protecting whole areas rather than individual route closures.
- Maintain large unfragmented, undisturbed blocks of forest land where no routes are designated.
- Avoid creating loop routes that would isolate wildlife habitat within interior loops.
- Close routes that are duplicative.
- ORV event permits shall ensure use of routes that can sustain such a level of use without leading to an increase in wildlife habitat degradation and/or wildlife displacement that no longer meets desired ecological conditions.

The final report on the 15-year Montana cooperative elk logging study on responses of elk to logging and recreational disturbance across seven sites in western/central Montana suggested several criteria for selecting roads to be closed to maintain low road densities where elk habitat quality and security are an important consideration (Lyon et al. 1985). Year-long closure is preferred to seasonal closure as a general rule. High priorities for closure include:

⇒ roads in known calving areas (especially in spring)
⇒ roads in the heads of drainages, saddles, and low divides
⇒ roads through moist areas and wet meadows
⇒ loop roads that encourage through traffic
⇒ trunk roads with many dead-end side roads under one-half mile in length
⇒ midslope roads in the lower two-thirds of the drainages
⇒ roads in areas with poor cover
⇒ roads in drainages intended to provide secure habitat for elk displaced by disturbance in an adjacent drainage

The report also recommends confining disturbance events to the smallest area (i.e., a single drainage) and shortest possible time to reduce the distance elk are displaced from disturbed sites and increase the probability of an immediate or quick return by displaced animals.

Based on their interpretation and synthesis of relevant scientific literature on effects of recreational activities on ungulates on summer range, Canfield et al. (1999) proposed several guidelines for managing recreation to reduce human disturbances to ungulates, including:

♦ Consider restrictions on existing roads and trails near key foraging areas (drainage heads, mesic areas) to minimize disruption of these important areas
♦ Establish designated routes within area closures to make human use of summer range as predictable as possible.
♦ Reduce human intrusions (through road or trail restrictions) into areas where ungulates are limited to easily identified habitats or where limited areas of habitats are either desirable or exceptionally productive
♦ Limit open road densities to zero in scattered key areas and less than 1 mile per section elsewhere; reclaim closed roads to help keep travel violations to a minimum
♦ Minimize administrative uses and granting of travel variances for closed routes on summer range

Wisdom (2007) suggested the following points could be considered to mitigate elk avoidance of ATV trails.

(1) Evaluate effects of ATV trails on elk in the same way as roads open to motorized traffic. Effects are similar, with large shifts in elk distribution away from all routes of motorized use

(2) Mitigate effects of ATV trails in concert with road mitigation to minimize effects on elk. Reduce density and linear feet of both roads and trails together in a cumulative effect analysis by implementing road and trail closures with gates, obliteration, or other techniques to impede or prevent use.

(3) For trails open to ATVs, maintain a minimum, narrow trail width (e.g., no wider than two ATV widths) to minimize the effect on elk avoidance. The wider the trail, the wider and longer the perpendicular distance from the trail the avoidance effect will occur. For example, a 200-meter wide trail (100-meter on each side) open to ATVs would dramatically increase the area avoided by elk and reduce habitat effectiveness over a substantial portion of many landscapes, given the network of trails often present.

(4) Area closures to all motorized vehicle uses, combined with designation of open roads and trails and all other areas closed unless designated open, and narrow road and trail widths are effective mitigation to maintain effective use of landscapes by elk.

Topographic Influences on Human Disturbance

Edge and Marcum (1991) reported that radio-collared cow elk in western Montana showed displacement from sources of human disturbance to be more pronounced when activities occurred on ridgetops or in simple bowl-shaped basins without internal ridges. The authors also found that areas with topographic barriers to disturbance sources (road traffic) consistently had higher probabilities of elk use during the calving and summer seasons. Also in western Montana, Lyon (1979) reported that undisturbed timber and even long distances across undisturbed drainages were not as effective as topography in reducing the distances elk moved away from human disturbances associated with logging. Likewise, ridge lines (topographic barriers) were of prime importance in maintaining the integrity of security areas in Blue Mountain elk summer range in northeast Oregon (Pedersen et al. 1979). Security areas should provide a line-of-sight topographic barrier (i.e., ridgeline) to the disturbance, be inaccessible to motorized traffic and be at least as large as the area disturbed (Lyon 1979). Where human activities occur in these topographic locations, limiting or restricting use of roads, duration of disturbance and activities in adjacent drainages should be considered as elk management guidelines (Lyon et al. 1985, Edge and Marcum 1991, Pedersen et al. 1979) to minimize displacement and added energy costs of movement. The effects of roads on high-use elk areas or special habitats such as calving grounds can be reduced where a topographic barrier lies between the road and area of concern (Edge and Marcum 1991). Kuck et al. (1985) observed use of topographic barriers by elk calves in response to human disturbance.

Human disturbance relative to topography is an important management consideration in MAC1 because of motorized trail loops on main ridgelines surrounding the MA and cutting through the core elk calving habitat on ridges within the MA interior. These ridgetop trails also pass through areas of relatively low forest cover. Several studies have demonstrated that forest cover tempers the effects of roads and human disturbance on elk (Lyon 1979, Basile and Lonner 1979, Lyon and Jensen 1980, Preisler et al. 2006). The trails also cut through low hydrologic divides (preferred movement corridors, Hershey and Leege 1982 and Lyon 1985) connecting MAC1 to adjacent key elk summer habitat (MAsC6 and C8S), and isolate elk within the interior of the loops. Their location is a disturbance source that compromises elk security across several interconnected watersheds designated as key elk summer range and calving habitat.

Road Closures

In addition to extensive documentation of the impacts of roads on elk, studies have shown that closing roads has benefitted elk. Irwin and Peek (1979) found that road closures allowed elk to stay in preferred habitats longer while elk in roaded areas were displaced. Roosevelt cow elk in the southern Oregon Coast Range reduced their daily movement (18%), home range (12%) and core activity area size during a limited vehicle access(<4 trips/week) program that reduced human disturbance by restricting access on 35% of roads in the study area (Cole et al. 1997). In western Montana, Marcum (1975) found that elk favored roads closed to vehicle traffic, but did not avoid open spur roads and jeep trails with little traffic. He reported that elk use following road closures appeared about equal to that in similar unroaded areas. Edge (1982) reported that closed and lightly traveled roads were not avoided by elk in Chamberlain Creek. Also, Basile and Lonner (1979) found that road closures reduced "en masse" elk movements to less accessible areas in Montana. Studies have also recommended closing entire areas to motorized use, as opposed to individual roads, to best maintain healthy elk populations (Hurley 1994, Burcham et al. 1998, Rowland et al. 2005).

Recommended road and trail motorized closures or seasonal use restrictions to reduce disturbance within core elk calving habitat in the interior of MAC1 and in Weitas MAC8S in addition to those already described in the Travel Planning DEIS preferred alternative include:

- Sections of a relatively parallel trail system (#105, 191, and 200) offer an opportunity to eliminate a loop and parallel linear routes in the Junction Mountain area
- Likewise, road 555, trail 632 and Hungry Point trail in the Weitas offer opportunities to eliminate linear connections forming loops through the Bighorn- Weitas Roadless Area.

Rowland et al. (2005) listed several benefits of road closures, including:

- ✓ Decreased energy expenditure by elk with potential gains in animal performance, as a result of less frequent disturbance from motorized traffic
- ✓ Increases in amount of effective elk habitat and security in the areas affected by closures
- ✓ Improved diet quality and potentially animal fitness and population performance where elk can forage undisturbed in previously avoided areas due to motorized traffic

Lyon (1983) stated that the best method for attaining full use of habitats appears to be effective road closure.

Calving Habitat

Phillips (1998) recommended that recreational traffic be routed away from areas in which elk are known to calve. Phillips and Alldredge (2000) suggested maintaining low trail densities in traditional calving areas and selective use of calving-season closures to ensure that adequate areas of calving habitat remain undisturbed. If elk are left inadequate calving-season habitat and can no longer escape disturbance from high levels of off-trial activity, then reproductive success in populations may decline. Shively et al. (2005) recommended selective closures, or at least restrictions on recreational activity may be warranted during calving season. Even though their study provided evidence that elk reproduction can rebound from depressed levels when human disturbances are removed or reduced they recognized that it is seldom easy to curb human activities that have become traditional. They recommended developing specific habitat and wildlife protection regimes a priori rather than managing reactively once potentially irreversible damage is done. Witmer and deCalesta (1985) found that road closures, especially during the calving and rutting seasons, can mitigate the impact of human activity on forest roads on Roosevelt cow elk. Servheen et al. (1997) suggested buffering elk calving areas from human disturbance and activity.

Current guidelines for managing elk summer elk habitats in northern Idaho (Leege 1984 and Servheen et al. 1997) recommend restricting human activities on established elk calving and rearing areas from May 1 through July 15. Based on information reported in this review and summarized below relative to timing of elk parturition and rearing biology with the progression of calf physical maturity and plant phenology on western North America ranges, August 1 may be a more appropriate end date for restrictions on human activities to protect elk calving and rearing habitats in north-central Idaho.

- peak birthing period - 1st week in June
- nursery group formation - 3 to 6 weeks post-partum (p-p)
- long distance movements of nursery groups from calving area - 4 to 6 weeks p-p
- changes in selected physical habitat components - 4 to 6 weeks p-p
- switch from total dependence of calf on maternal milk to greater dry feed intake - 7 to 10 weeks p-p
- end of intensive nursing period - 10 weeks

Habitat Effectiveness
The literature contains several recommendations for managing open road density within summer elk habitats. Using Lyon's model for habitat effectiveness based entirely on road density (Lyon 1983), Christensen et al. (1993:2-3) recommended that habitat effectiveness should be 70% or greater (open road density <0.7 mi/sq. mi) for areas intended to benefit elk summer habitats and retain high use. Areas where elk are one of the primary resource considerations should have habitat effectiveness of 50% or greater (open road density <1.9 mi/sq. mi). Areas with <50% habitat effectiveness (>1.9 mi/sq. mi) were expected to make only minimal contributions to elk management goals (Christensen et al. 1993:2). Frair et al. (2008) found that road densities < 0.80 miles/sq. mile yielded the highest probability of elk occurrence where elk were hunted and sensitive to roads. Stubblefield et al. (2006) suggested that the best way to provide and preserve quality elk habitat without prior knowledge of elk distributions is to reduce open road densities. They recommended making landscapes available where elk have the potential to distance themselves > 0.31 miles on all sides from an improved road. Rowland et al. (2000) concluded that management of roads and related human activities during spring and summer should remain an important consideration for managing the elk resource.

Conclusions

By the time the Clearwater Forest Plan was implemented in 1987, the potential effects of increasing human access on elk and their summer habitats from an expanding road network to facilitate timber harvest was well documented, especially in numerous publications from the cooperative Montana elk-logging study. Off-road vehicle travel on system and user-created trails, two-tracks and cross country was not recognized as a threat to elk welfare at the time. Now, an extensive and still growing demand for off-road motorized back-country recreation poses a similar or even greater threat to elk than the building of extensive road systems after World War II to respond to our growing demand for timber products.

Every travel management decision on elk summer range is an elk management decision. Recognition of the potential consequences of travel management actions on elk welfare as noted in this review is necessary for integrated management of recreation and elk. Decisions on travel management must be examined for anticipated short- and long-term effects on elk to minimize negative consequences and realize opportunities for improving current conditions. Conscious attention to the relationships described in this report during planning and application will help assure compatible management of back-country recreation and a suppressed elk population presently struggling to recover from a severe winter die-off a decade ago, declining habitat conditions and incessant mortality from predators. Allen (1977) stated: "there could be more potential for improving or enhancing elk habitat by altering the uses of the landscape than there may be in altering the landscape itself."

The existing literature does not identify a clear, irrefutable link between motorized travel disturbances and elk population demographics. Conclusions on expected effects of motorized access on elk generally only address movement rates, flight responses, resource selection, spatial distributions, and use of foraging versus security areas on summer range as indices to possible changes in population performance. More research is needed to estimate the energetic and nutritional costs associated with these response variables to off-road activities to assess the resultant impacts on elk productivity and survival. Although, the cause-effect relationships described in this review still are not complete nor precise, they will be improved as ongoing research is completed and results are applied on the ground and monitored for effectiveness. Until that information is available, relying on the precautionary principle to restrict the present incremental trend in back-country recreational travel will help assure that unknown population-level impacts on elk in the Bighorn-Weitas are not realized unintentionally. Protecting areas preferred by elk is an important aspect of managing high quality key summer habitats (Leege 1984). Although, perhaps only a subtle connection to elk population performance compared to other factors now acting on the Lolo elk herd, the effects of increased energy expenditure, lost foraging opportunity, and displacement from selected feeding sites and preferred forages from recreational back-country travel might be magnified as a cumulative contributing factor acting to suppress this struggling population.

Hunted populations of elk respond to human intrusion from any mode of travel. A preponderance of information from mostly observation/correlation and comparative field studies indicates that both traditional means of recreational travel and more modern mechanical vehicles have been found to elicit behavioral and physiological responses in elk. Exposure to non-motorized and motorized disturbances on- or off-linear routes through their summer habitat across a spectrum of geographic and ecologic conditions throughout North American elk range is occurring with increasing frequency, intensity and duration as more recreationists venture into back-country on public lands.

Despite the limitations of our present knowledge of cause-effect relationships from recreational travel impacts on elk population performance, the literature does offer an understanding of behavior level effects of motorized and non-motorized recreation on elk that is useful to managers and planners at the project and landscape scale. Many of these effects were already summarized by previous literature reviews and are repeated here to support more recent field studies of the effects of an escalating trend of off-road motorized travel in elk summer range.

Back-country recreational travel predictably evokes an avoidance response by elk and reduces elk habitat use along travel routes, although seasonal responses vary from weak to strong avoidance. Elk move to areas farther from human activity, into generally denser cover and frequently beyond a topographic barrier. Repeated motorized vehicle use on roads or trails and off-road reduces summer habitat effectiveness by at least temporarily displacing elk to areas removed from disturbance sources, increases home range size and fragments secure habitats. Some effects on elk behavior and physiology are common to both motorized and non-motorized recreational travel, but differences occur in the severity and duration. Elk generally showed the strongest avoidance response to motorized travel. Recent controlled studies in the Starkey experimental enclosure demonstrate that elk response to off-road vehicles traveling on trails, two-tracks and off-road is comparable to their behavior when disturbed by more conventional vehicles using roads. Elk are more likely to take flight, at a greater rate of movement and duration, and at a longer distance from motorized than non-motorized off-road recreation. They travel farther and continue to avoid areas near motorized trails/roads when exposed to repeated disturbance from traffic even when routes are not being used by off-road/conventional vehicles. Increased travel time at the expense of reduced feeding and resting, is an energy cost from escape and associated stress that can be compounded by movement from preferred foraging areas near travel routes to more distant areas of potentially lesser forage values and/or greater competition. The cumulative consequences of these effects and greater exposure to predators during movement through less familiar terrain can potentially impact individual fitness, survival, reproductive performance and herd welfare.

Hunted elk summering in back country environments do not habituate to human disturbances from either non- motorized or motorized off-road recreation. But not every disturbance event elicits a flight response from elk. Wisdom et al. (2005a) and Preisler et al. (2006) found that at least one-third of the time elk failed to take flight when close to off-road activity. They reasoned that local topography and/or cover, or possibly other factors may provide the security necessary for elk to remain static. Still, these elk may experience increased alertness and physiological changes such as an increased heart rate or elevated hormone levels from stress. Subtle physiological responses, such as an elevated heart rate (MacArthur et al. 1982) and changes in alertness and posture also have energetic costs.

Location, spatial distribution, and density are physical attributes of travel routes that have been shown to be disturbing to elk security. "Security is important to elk year around . . . " (Allen 1977) and should be one of the basic tenets of elk habitat management. Maintaining a high level of habitat effectiveness may result in adult female elk in better physical condition during late gestation and lactation, which typically should birth heavier calves with a faster growth rate, better summer survival and enter winter in better condition.

Clear short- term behavioral effects and potential population impacts of human disturbance stimuli on elk cows and calves during the calving/nursery period were echoed by several studies. Effects of human disturbances on spring calving areas are manifested in greater movements over larger areas, displacement and abandonment of traditional use areas, less cow/calf group cohesion and greater use of less optimal habitat. Increased energy expenditures associated with these reactive responses are of concern if depletion rates of nutrient body stores affect the nutritional demands of late gestation and lactation (Cook 2002, Cook et al. 2004) to the extent of reduced calf production and survival. Repeated displacement of cow/calf pairs by an observer directly approaching on foot resulted in declines in calf survival great enough to curtail population growth in a Colorado herd (Phillips and Alldredge 2000).

Timing restrictions to minimize the effects of disturbance during this biologic period should be in place and monitored for effectiveness. The present recommendation on restriction of human activity in elk calving/nursery areas should be extended from July 15 to August 1. Phillips and Alldredge (2000) concluded that "to ignore potential effects of human-induced disturbance to elk during calving seasons is to risk declining reproductive success in elk populations." The escalating trend of off-road recreation activities in the Bighorn-Weitas Roadless Area, and especially in the upper Fourth of July Creek and Weitas Creek core elk calving area, is a potential annual threat to the immediate well-being of cow and calf elk and the productive capability of an already struggling Lolo elk herd population. Because elk calf survival greatly influences population trajectories, it is critical for resource managers to minimize/mitigate human disturbance factors that can affect maternal fitness during late gestation and lactation; calf birth date, birth mass and growth rate; and unnecessary exposure to predation through increased movements and displacement to more marginal habitats. Therefore, restrictions on travel through calving areas should remain a management priority and be monitored for project implementation and effectiveness.

Although much more limited than behavioral observations, some literature does attempt to draw the physiological connection that links disturbance, stress, energy expenditure, nutritional limitations, maternal condition, calf fitness and survival and population performance. Few studies of controlled experimental design demonstrate firm conclusions about the indirect impact of summer recreational disturbance on elk population performance through measures of adult or juvenile survival and recruitment. Short-term, un-replicated information does indicate that human disturbance can be a contributing factor acting on maternal behavior and condition, and subsequently calf survival and population recruitment rates. However, even impacts from large scale changes in environmental conditions may take decades to manifest in population performance measures. Most of the reviewed studies were less than five years of field research which is not long enough to give long-lived populations time to equilibrate to loss of habitat effectiveness and repeated exposure to stressful disturbance events manifested in behavioral and physiological reactions.

Invoking the Precautionary Principle, limited evidence of proof of population impacts associated with human disturbances should not be confused as evidence of the relative absence of such an effect. Intuitively, elk populations may be negatively affected by human disturbance and the level or threshold of population level impacts is likely related to the intensity, frequency, extent and duration of disturbance. Elk may be able to avoid immediate population impacts by avoiding disturbed areas, but displacement could have potential cascading effects and cumulative negative impact through increased animal density and competition with other elk in their habitats for limited forage resources. The effects and impacts of linear travel routes and off-road travel on elk herds and their habitat are realized not only on a site-by-site basis at the scale of the individual route segment, or at intermediate scales across a route network, but through the cumulative effects of recreational disturbances over a large landscape of variable density and spaced interconnected route networks across federal/private land boundaries. As demands for back-country recreation increase, so do the cumulative effects on elk and their seasonal habitats over time and space.

Few actions in resource management provide a better opportunity for immediate improvement of elk habitats than travel restrictions. Christensen et al. (1993) in providing an overview of elk management considerations in forest plan revisions in the Northern Region of the Forest Service state that roads are undoubtedly the most significant consideration on elk summer range. They further recognized that all forms of motorized vehicles and all uses on roads will reduce the amount of available habitats usable by elk to meet their needs on summer range. Management recommendations from earlier field studies on effects of roads and associated human disturbances on elk behavior and physiology still hold, and more recent controlled comparative research on vehicles (ATV, UTV, motorbike) specifically designed for off-road travel indicate that these same recommendations are applicable to motorized travel on trails and off-road.

A core area of key elk summer range in the Bighorn-Weitas Roadless Area managed at 100% of habitat potential will help ensure population maintenance and connectivity at a larger, landscape scale. Here, elk can meet their daily and seasonal habitat needs without the threat of the current escalating trend in motorized recreation disturbance reaching a critical threshold that causes a decline in population fitness. Continued recognition of the need to protect these core key habitat areas as done by Clearwater National Forest resource planners and managers and elk advocates during implementation of the Forest Plan in 1987 is the enlightened path to recovery of the struggling Lolo elk population. They have already provided the management framework necessary to restore the elk herds and their habitats in the Lolo Zone to the preeminence they were noted for from the 1950s through the late 1980s. All the current travel plan revision must do is to implement the intent and spirit of their foresight and monitor the results to help assure effective protection and restoration of elk habitat needs. "Protecting areas preferred by elk is an important aspect of preserving quality habitats" (Serveheen et al.1997).

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