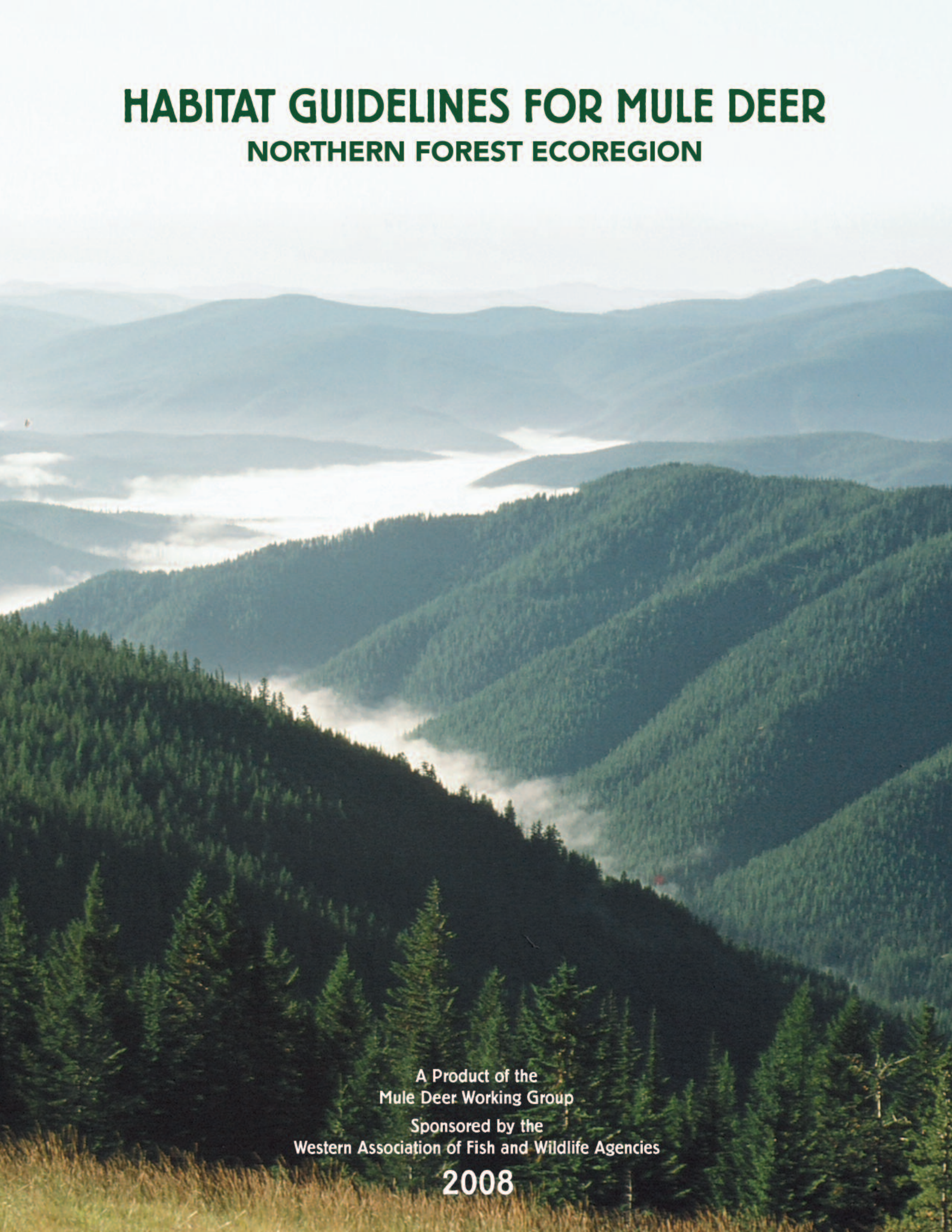
HABITAT GUIDELINES FOR MULE DEER

NORTHERN FOREST ECOREGION



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INTRODUCTION

Mule and black-tailed deer (*Odocoileus hemionus*) are icons of the American West. Few animals represent the West better in the minds of Americans. Because of their popularity and wide distribution, mule deer are one of the most economically and socially important animals in western North America. A survey of outdoor activities by the U.S. Fish and Wildlife Service in 2001 showed that over 4 million people hunted in the 18 western states. In 2001 alone, those hunters were afield for almost 50 million days and spent over $7 billion. Each hunter spent an average of $1,581 in local communities across the West on lodging, gas, and hunting-related equipment. Because mule deer are closely tied to the history, development, and future of the West, this species has become one of the true barometers of environmental conditions in western North America.

Mule deer are distributed throughout western North America from the coastal islands of Alaska, down the west coast to southern Baja Mexico and from the northern border of the Mexican state of Zacatecas, up through the Great Plains to the Canadian provinces of Saskatchewan, Alberta, and British Columbia and the southern Yukon Territory. With this wide latitudinal and geographic range comes a great diversity of different climatic regimes and vegetation associations. With this range of habitats comes an incredibly diverse array of behavioral and ecological adaptations that have allowed this species to succeed amid such diversity.

These diverse environmental and climatic conditions result in a myriad of dynamic relationships between mule deer and their habitats. Within the geographic distribution of mule deer, however, areas can be grouped together into "ecoregions" within which deer populations share certain similarities regarding the issues and challenges that land managers must face. Within these guidelines we have designated 7 separate ecoregions: 1) California Woodland Chaparral, 2) Colorado Plateau Shrubland and Forest, 3) Coastal Rain Forest, 4) Great Plains, 5) Intermountain West, 6) Northern Forest, and 7) Southwest Deserts.

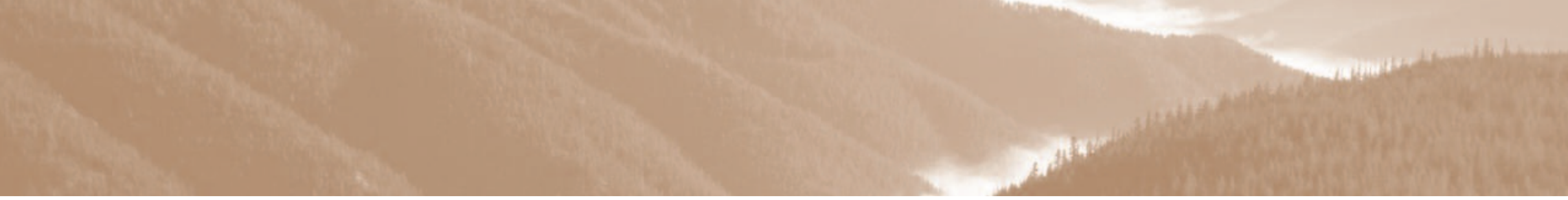
The diversity among the ecoregions presents different challenges to deer managers and guidelines for managing habitat must address these differences (deVos et al. 2003). In many ecoregions, water availability is not a major limiting habitat factor. However, in others, such as the Southwest Deserts ecoregion, water can be important. A significant factor affecting deer population fluctuations in the northern forest is severe winterkill. Winterkill is not a problem in the Southwest Deserts, but overgrazing and drought can seriously impact populations.

The shrubs on which deer heavily rely in the Intermountain West are disappearing from the landscape, partially because invasions of exotic plants like cheatgrass (*Bromus tectorum*) have increased the frequency of fire and resulted in a more open landscape. In contrast, the California Woodland Chaparral and many forested areas are lacking the natural fire regime that once opened the canopy and provided for growth of important deer browse plants. Yet, an intact forest canopy is important in some northern areas of coastal rainforests to intercept the copious snow that falls in that region and impacts black-tailed deer survival.

Across these different ecoregions, the core components of deer habitat are consistent: water, food, and cover. An important aspect of good mule deer habitat is the juxtaposition of these components; they must be interspersed in such a way that a population can derive necessary nutrition and cover to survive and reproduce. Over time we have learned much about mule deer foods and cover, but more remains to be learned. For example, we have learned that cover is not a simple matter; the amelioration that vegetation and topography provide under highly variable weather conditions is a key aspect of mule deer well being. Mule deer have basic life history requirements that weave a common thread throughout many issues facing mule deer.

Mule deer are primarily concentrate feeders with a majority of their diet comprised of forbs (non-woody, broad-leaved plants) and browse (leaves and twigs of woody shrubs). Deer digestive tracts differ from cattle (*Bos taurus*) and elk (*Cervus elaphus*) in that they have a smaller rumen in relation to their body size and so they must be more selective in their feeding. Instead of eating large quantities of low-quality feed like grass, deer must select the most nutritious plants and parts of plants. Because of this, deer have more specific forage requirements than larger ruminants.

The presence and condition of the shrub component is an underlying issue found throughout different ecoregions and is important to many factors affecting mule deer populations. Shrubs occur mostly in early successional habitats; that is, those recently disturbed and going through the natural processes of maturing to a climax state. This means disturbance is a key element to maintaining high quality deer habitat. In the past, different fire cycles



and human disturbance, such as logging, resulted in higher deer abundance than we see today. Although weather patterns, especially precipitation, drive deer populations in the short-term, only landscape-scale habitat improvement will make long-term gains in mule deer abundance over many areas.

As mule deer populations increase towards carrying capacity, they begin to negatively affect their habitat. Populations at, or above carrying capacity may severely impact that habitat with long-term consequences. The manager must also be aware that long-term influences such as drought or vegetation succession can significantly lower the carrying capacity for deer. Even when a drought period ends, the overall capacity may be lower than it might have been 20 years earlier. This may well be the situation in many mule deer habitats in the west and the manager must be cognizant of this factor.

Because of the vast blocks of public land in western North America, habitat management throughout most of the geographic range of mule deer is primarily the responsibility of federal land management agencies. Mule deer habitats are facing unprecedented threats from a wide variety of human-related developments. If mule deer habitats are to be conserved, it is imperative that state, provincial and federal agencies and private conservation organizations are aware of key habitat needs and participate fully in habitat management for mule deer. Decades of habitat protection and enhancement under the label of "game" management benefited countless other unhunted species. A shift away from single-species management toward an ecosystem approach to the management of landscapes has been positive overall; however, some economically and socially important species are now de-emphasized or neglected in land use decisions. Mule deer have been the central pillar of the North American conservation paradigm in most western states and provinces and thus are directly responsible for supporting a wide variety of conservation activities that North Americans value.

Habitat conservation includes active habitat manipulation and directed management of other land uses at a variety of scales. An effective manager will provide support at all scales from policy development, affecting habitat at a very broad scale, to project development, possibly affecting habitat at a very fine scale. The manager must be able to link management goals to an appropriate scale in a realistic manner. This is not to say, however, that only large management projects can have a major impact to mule deer populations. Often, a number of smaller projects in a mosaic or patchy pattern are more beneficial than a single large project. Treatments to improve deer habitat should be planned to work as parts of an overall strategy. For example, the initial focus of a broad strategy may be to concentrate efforts in an area where the benefit will be greatest, with subsequent habitat improvement efforts linked to this initial core area.

Equally important for conserving mule deer habitat on public lands in the west is the need to adequately plan for and mitigate the effects of adverse habitat impacts. Just as habitat managers must recognize that habitat treatments affect larger areas, so too, do adverse habitat impacts caused by activities such as human encroachment and energy or mineral development. Land managers and decision-makers must consider landscape-level plans that fully address the habitat needs of local mule deer herds. Such plans need to address the yearlong needs of any local deer herds that will be potentially affected by other land use decisions.

The key to the well-being of mule deer now and in the future rests with condition of their habitats. Habitat requirements of mule deer must be incorporated into land management plans and land use decisions so improvements to mule deer habitat can be maintained on a landscape scale. The North American Mule Deer Conservation Plan provides a broad framework for managing mule deer and their habitat. These habitat management guidelines tier off that plan and provide specific actions for its implementation. The photographs and guidelines herein are intended to communicate important components of mule deer habitats across the range of the species and suggest management strategies. This will enable public and private land managers (policy makers, regulatory boards, planning boards, etc) to execute appropriate and effective decisions to maintain and enhance mule deer habitat.

THE NORTHERN FOREST ECOREGION

Description

The Northern Forest ecoregion is centered in British Columbia, extending southward to northern Idaho, the western portions of Montana and Wyoming, northern Washington, and northward into the Yukon, and Alaska (Fig. 1). To the east, it includes portions of Alberta and Saskatchewan. The high elevations of the Cascade and Sierra Nevada ranges in Washington, Oregon, and California are also included in this ecoregion to the west. This area includes the northern mountain and Canadian boreal forest deer habitat provinces described by Wallmo (1981).

Vegetation in this mountainous region varies with latitude, elevation, and aspect, but is generally of a forested type consisting of pine (*Pinus* spp.), spruce (*Picea* spp.), fir (*Abies* spp.), Douglas-fir (*Pseudotsuga menziesii*), hemlock (*Tsuga* spp.), or larch (*Larix* spp.), with an intermixing of quaking aspen (*Populus tremuloides*) stands, riparian areas, and meadows, particularly at higher elevations (Fig. 2). Forest canopy coverage is reduced as elevation increases from the mountain-forest zone through the sub-alpine zone into the alpine zone. Forest canopy coverage is also reduced as precipitation declines from the crest of the southern Cascades traveling east with a corresponding change in forest composition from hemlock, to mixed conifer, to pine. Correspondingly, the high-elevation, closed forest canopy of hemlock and mixed conifer transitions to a low-elevation, closed-canopy lodgepole pine (*P. contorta*) or open-canopy ponderosa pine (*P. ponderosa*) forest.

In the Northwest Territories, boreal forest transitions into open, sub-arctic woodland which marks the northern distribution of mule deer. Winters are typically long and cold with large accumulations of snow (>100 in) at higher elevations. Average annual precipitation varies greatly with elevation and topography (rain shadow effect), but ranges from about 10 inches in the valleys to as much as 60-120 inches in alpine zones (Ziegler 1978). In much of British Columbia the high elevation is characterized by Engelmann Spruce – Sub-alpine fir forests just below the alpine parkland that collectively provide valuable summer range. Deer move to lower elevation Douglas-fir forests (winter range) as snow builds in early November. In the southern reaches, forest stands transition from closed-canopy hemlock and mixed conifer to closed-canopy lodgepole pine (transition range) or more open-canopy ponderosa pine (winter range). Typically, snow comes to the higher elevations in mid-November, forcing mule deer into lower elevations with open-canopied ponderosa pine stands. Often this migration extends into shrub-steppe habitats more typical of the Intermountain West ecoregion. Average annual precipitation ranges from 10 inches in the shrub-steppe fringe to over 50 inches at the crest of the Columbia Mountains (Natural Resources Canada 2008). These habitat guidelines are also applicable to the Black Hills and the Cypress Hills which are islands of forest located within the Great Plains Ecoregion. Guidelines for the Great Plains focused on grassland, steppe

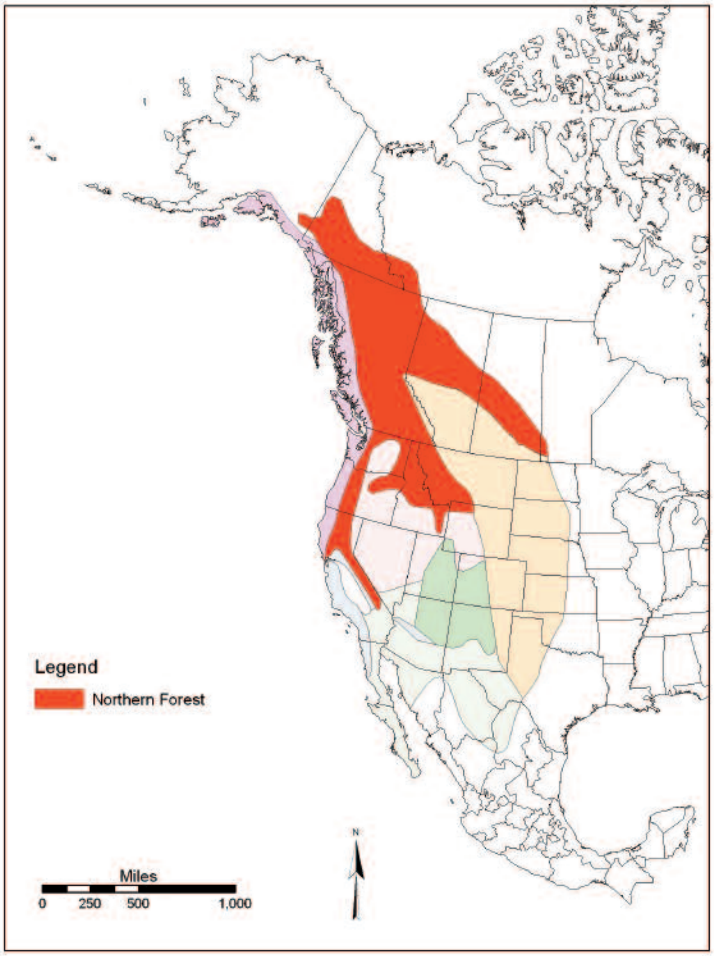


Figure 1. The Northern Forest Ecoregion, shown in red, extends from Yukon to southern California and from Manitoba nearly to the Pacific Ocean.

Figure 2. Mule deer in the Northern Forest Ecoregion commonly inhabit high elevation areas during summer and fall transition periods. (Photo courtesy Jim Hayden, IDFG)

and converted habitats and acknowledged that guidelines for forested habitat would be covered in the Northern Forest and the Colorado Plateau ecoregions sections.

Ecoregion-specific deer ecology

Summer Habitat Use

Mule deer show a strong selection for spruce-fir forests in northern latitudes of this ecoregion during summer and for mixed coniferous habitats during winter. In British Columbia summer range is highly variable ranging from alpine to moist valley bottoms that are rich in forage (Fig. 3). In southern latitudes, mule deer summer in both mixed conifer and pine stands, but are forced to lower elevation pine stands, juniper woodlands, and shrub-steppe habitats in winter due to snow depth. Plant communities vary widely depending on latitude, elevation, aspect, and soil type. Transition and summer ranges are typically forested communities. Overstory vegetation includes ponderosa pine, lodgepole pine, Douglas-fir, true fir, and quaking aspen. Shrub communities may include serviceberry (*Amelanchier* spp.), snowbrush (*Ceanothus* spp.), willow (*Salix* spp.), and ninebark (*Physocarpus* spp.).

Availability of forage is generally low within closed-canopy forests, and high within early successional openings in the forest created naturally by fire, wind-throw, insect infestation, and disease (Crouch 1981). Many insect and disease areas are poor foraging areas due to the abundance of deadfall – especially in lodgepole pine areas. Often, high-quality mule deer foraging areas are transitory in this ecoregion, generally decreasing in quality as succession advances.

Figure 3. During summer, high elevation range provides succulent forage for during late summer. (Photo courtesy Jim Hayden, IDFG)

Winter Habitat Use

Mule deer in this ecoregion show a strong selection for coniferous or mixed coniferous-deciduous habitats during winter. During winters of high snow accumulation, closed-canopy forest stands at low elevations are crucial for wintering mule deer populations. Forest canopy can intercept snow, resulting in shallower snow depth on the ground, decreased energetic costs of locomotion, and increased forage availability (Poole and Mowat 2005). Where deer winter in forests with deep snow conditions, removal of forest canopy may have deleterious effects on deer survival (Hanley 2004). Forest canopy cover reduces wind speeds at the ground and decreases severity of winter conditions. High-quality mule deer range in the northern forest ecoregion, therefore, includes both transitory open stands for foraging, and closed-canopy, low elevation stands in areas where snowfall can be abundant.

In British Columbia, deer select older forests with lower snow depths (Armleder et al. 1994). Mature trees provide litter-fall forage from arboreal lichens and broken branches of Douglas-fir (Dawson et al.1990; Waterhouse et al. 1991). A combination of mature and old forest that intercepts snow with small forage-producing openings provides the best winter habitat for deer. At all snow depths deer concentrate their activities in old Douglas-fir forests where these are available (Armleder et al. 1994).

Shrubs such as serviceberry (*Amelanchier* spp.), wild rose (*Rosa acicularis*), willow, and redstem ceanothus (C. sanguineus) provide important winter forage (Fig. 4), but during periods of deeper snow, mule deer in this ecoregion often are found primarily under forest canopies where snow depths are less (Fig. 5). Here, winter foods often consist of Douglas-fir (Armleder et al. 1986), western redcedar (*Thuja plicata*), subalpine fir (*Abies lasiocarpa*), and arboreal lichens on litter-fall (Waterhouse et al. 1994).

Winter range tends to be the most important limiting factor for deer in the Northern Forest ecoregion. Deer use the

Figure 4. During winter, mule deer expend substantial energy foraging. Nearby closed canopied forest stands substantially reduce energy costs for travel. (Photo courtesy IDFG)

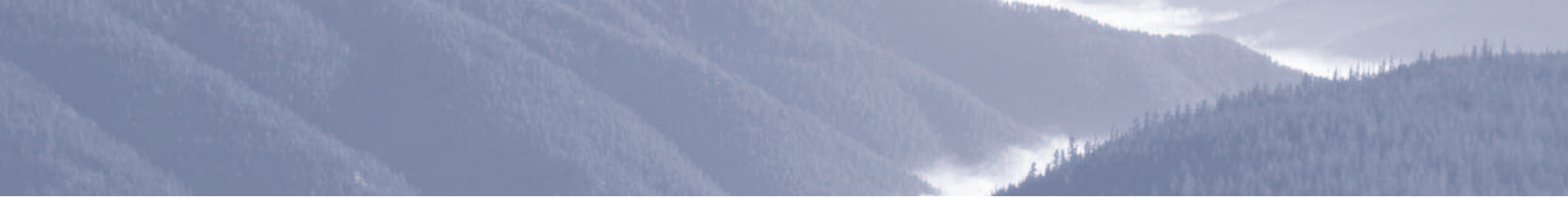
Figure 5. Closed-canopied, low elevation Douglas-fir stands intercept snow, allowing mule deer to reduce energy costs associated with movement. (Photo courtesy Dave Powell, USDA Forest Service/Bugwood.org)

following energy conservation strategies in winter: decreasing forage intake, decreasing metabolism, and limiting movements (Mautz 1978). Despite these measures, body condition declines throughout the winter as fat and muscle reserves are catabolized (Short 1981, Parker et al. 1999). However, the presence of abundant nutritious forage and a lack of disturbance can limit the amount of body reserves used, increasing likelihood of survival and allowing more rapid recovery of body condition. This scenario provides more potential energy for gestation and lactation. Winter ranges throughout the ecoregion are rapidly undergoing human development. One of the best winter survival mechanisms a mule deer has is the fat reserves built up during summer, and fall (Mautz 1978, Short 1981, Parker et al. 1999). If foraging habitats are inadequate on and adjacent to summer ranges, they can become as important a limiting factor as conditions on winter ranges. Further, barriers to migration can severely impact mule deer populations. Interstate highways, hydropower reservoirs, deer-proof fences, and urbanization can form barriers to migration and potentially limit mule deer numbers in this ecoregion.

In the southern reaches of the ecoregion, plant communities vary widely depending on latitude, elevation, aspect, and soil type. Winter ranges may be characterized by Douglas-fir, western juniper (*Juniperus occidentalis*), ponderosa pine, lodgepole pine, curl-leaf mountain-mahogany (*Cercocarpus ledifolius*), antelope bitterbrush (*Purshia tridentate*), sagebrush (*Artemisia* spp.), rabbit-brush (*Chrysothamnus* spp.), fescue (*Festuca* spp.), and wheatgrass (*Agropyron* spp.).

Migrations

Migration strategies have evolved to allow animals to respond to spatial and temporal availability of food and cover, thus maintaining their energetic balance (Garrott et al. 1987, Nicholson et al. 1997). Mule deer populations exhibit different strategies in response to seasonal variation of resources. Mule deer populations may be entirely residential (Eberhardt et al. 1984, Bowyer 1986), entirely migratory (Gruell and Papez 1963, Zalunardo 1965, Garrott et al. 1987), or contain both migratory and resident deer (Brown 1992, Nicholson et al. 1997, Matthews and Coggins 1998). Resident deer may shift areas of activity within their home ranges seasonally and may share winter range areas with migratory deer (Brown 1992). Migratory deer make movements from high-elevation summer ranges to low-elevation winter ranges. Individual deer from a single winter range can migrate to several summer ranges, or from a single summer range to several winter ranges, creating a complex pattern of seasonal distribution (Gruell and Papez 1963, Brown 1992). Migrating deer may move through summer and winter ranges of other deer, which complicates interpretation of distribution and movement patterns (Gruell and Papez 1963, Brown 1992). However, deer movement appears to be more unidirectional in some populations, as influenced by landscape-level topographic and vegetative patterns (Garrott et al. 1987, Thomas and Irby 1990).



Migratory mule deer exhibit high fidelity to summer and winter ranges (Gruell and Papez 1963, Zalunardo 1965, Garrott et al. 1987, Thomas and Irby 1990, Brown 1992, Nicholson et al. 1997, Matthews and Coggins 1998). However, Brown (1992) suggested that deer in Idaho exhibited less fidelity to winter ranges than summer ranges, particularly during mild winters. Timing of migration may be influenced by temperature, relative humidity, snow depth, insect activity, photoperiod, and vegetative phenology (Garrott et al. 1987, Nicholson et al. 1997). During migration, deer tend to follow broad corridors, influenced by topographic features, which become less distinct as the distance from winter range increases (Thomas and Irby 1990). In addition, transition ranges may be important for weight gain during migration in some years (Thomas and Irby 1990). Winter range, migration corridors, and transition areas may be important to mule deer survival in severe winters, and thus need to be evaluated for potential impact by development and other land use activities (Thomas and Irby 1990).

Most deer in this ecoregion are migratory, following the retreating snowline in spring through mountain-forest, sub-alpine, and alpine zones to utilize emerging forage (Fig. 6). Deer are frequently excluded from high elevation sites by deep snows during early winter, moving to lower foothills and valleys. Poole and Mowat (2005) reported that both mule deer and white-tailed deer (*Odocoileus virginianus*) avoided areas with >16 inches of snow in late winter, and Gilbert et al. (1970) documented little use where snow depth was 18 inches.

Migrations to wintering areas of up to 100 miles have been reported in this ecoregion (Wallmo 1981, Mackie et al. 1987). However, some deer stay at lower elevations year-round, and others may remain on higher summer range during years without heavy snowfall or on steep, open, southerly slopes where snow accumulation is reduced (Ziegler 1978).

Winters are long and summer growing seasons are relatively short compared to other ecoregions, but the migratory strategy allows deer to access the most nutritious forage throughout the year. Thus, deer diet quality is generally good throughout the year, although winter restrictions may occur, especially in years of severe cold and/or snowfall (Ziegler 1978). Migratory movements allow deer to fawn on transitional ranges between winter ranges and summer ranges. Unlike winter ranges, these transitional ranges have not been used all winter, and thus provide greater amounts of nutritious forage during the last trimester of pregnancy when protein and energetic needs of growing fetuses increase greatly (Ziegler 1978, Short 1981, Robbins 1983).

Migration allows deer in this ecoregion to maintain good body condition, particularly during the periods of greatest energetic demands—lactation for does and antler genesis for bucks (Ziegler 1978, Short 1981). Excellent nutrition results in good body condition, and high pregnancy rates, productivity, and recruitment of fawns in most years. However, harsh winters with prolonged periods of deep snow and poor forage conditions result in periodic die-offs, which can reduce deer populations (Edwards 1956, Ziegler 1978).

In the non-mountainous boreal forest in Alberta and in Saskatchewan mule deer are more sedentary although they may move between seasonal summer and winter range. These movements are probably not true migrations because of the lack of significant altitudinal differences in topography and associated zoning in vegetation that give deer in mountain habitats an incentive to move significant distances. Mule deer densities are very low in the boreal forest and boreal forest transition zones in Saskatchewan. Whether this is due to habitat, weather or predation

Figure 6. Migration behavior allows mule deer in the northern forest to take advantage of high-quality forage as it emerges with snowmelt at successively higher elevations. During summer, migratory mule deer move to new grazing areas at progressively higher elevation areas. (Photo courtesy G. Keith Douce, University of Georgia/Bugwood.org)

influences of a species at the northern limit of their range or due to historic factors such as over-hunting when the province was settled has not been determined.

Population Dynamics

A variety of interactive factors influence mule deer populations, including habitat quality (forage, water, cover), human disturbance (harassment), diseases and parasites, predation, hunting, inter- and intra-specific competition, and environmental factors (winter severity, drought, distribution of water). Understanding the relative influence of these variables is necessary to evaluate potential impacts of land uses that influence habitat quality and quantity, as well as to intensively manage populations for regulated harvest.

In northern Washington, 100% pregnancy rates are typical in most years regardless of doe age (Ziegler 1978). Fetal numbers averaged 1.6 fetuses/doe for yearlings, and 1.8 for prime (2-7 years) and old (≥8 years) does (Ziegler 1978). Thus, under typical winter conditions, deer populations in this ecoregion are characterized by high productivity, a young age structure, and rapid population growth potential.

Recruitment of young animals is an important factor determining population growth. Neonatal mortality of mule deer fawns can be high, and predation, particularly by coyotes (*Canis latrans*), can influence fawn survival (Trainer et al. 1981). Deer in the Northern Forest periodically experience substantial die-offs during severe winters (Edwards 1956, Ziegler 1978). Over-winter losses of 35-40% of the total population have been documented in Washington following severe winters, and spring fawn:doe ratios can be <30:100 (Ziegler 1978). Although atypical, during the extremely severe winter of 1996-1997, some wintering herds in western Montana and northern Idaho were believed to have incurred ≥70% mortality, particularly fawns (Dusek et al. 2006).

Populations fluctuate in response to direct winter mortality of all age classes, although nutritional conditions often cause a disproportionate mortality of fawns (6-10 months). White et al. (1987) suggested that mule deer populations were limited by recruitment of fawns into the adult population, particularly as moderated by over-winter survival. Similarly, Unsworth et al. (1999) found that annual variation in winter weather determined over-winter survival of fawns, but not does, in Colorado, Idaho, and Montana. Over-winter survival of fawns has been correlated with fawn mass, with heavier fawns experiencing greater survival (Unsworth et al. 1999). Thus range condition, deer density, and weather are interrelated factors.

Severe winter conditions may also affect nutrition of does in the first half of gestation to a degree that fetus development is retarded in the following year (Verme 1962, Dusek et al. 2006). In addition to nutritional deficiencies, thermoregulation and locomotion during a cold winter with deep snow increases the amount of energy required to survive on winter range (Short 1981, Parker et al. 1999). Similarly, spring and early summer drought can reduce body condition of does while lactating and lessen milk available to fawns, resulting in significant mortality to both does and fawns the following winter, even in average winter conditions (Ziegler 1978).

Because of climate and weather influences on plant productivity and winter severity, Unsworth et al. (1999) suggested that large-scale environmental conditions can contribute to declines of mule deer populations on a regional basis. Predictive models have been utilized to estimate over-winter survival of deer based on environmental factors such as temperature, wind speeds, precipitation, and snow depths (Bartmann and Bowden 1984, Picton 1984, Leckenby and Adams 1986, Hobbs 1989).

The productivity possible in this ecoregion allows annual rates of population growth >27% (Ziegler 1978). This high growth potential in the Northern Forest ecoregion usually allows them to recover quickly from decimating winters. Bartmann et al. (1992) suggested that mule deer fawn mortality in some situations was largely compensatory in a density-dependent manner, with an increase in death due to starvation commensurate with a decrease in predation by coyotes. High-quality forage is available for an extended period of time in this ecoregion as plants progressively develop as the snowline recedes (Ziegler 1978). Thus, the balance between annual energy acquisition and expenditure on winter range plays a significant role in deer population dynamics in this ecoregion.

MAJOR IMPACTS TO MULE DEER HABITAT IN THE NORTHERN FOREST

1. Vegetative structure has been modified.
Both increases and decreases in woody species can decrease mule deer habitat quality. Increasing woody cover in some cases decreases the amount and diversity of herbaceous species. Conversely, decreases in some woody species often results in less cover and winter forage.

2. Nutritional quality has decreased.
Increasing age of woody shrubs can result in forage of lower nutritional quality and plants growing out of reach of mule deer. Browse plants eventually become senescent and die if not disturbed. Some factors can also result in the death of woody plants or in a growth form where much of the nutrition is beyond the reach of deer.

3. Vegetative species composition has been modified.
In some cases noxious or invasive species have proliferated in native plant communities, frequently reducing species richness by replacing native flora in near-monocultures. More subtly, some less desirable species have become more abundant at the expense of more desirable species.

4. Loss of usable habitat due to human encroachment and associated activities.
Mule deer habitat is completely lost due to expansion of urban and suburban areas and other associated activities such as oil or gas exploration, road building, and motorized recreation. Related human activity can also displace mule deer from otherwise suitable habitat.

Mule deer are commonly found at upper elevations in the Northern Forest Ecoregion. Avalanche chutes provide high-quality forage in persistent brush fields adjacent to cover. (Photo courtesy Shelleysphotos, Morguefile.com)

Figure 7. Natural openings are valuable in the Northern Forest Ecoregion. Avalanche areas such as these provide reliable, long-term foraging areas. (Photo courtesy Morguefile.com)

Forest Management

Background

Forest management activities in the Northern Forest Ecoregion have had, and will continue to have, tremendous effects on the habitat of mule deer. Large-scale habitat alteration from logging began relatively recently, associated with the onset of mining rushes during the mid-1800s and development of western rail lines during the late 1800s. Unregulated logging occurred in western North America through the mid-to-late 1900s. During the 1970s, state Forestry Practices statutes and new federal laws significantly modified how logging operations were conducted.

In a landscape dominated by forest cover, natural openings are valuable, providing high-quality forage. Many openings are semi-permanent, the consequence of soils and climate. Others are more temporary, the result of wildfire, wind storms, forest pathogens, and other events (Fig. 7, Greene et al. 1992, Lertzman et al. 1996). Some characteristics of natural openings can be replicated through timber management. Conversion of closed-canopy forest stands via timber harvest or natural events leads to a period of early successional habitat that may persist for ≥30 years following disturbance (World Forestry Center 1992).

The manner in which timber harvest is conducted and methods used to re-establish forest stands have ongoing, landscape-scale effects on the quality of mule deer habitat. Typically, forest management increases vegetative diversity, increasing abundance of mule deer forage and decreasing cover. Local conditions dictate impacts on mule deer. Successful deer habitat management requires a considerable number of very detailed, site-specific decisions, such as those embodied here and in various management handbooks (e.g., Armleder et al. 1986; Dawson et al. 2006, 2007).

Issues and Concerns

Vegetative Composition

Although diets of mule deer differ across their range, deer are selective concentrate feeders, generally requiring forage that is high in digestible energy (Collins and Urness 1983, Wickstrom et al. 1984, Beck and Peek 2005, Damiran 2006). Deer obtain most of their digestible energy and protein from clearcuts when given the choice between foraging in clear cuts versus uncut lodgepole pine-spruce-fir forests in Colorado (Regelin et al. 1974). Removal of forest canopy has generally been described as beneficial to deer when associated with retention of a mosaic of cover patches across the landscape (Fig. 8, Brown and Curtis 1985, World Forestry Center 1992, WDFW 1991, WDG 1961).

Biomass of herbaceous vegetation increases after timber harvest in response to decreased competition for sunlight, soil minerals, and precipitation (Fig. 9, Moir 1966). For example, in ponderosa pine stands, herbaceous vegetation can increase from near 0 pounds/acre when canopy cover is 100% to >678 pounds/acre with little conifer canopy cover (Jameson 1966). In Utah, Collins and Urness (1983) found that 18 years after clearcutting lodgepole pine stands, forage

production was 13 times that of adjacent uncut stands.

Aspen stands provide cover and forage for mule deer (Beck and Peek 2005). Stand replacement is naturally accomplished through sprouting (Fig. 10), but conifers may grow up through an aspen canopy, reducing value to mule deer (Fig. 11). Aspen stands can be successfully regenerated with by coppicing methods (Crouch 1983), but ungulate herbivory of regenerating stands can impede growth and establishment of sprouting aspen (Bartos et al. 1994). Collins and Urness (1983) found that mule deer preferred logged aspen stands over logged and unlogged lodgepole pine and meadow complexes, and total herbage production in logged aspen stands doubled 3 years after logging.

Regardless of whether managing forest stands for ecological restoration or timber production, timber harvest will affect forage composition that consequently could affect mule deer population performance, and it may take several years before herbaceous and shrub vegetation production exceeds pretreatment conditions. As harvested areas mature, mule deer forage abundance gradually decreases.

In Douglas-fir/ninebark stands associated with drier coniferous habitat in the inland West, early seral stages following timber harvest have the greatest species diversity and forage values, but as succession advances, forage biomass declines (Steele and Geier-Hayes 1989). Peek et al. (2001, 2002) concluded that mule deer populations in south-central Oregon declined over a 35-year period, partially due to long-term decline in biomass of understory forage as canopy cover increased in forests dominated by ponderosa pine. In subalpine fir stands that were clearcut, forage production more than doubled, and deer spent 72% of foraging time in clearcut areas (Wallmo et al. 1972). However, 20 years after timber harvest, the amount of forage available on cut stands was only 36% greater compared to uncut stands (Regelin and Wallmo 1978).

Even though forage production typically increases following timber harvest, benefits to mule deer differ among conifer habitat types and may even be inconsequential when considered in conjunction with winter range constraints (Fig. 12). For example, Wallmo et al. (1977) concluded that forage on subalpine summer ranges in Colorado would support many more deer than would the associated winter ranges, making efforts to improve high-elevation summer habitat unnecessary. Forage benefits may also be offset by loss of cover needed to intercept snowfall, or increased exposure to human disturbance. Understory burns to remove slash, frequency of under-burning, rest from cattle grazing following timber removal, and timing of grazing can affect long-term composition of vegetation. In Douglas-fir habitat in Idaho, Steele and Geier-Hayes (1989) found herbaceous and shrub biomass 10 years post-treatment was

Figure 8. Removal of forest canopy has generally been described as beneficial to mule deer when associated with retention of a mosaic of cover patches across the landscape. (Photo courtesy Digiology/Morguefile.com)

Figure 9. Both woody and herbaceous forage commonly increase after silvicultural treatment. (Photo courtesy of IDFG)

Figure 10. Aspen sprouts readily, producing abundant forage. (Photo courtesy of Doug Page, USDI Bureau of Land Management, Bugwood.org)

Figure 11. Conifers may crowd out aspens without conifer removal. (Photo courtesy of Dave Powell, USDA Forest Service, Bugwood.org)

Figure 12. Forage production generally increases after logging, but populations may be constrained by other factors such as availability of suitable winter range. (Photo courtesy of IDFG)

greater in prescriptively burned areas vs. unburned areas, but that a high-intensity broadcast burn resulted in reduced biomass. Moore et al. (2006) found no difference in herbaceous biomass in ponderosa pine stands in Arizona that were thinned from below, or thinned from below and then periodically burned over a 12-year period. Both treatments resulted in herbaceous biomass greater than that of untreated stands within 2 years.

Cattle grazing immediately after silvicultural treatments or wildfire can affect herbaceous growth and composition (Vavra 2005). Late summer cattle grazing has a worse effect on shrub composition than does early summer grazing in regenerating ponderosa pine stands (Ganskopp et al. 1999, Vavra et al. 2005). Early summer grazing may reduce subsequent biomass, but remaining biomass will be nutritionally superior (Ganskopp et al. 2004).

Vegetative Structure

Structure of forest stands affects key habitat characteristics such as snow interception, cover, and security. Simplification of complex forest communities that once featured multi-storied canopies, robust shrub components, a diverse array of overstory species, and small irregular openings, into short-rotation, monotypic, low-diversity stands generally has not benefited deer. Owens (1980) detected significant associations between the amount of visual obstruction provided by vegetation, and use by free-ranging mule deer.

Forested habitats play a key role affecting survival of deer during winters with heavy snowfall (Longhurst and Robinette 1981). Where snowfall is deep (> 20 in) in Alaska, deer typically select productive, coarse-canopy, old-growth forests on southerly aspects below 800 feet elevation during winter (Schoen and Kirchhoff 1990). In these stands, the forest canopy intercepts snow, but breaks in the canopy also allow sunlight to reach the forest floor, producing patches of abundant understory vegetation. Thus, deer are able to move and find forage during most winters with snow.

Logging of winter range habitat can be beneficial, providing additional forage, as long as snow-intercept characteristics are not compromised. In naturally uneven-aged interior Douglas-fir forests, a combination of tree densities that produces a mosaic of cover and rooted forage simulating old-growth Douglas-fir forests is ideal for winter range (Armleder and Dawson 1992). In other ecological zones in more mesic conifer habitats, without short-term physical disturbance, winter range habitat will become poorly suited for mule deer.

In areas with lower snowfall and during snow-free months, deer are more general with respect to habitat selection, but

stand structure remains important. Germaine et al. (2004) examined summer diurnal bed sites for mule deer in ponderosa pine stands and found soil temperatures at bed sites under closed canopy were cooler by 7° F.

Distribution of habitats and topography are as important as habitat composition with respect to habitat selection and risks of mortality. Deer are attracted to landscapes dominated by young clearcuts during snow-free months (Yeo and Peek 1992; ADFG, unpublished data). Hunters are also attracted to these areas because they are accessible by roads and deer are visible. Consequently, use of these landscapes by deer increases risk of death from legal and illegal harvest (Farmer et al. 2006).

Wolves prefer hunting flat terrain and take advantage of edges and fragmentation to detect and pursue deer (Kunkel and Pletscher 2001, Farmer et al. 2006). Consequently, silvicultural practices that create fragmentation and edge on flat terrain increase risks to deer of predation by wolves, where present (Farmer et al. 2006).

Roads

Harvest of forest products and transport of these commodities to processing and marketing often require creation or expansion of forest road systems. Additional habitat is impacted by features such as landings, rock pits, equipment storage areas, and spoil disposal areas.

Impacts of roads related to disturbance and resulting distribution of ungulates has been well-documented (Thomas 1979, Witmer et al. 1985, Stewart et al. 2002, Powell and Lindzey 2004). These impacts include increased vulnerability of deer to both legal and illegal harvest, dispersal of undesirable plants, increased predation, fragmentation and isolation of habitats, energy loss due to movement caused by disturbance, avoiding forage areas due to disturbance, and direct loss of habitat due to establishment of hardened surfaces (Fig. 13).

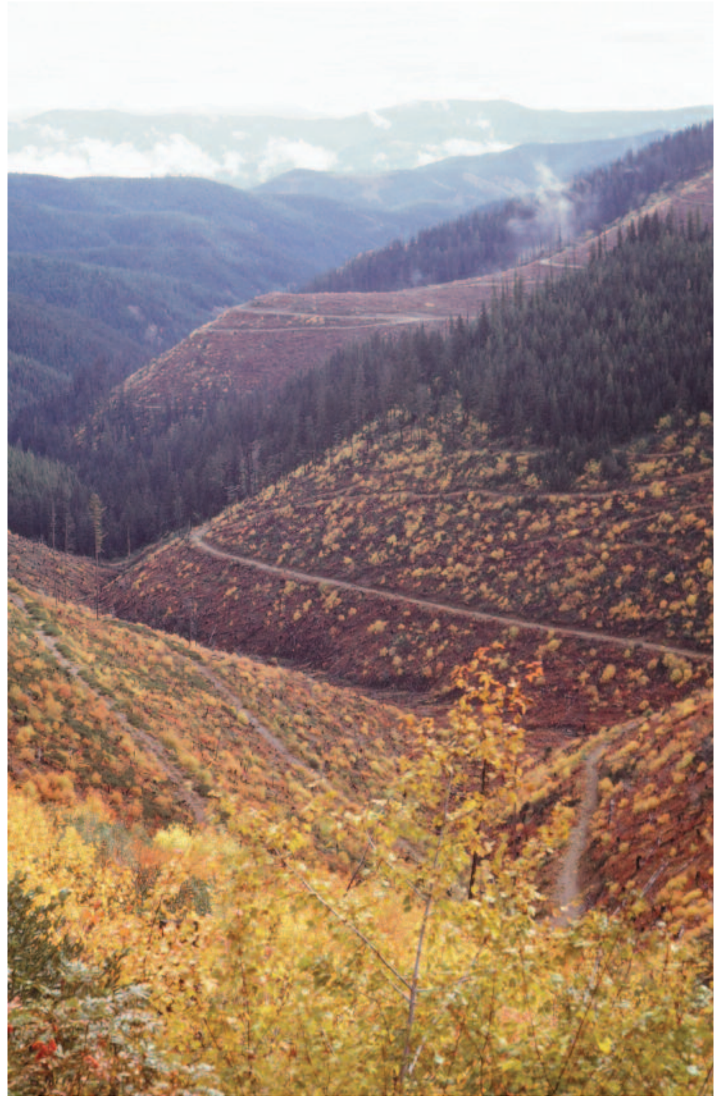


Figure 13. Without vegetative buffers along roads, mule deer are exposed and vulnerable to disturbance and hunting mortality. (Photo courtesy of IDFG)

GUIDELINES

Forest Management Planning

1. Include needs of mule deer in federal, provincial, and state management plans; rural planning and zoning efforts; state Forestry Practices statutes, environmental law, etc.
2. Highlight needs of mule deer in reviews of specific forest management proposals.
3. Provide sources and materials (e.g., these guidelines and the more region-specific literature cited) to assist land managers in providing benefits to mule deer.
4. Monitor efforts and adjust management as needed to benefit mule deer. Define measurable benchmarks of success and plan compliance (see Nyberg et al. 1989; Dawson et al. 2006, 2007).
5. Designate specific mule deer habitat management objectives in planning documents (e.g., Armleder et al. 1986; Dawson et al. 2006, 2007).
6. Develop geographically and seasonally explicit deer habitat management strategies. Map crucial seasonal ranges, riparian areas, proposed timber sales, proposed and existing road networks (Fig. 14).
7. Emphasize long-term maintenance of habitat values by constructing objectives and strategies that account for predictable successional trajectories and a balance between economically optimal stand rotations and those that are ideal for deer.

Road Management

Develop and implement a formal road management strategy prior to writing silvicultural management prescriptions.

Figure 14. Roads associated with logging increase disturbance to deer and increase vulnerability to hunting and other man-caused sources of mortality. For best results, plan road locations, buffers, and closures during initial project development.

Figure 15. The post-logging strategy for road management should be part of the initial sale design, with temporary roads signed as such. Gates, barriers, and road re-contouring should be used where appropriate to maintain less than 1.9 miles of open road per square mile. (Photo courtesy IDFG)

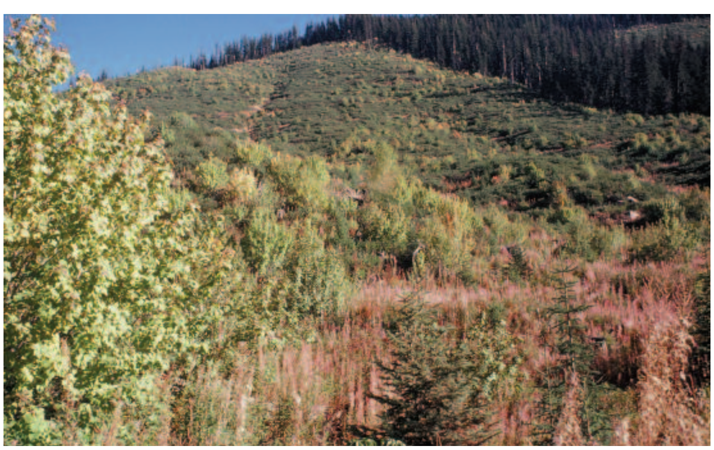


Figure 16. Overstory removal will typically improve the abundance and variety of forage available to mule deer. In this example from Idaho, forage production has been improved substantially, but the large cutting block size and the lack of interspersed cover and visual screening negates some of the benefit of this benefit (Photo courtesy IDFG).

1. Emphasize timber harvest methods that require relatively fewer roads (e.g., lateral cable harvest systems, mobile yarding, or helicopter logging).
2. Minimize open road densities as much as possible. Maintain an average of ≤1.9 miles of open road per square mile of forest land, less on winter range.
3. Close all roads not currently in use to all motorized access (Fig. 15).
4. Abandon, re-contour, and re-vegetate roads that are no longer needed.
5. Enforce motorized vehicle restrictions.
6. Avoid constructing roads within topographic or vegetative buffers.
7. Avoid road construction within designated old-growth and closed-canopy, mature forest stands.
8. Implement road buffers to maintain deer security cover and reduce harassment along open roads.
9. In areas with low security, design new road systems without "circle" or "loop" routes.
10. Minimize plowing of nonessential roads during winter.

Habitat Structure

1. Design landscape treatments to provide a mosaic of forested conditions that incorporate concepts of forage production, escape and hiding cover, snow-intercept cover, travel corridors, and visual screens to reduce disturbance along roads and trails.
2. Maintain or improve a matrix of forage conditions across the landscape with emphasis on increasing the variety of forage plants available and a mixture of shrub age classes (Fig. 16).
3. Encourage and maintain small forest openings; preferably < 50 acres on summer range, and less than 10 acres on winter range that does not experience snow accumulation.
4. On winter ranges that experience significant snow accumulation consider single-tree selection that continuously maintains a high basal area within the forest (Dawson et al. 2007).
5. On the heaviest snowpack winter ranges, consider group selection that produces several even-aged small cohorts within the stand (Dawson et al. 2006). Within Douglas-fir stands in wetter ecosystems, the required cohort size should be ≤1 acre on warm aspects, and ≤2.5 acres on cool aspects (Waterhouse and Eastham 2005).
6. Design winter ranges with a variety of habitat types to reflect the range of winter conditions that deer will experience both within and among winters of varying severity. However, emphasis should be on those forest habitats that are most limiting to deer within the ecological setting.
7. Retain areas of complex, multi-layer canopy across the landscape for cover throughout the year. In general, emphasize uneven-age stand management (Fig. 17).
8. In wintering areas with deep snow accumulation,

consider using a "thin-from-below" strategy to maintain snow interception capacity in the short term while promoting increased stand vigor and tree forms of greater value to deer in the long term (Dawson et al. 2006).

9. Design forest openings such that cover is within 200 yards of all parts of the opening,
10. Retain areas with high escape and hiding cover values within the landscape.
11. Provide patches of hiding cover that are capable of hiding 90% of a standing adult deer at 70 yards within large cut units. Within ponderosa pine stands, tree clumps of ≥ 0.1 acres in size may be adequate (Germaine et al. 2004).
12. Favor tree species with known winter forage value, such as Douglas-fir and hemlock, as retention trees over those with little forage value (e.g., spruce, lodgepole pine).
13. Stand prescriptions should be tailored to specific environmental conditions such as soils, slope, aspect, elevation, latitude, climate, etc. (Fig. 18; see Dawson et al. 2006, 2007).
14. Buffer important habitat features such as ridge tops, knolls, meadows, wetlands, and riparian areas.

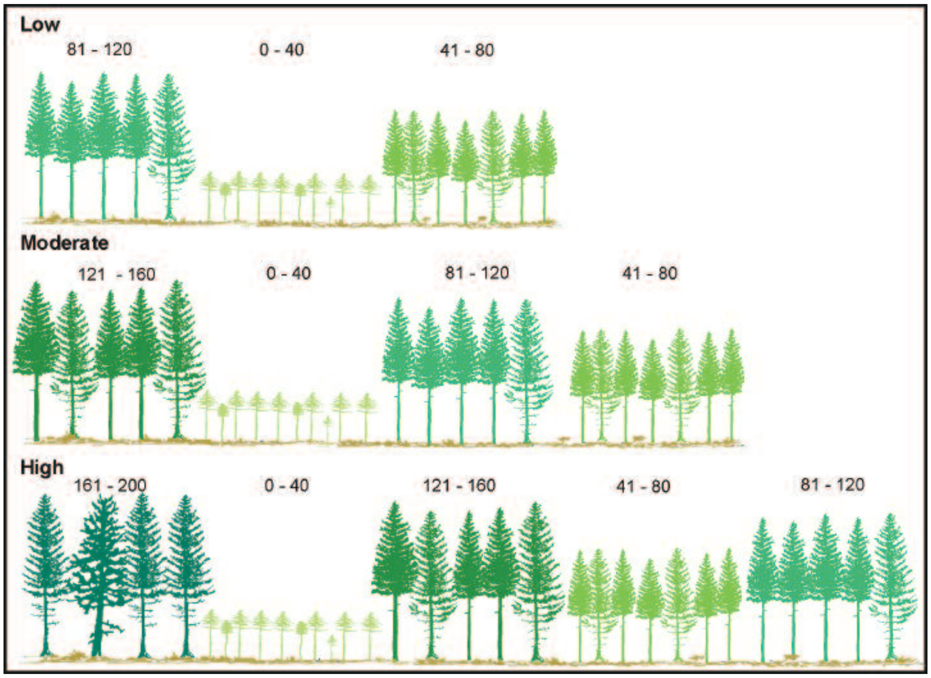


Figure 17. Age cohorts for low, moderate, and high stand structure habitat classes designed for winter areas with deep snowpack, where Douglas-fir forests are typically even-aged. These cohorts range in size from about 1.0 to 2.5 acres and illustrate a 40-year cutting cycle (from Dawson et al. 2006).

Figure 18. Stand prescriptions should be tailored to specific environmental conditions such as slope, aspect, elevation, and soils; and should include patches of hiding cover as well as buffers for important habitat features such as ridge tops, knolls, meadows, wetlands, and riparian areas.

Post-entry Stand Maintenance

1. Treat post-entry stands by means other than aerial herbicide applications to maintain forage species. Use ground-based spraying, mechanical or hand thinning of unwanted tree species, slash burning, etc. where practical.
2. If the stand is to provide significant habitat value for deer, understory forage should be conserved.
3. Avoid broad slash piles that hinder deer use and travel. If economically feasible, burn or chip slash on site (Fig. 19, 20).
4. If reforestation is planned, plant <300 seedlings/acre.
5. Conduct pre-commercial thinning in young conifer stands in advance of canopy closure. Promote a clumpy stem distribution to simulate a natural uneven-aged stand where ecologically applicable (Armleder 1999).
6. Allow plant species that do not interfere with forestry efforts to proliferate. Identify those understory plants that provide deer forage but compete minimally with commercial timber.
7. Minimize soil scarification and other disturbances that promote invasive plant species colonization.
8. Follow non-native invasive species recommendations after treatment

Long-Term Fire Suppression

Background

The importance of fire in shaping and maintaining western landscapes is well documented (Stewart 1956, Wright and Bailey 1982, McPherson 1995, Frost 1998). Fire in the Northern Forest Ecoregion is often beneficial, returning forest communities to a more productive, earlier seral stage. However, fires that remove closed-canopied forest stands on winter range can have a major

Figure 19. Piling slash, then burning during winter should be considered in some situations to reduce the opportunity for fire to escape. (Photo courtesy Scott Roberts, Mississippi State University/Bugwood.org)

Figure 20. Treat slash by burning or chipping on site to facilitate use by mule deer.

Figure 21. Depending on site conditions, brush fields may persist for more than 25 years before succession to coniferous forest. (Photo courtesy IDFG.)

negative impact, reducing the effectiveness of wintering areas where tree canopies provide snow-intercept. Before European settlement, many forests in the interior were more open. Many of these forests are now densely over-stocked with small diameter trees that offer little value to deer. Fire scar analyses in interior Douglas-fir forests show that low-to-mixed severity fires were frequent before European settlement, but essentially ceased by the early to mid-1900s (Daniels 2005). These fires would have limited tree establishment and early survival, but would not have killed many of the large trees with thick, fire-resistant bark (Taylor and Baxter 1998, Daniels 2005), resulting in open stands of wide-crowned trees that are ideal for deer in many seasons.

Keay and Peek (1980) reported that mule deer preferred burned dry forests in north-central Idaho whereas white-tailed deer preferred dense cover associated with unburned forest. Yeo and Peek (1994) concluded that cedar-hemlock forests with deeper snow than drier ponderosa pine/Douglas-fir forests could be occupied by mule deer as long as they could persist on winter/spring range created by fire on low-elevation, southerly aspect forests.

Early successional habitats, such as those produced by fire, provide an abundance and diversity of young forbs and shrubs that are high in protein and other nutritients. Cantu and Richardson (1997) stated mule deer require a diet of approximately 16% protein, along with carbohydrates, fats, vitamins, and a variety of trace minerals, but no single forage provides adequate levels of all these nutrients. A wide variety of browse and forbs allows mule deer to take advantage of plant availability, especially those with higher nutritive value.

Forage quality and quantity will vary with type of habitat and other conditions (Demarchi and Lofts 1985). Soil moisture at time of burning, age and species of plant, fire intensity, season of burn, and frequency of droughts affect production and quality of understory plants. Increases in nutrient levels typically last only a few years, whereas increased production may last for a longer period (Merrill et al. 1982, Demarchi and Lofts 1985). Shrub species such as ninebark (*Physocarpus* spp.) that normally are not very palatable can become more palatable as they re-sprout following fire (Keay and Peek 1980).

Mule deer populations thrive in the more open areas of forest where fire and logging have allowed forbs and shrubs to proliferate. These seral stages of forest persist in productive condition in northern Idaho and similar forests in adjacent areas for ≥25 years in drier areas (Fig. 21), but ≤10 years in more productive forests (Wittinger et al. 1977, Irwin and Peek 1979, Wykoff et al. 1982, Moeur 1985).

In Jasper National Park, Alberta, Tande (1979) reported the natural fire return interval averaged 65 years prior to effective fire suppression. Return intervals for taiga forests composed of spruces vary from 50 to 200 years (Viereck and Schandelmeier 1980). In these more northern forests, persistence of the productive forage stage depends on how long before balsam poplar (*Populus balsamifera*), aspen, and conifers establish and grow to the point where they shade understory vegetation, likely at rates similar to those predicted for more southerly mixed-conifer forests. Thus, productive mule deer habitat in northern coniferous forest is transitory in nature and typically short-lived. Frequent fires are needed on the landscape to maintain productive forage for extended periods of time.

Mule deer population responses also depend on whether fires are large enough to cause vegetation responses at a population-level scale. The large fires of 1910 and 1919 in north-central Idaho burned between one-third and two-thirds of mule deer winter range in the major drainages (Norberg and Trout 1957). Large increases in elk and mule deer populations followed these burns. In subsequent years mule deer populations declined as elk continued to increase.

Reports from central Idaho suggest that mule deer populations also increased following wildfires that burned >250,000 acres in 2000 (IDFG, unpublished date). Deer populations had been relatively low prior to the fires. Conversely, some elk populations that were at all-time highs and unproductive prior to the fires have had mixed results, with some herds increasing while others decreased. Gray wolves (*Canis lupus*), mountain lions (*Puma concolo*r), coyotes, and black bears (*Ursus americanus*) were present throughout the burned area. While documentation is inadequate to define responses more accurately, the example provides evidence that population density, momentum, and dynamics have affected responses of the 2 species to the fire.

Issues and Concerns

Fire suppression during the past 75 years has generally promoted large, somewhat uniform blocks of mid and late seral forest in some areas, and overly dense forest stands in poor condition in others. The absence of abundant and diverse high quality forage in late-seral communities often fails to provide the diet quality and nutrition required for most aspects of deer production and survival (Short 1981, Wakeling and Bender 2003). Fire suppression allows large areas of forest to attain maturity. This can be beneficial to mule deer wintering in deep-snow areas, but has a detrimental affect on forage production. Local conditions dictate the proper balance between the various needs of mule deer.

Figure 22. Prescribed fire is an effective tool for manipulating mule deer habitat. Burning during fall is advantageous for regenerating aspen and for encouraging redstem seedling establishment. (Photo courtesy of IDFG.)

Guidelines

Most habitat manipulation that can benefit mule deer will occur as part of larger-scale programs involving multiple goals in the Northern Forest Ecoregion. Winter ranges may be purposefully managed for deer forage in some instances, for cover in others. Most management should concentrate on providing forage on winter and spring ranges. When practical, management should be focused on large blocks of land where monitoring of forage condition and mule deer trends may be used to evaluate response.

Prescribed Fire

After nearly a century of fire prevention that caused forest canopies to close, current forest management trends in much of the northern Rocky Mountains and associated forests that contain mule deer are moving towards restoring more open forest stands with shade-intolerant species (Arno 1980). Prescription fire (Fig. 22) is often a part of timber management programs to provide seedbeds for conifers and reduce slash. In wilderness areas, national parks, and other areas where timber harvest is precluded, wildfire has become an important part of the overall management program. These trends should benefit mule deer, depending upon the size and frequency of management actions.

Prescribed fire is an effective tool for returning understory plant communities that are fire adapted to early succession stages. However, an increase in fire frequency can be devastating to plant communities that did not evolve with periodic fires. Managers need to strive to re-introduce fire where ecologically appropriate, yet protect some plant communities from harmful fires. Prescribed fire can often

Figure 23. Prescribed burns should be conducted after careful consideration of the ecology of the local vegetative community. For example, fall burning will result in substantially higher seed germination than spring burning for redstem ceanothus shown here. (Photo courtesy IDFG)

Figure 24. Used in conjunction with timber harvest, under-burning can help remove the overstocked understory of trees and promote forage production. (Photo courtesy Russ Davis/ACOE)

serve as a highly effective and cost efficient tool for enhancing mule deer habitat (Fig. 23). In areas where wildfire naturally helps maintain the plant community in an early seral stage, prescribed burning is one of several tools available to habitat managers.

Under-burning (Fig. 24), used in conjunction with timber harvesting, is a tool that can be used in forests that historically had a low-to–mixed severity fire regime. This approach can remove the over-stocked understory of trees and promote increases in forage while keeping most of the canopy intact (Steen and Armleder 2008). Prescription fire, used appropriately, can create a natural mosaic of diverse plant communities that provide for important habitat needs at any given time. Prescribed burning must follow specific guidelines that establish the conditions and manner under which fire is applied to an area in order to achieve well-defined, short- and long-term management objectives. Considerations for the location, size, timing, frequency, and intensity of fire are critical for achieving burn objectives.

1. Design landscape treatments to provide a mosaic of forested conditions that incorporate the concepts of forage production, escape and hiding cover, snow intercept cover, travel corridors, and visual screens to reduce disturbance along roads and trails.
2. Maintain or improve a matrix of forage conditions across the landscape with emphasis on increasing the variety of forage plants available and a mixture of shrub age classes.

Natural Fire

Natural fires are usually fought in an effort to reduce danger to humans, minimize loss of resources (e.g., wood fiber), and address social concerns. When planning for wildland fire management and resource needs, managers should identify areas where wildfire would benefit mule deer and areas where fire would be detrimental to mule deer, thereby helping decision-makers include the needs of mule deer when prioritizing fire-fighting resources. This is especially important in Wilderness areas where other vegetative management techniques may not be available.

Additional Tools to Consider

In the absence of fire, timber harvest can be a useful tool for converting forest stands to an earlier successional stage and improving forage conditions. In areas where shrubs are sensitive to fire, use of mowers to reduce fuel loads typically removes older shrubs while releasing younger, more palatable shrubs that prescribed burning would eliminate. In dry ponderosa pine forests, shrubs usually regenerate faster in mowed areas than in burned areas. In situations where use of prescribed fire is not tenable, use of herbicides can produce satisfactory results, although sprouting may not be as prolific as with treatment by prescribed fire (Asherin 1973).

Invasive, Non-Native Plant Species

Background

Habitat alteration is a critical issue for native fauna. Invasive non-native plant species cause significant environmental damage. The Northern Forest Ecoregion spans a large geographic area and includes a substantial number of non-native, invasive species. Taylor and MacBryde (1977) found 21% of all vascular plants species in British Columbia were exotic. The Invasive Plant Resource Guide (Center for Invasive Plant Management 2005) and the Electronic Atlas of the Plants of British Columbia provide useful information on specific weed species and further links to non-native, invasive weed resources (Klinkenberg 2006).

Issues and concerns

Invasive, non-native plant species have several negative ecological impacts: displacement of native plants, reduction in biodiversity, alteration of normal ecological processes such as nutrient and water cycling, and increased soil erosion and stream sedimentation. Lacey (1989) found that spotted knapweed (*Centaurea maculosa*) infestations on hillsides (Figs. 25, 26) increased runoff by 56% and sediment yield by 192% compared to adjacent hillsides covered with native bunch grass. Infestations of invasive, non-native plants can have significant impacts to native plant communities, wildlife habitat, and wildlife species supported by those communities. Negative effects of non-native plant invasion have gone largely unnoticed, but this factor has had an insidious, often long-term effect on the overall quality of mule deer habitat.

There is a severe lack of direct research available regarding specific impacts of invasive, non-native plants to mule deer. When non-native plant species invade native plant communities they change the structure, species composition, and functional dynamics of those communities. These changes can reduce mule deer forage, alter cover, reduce water availability, reduce distribution of individual or groups of mule deer, and concentrate mule deer on remaining non-infested areas resulting in over-utilization of critical habitats such as winter range.

Presence of an infestation does not necessarily indicate that treatment is warranted. The decision of whether to treat an area must balance the likelihood for improvement of the vegetative community against damage caused by the management methods, while considering the ecological significance to the mule deer population.

Management of non-native, invasive species centers on preventing expansion of the distribution of the species and minimizing abundance within that distribution. Once established, it is extremely difficult to eradicate a non-native invasive species except at a local level, and even then, only with intensive efforts and a continuous program for monitoring and further treatment.

The key to preventing new infestations is limiting transport of seeds or plant parts into a new area, and limiting characteristics conducive to establishment of those species. Implementing a monitoring plan to detect infestations is important so that treatment can be considered and accomplished early, before infestations become too difficult to treat effectively. The extent of treatments utilized depends upon the ecological and social implications associated with impacts to the target species, non-target species, and subsequent cascading of effects into other plant and animal communities.

Figure 25. Spotted knapweed, a prolific seed-producer, colonize large areas quickly. (Photo courtesy John Cardina, Bugwood.org)

Figure 26. Infestations of non-native plants such as spotted knapweed may exclude native plants over significant areas for long periods of time. (Photo courtesy John M. Randall/The Nature Conservancy)

Guidelines

Planning and Coordination

Planning elements that should be considered for a successful non-native, invasive plant species management program include:

1. Provide information to the general public regarding the nature of the problem, its extent, what measures they can take to help address the problem, and what direct measures may be taken by the land manager to address the problem.
2. Provide materials such as media releases, signs, kiosks, invasive plant identification brochures, and informational material for hunter education classes or school groups.
3. Coordinate with local weed management groups (and other agencies, landowners, etc) to partner on additional materials and active suppression.
4. Map which undesirable species are present, their range and relative abundance, the biological significance to mule deer, and associated factors likely to influence decision-making, such as presence of rare plant species, disruption of the existing biological community, or public concern. Inventory of non-native plant species need not be extensive. In many cases, a rudimentary inspection can reveal a severe weed problem is present. In other cases, it may be desirable to conduct an intensive survey. Pre-treatment inventory should be designed in coordination with post-treatment monitoring.
5. Coordinate and consult with government agencies and interested non-government entities prior to decision-making. Substantial information on weeds and weed control is available on the internet and through various agencies and private groups. Coordination with these entities can make a treatment program more effective, and provide general public support. It may also be required by law.
6. Clearly state your management objectives. Management is actively affecting the existing plant community through control and rehabilitation. Control, generally classified as mechanical, biological, or chemical, is treatment of the target area to eradicate the species from the area, or more commonly, to reduce abundance and slow the spread of an undesirable species. Rehabilitation is the re-establishment of the native vegetative community, often including seeding or planting with native species.
7. Conduct surveys prior to treatment, as well as at 2-5 year intervals during and following treatment. Monitoring evaluates efficacy of the treatment, and in some cases, includes evaluation of subsequent influences to mule deer and other wildlife. Monitoring is a key element in any non-native, invasive plant management program.

Table 1. Management prescriptions for varying levels of non-native plant invasions.

Level of Infestation	Habitat and Site Description	Management Prescription Emphasis*
Low	Native plant species dominate site. Invasive, non-native species are rare and distribution is very limited. Infestations comprise < 5% of herbaceous vegetation	Prevention Eradication Monitoring
Moderate	Native plant species comprise majority of plant species present. Invasive, non-native species distribution is limited. Some localized infestations can be dense. Infestations comprise 5-20% of herbaceous vegetation.	Prevention Active Control Monitoring
High	Native plant species may comprise majority of plant species present. Invasive, non-native species are common. Some infestations are dense and widely distributed. Infestations comprise 21-60% of herbaceous vegetation.	Active Control Passive Control Monitoring
Severe	Native species comprise a minority of the plant community, or may be absent. Invasive, non-native plant species dominate site. Infestations comprise > 60% of herbaceous vegetation.	Rehabilitation Monitoring

** Identifies priority management prescriptions for differing levels of invasion; however, all management prescriptions should be considered.*

Management Actions Inventory
Inventory will reveal the level of invasion by non-native plant species, which, in turn, will dictate the degree to which prescriptions should be emphasized (Table 1). The ecological significance to mule deer of the impacted habitat should be a primary factor considered when deciding the intensity and subsequent resource expenditures associated with implementation of silvicultural prescriptions. Using multiple management prescriptions is frequently the most effective approach to maximize resource benefits to mule deer.

Prevention
The emphasis of prevention is to prevent the pioneering and establishment of invasive, non-native plant species into ecologically significant mule deer habitats. Useful approaches include:

1. Implement information and education programs.
   - Create and post media releases, signs, and kiosks.
   - Develop and distribute invasive plant identification brochures.
   - Develop and distribute informational material for hunter education classes.
   - Develop and distribute educational materials for school groups.
2. Limit potential sources of introduction of invasive seeds or plant parts:
   - Avoid use of non-native plant species while attempting to "improve" habitat conditions or stabilize soils.
   - Consider the potential for non-native plant invasion when deciding whether to build, improve, or maintain roads (Fig. 27).
   - Clean motorized vehicles prior to entry to the area. Require this if infestations are severe.
   - Brush horses and clean hooves prior to entering area.
   - Feed horses certified weed-seed-free hay 96 hours prior to entering area
   - Use weed-seed-free hay or pelletized feed within the area;
   - Re-evaluate road and trail system and close non-essential roads and trails
   - Target a buffer area around non-invaded habitats for control or eradication of invasive species.
   - Confine domestic livestock in a holding pasture for 48 hours prior to releasing them onto open rangeland.
   - Limit or prohibit feeding and baiting of ungulates.
3. Limit or prohibit activities that result in soil disturbance.
   - Adjust season of use and utilization levels of livestock grazing to minimize impacts to soils.
   - Limit or prohibit road construction, logging and surface mining activities that result in moderate to high levels of soil disturbance; and,
   - Limit or prohibit OHV off-road travel to designated trails.
4. Implement a fire suppression program where appropriate to minimize colonization by invasive non-native plants (see also Long-term Fire Suppression section):
   - Develop Geographical Information System (GIS) maps of mule deer habitats targeted for fire suppression.
   - Coordinate fire suppression program with governmental agencies and interested non-government organizations.
   - Restrict use of non-contained fires during peak fire periods

Figure 27. Roadways are important vectors for the spread of invasive non-native plants. An aggressive weed control program may be needed prior to road re-construction to reduce the spread of non-native invasive plants during construction. (Photo courtesy Tom Huette, USDA Forest Service/Bugwood.org)

Figure 28. Aerial application of herbicide may be needed for non-native invasive plant eradication in areas with extensive infestations. (Photo courtesy of IDFG)

Eradication
Management emphasis for eradication is to remove invasive, non-native plant species from impacted mule deer habitats (Fig. 28). Typical treatment methods include use of herbicides and physical removal. Complete elimination of non-native species is unlikely, but the primary management goal should be to change vegetation composition to reduce non-native species dominance and spread, and promote

greater plant diversity. Measures include:
1. Target all known invasive, non-native plants for eradication.
2. Target a buffer area around ecologically significant habitats for eradication of invasive species.
3. Implement extensive invasive non-native plant species inventory.
4. Digitize perimeters of all infestations.
5. Consult with governmental agencies and interested non-government organizations weed control experts prior to treatment.
6. Record what, when, where, and how treatments of infestations were implemented.
7. Consult and coordinate treatment efforts with weed control experts, governmental agencies, and interested non-government organizations.
8. Monitor effectiveness of treatment annually and update GIS and record keeping.

Active Control
Management emphasis for active control is to contain invasive, non-native plant species in current locations and at current levels of infestation. Typical treatment methods include use of herbicides. There are some biological control agents that can be used with this prescription; however bio-control agents generally require 3-5 years and several applications before they start having the desired effect. Measures include:
1. Implement control or containment program (primarily herbicides).
2. Inventory in GIS format the location and perimeter of all infestations.
3. Target a buffer area around ecologically significant habitats for active control of invasive species.
4. Prioritize for treatment new infestations, and infestations that are outliers from dense infestations.
5. Consult and coordinate treatment efforts with weed control experts, governmental agencies, and interested non-government organizations.
6. Record what, when, where, and how treatments of infestations were implemented.
7. Monitor effectiveness of treatment annually and update GIS and record keeping.

Passive Control
Management emphasis for passive control is to decelerate the spread of invasive, non-native plant species. Typical treatment methods include use of bio-control agents such as insects, disease pathogens, and livestock that will target specific species. Treatments should be applied annually for 3-5 years. Measures include:
1. Implement passive control program (primarily biological-control).
2. Consult and coordinate treatment efforts with weed control experts, governmental agencies, and interested non-government organizations.
3. Monitor effectiveness of treatment annually and update GIS and record keeping.
4. Record what, when, where, and how treatments of infestations were implemented.

Rehabilitation
Management emphasis for rehabilitation is to restore preferred native plant species in degraded mule deer habitats. Often these efforts will be used in conjunction following eradication efforts (Fig. 29).
1. Seed native species and practice range management practices to expedite rehabilitation of deteriorated areas. Management considerations should include manipulation of grazing intensity and timing, rest rotation systems, etc. Identify areas that are deteriorated, but lacking invasive plant species, and make these a high priority for proactively seeding native species.
2. Promote native species production with the focus on those plants used or preferred by mule deer.
3. Coordinate rehabilitation efforts with governmental agencies and interested non-government organizations.
4. Evaluate native seed bank before purchasing seed to determine if seed resources are truly lacking.
5. Consult with regional natural resource managers who have been involved with past rehabilitation projects.
6. Use only certified weed-seed-free native seed.

Figure 29. With severe infestations such as this hawkweed stand, complete rehabilitation of the area may be required to return the area to native plant species. (Photo courtesy Washington State University Archives)

7. Prohibit livestock grazing until new vegetation has met established criteria. A minimum of 2 full growing seasons should be given to newly seeded pastures.
8. Inventory in GIS format the location and perimeter of all rehabilitation efforts.
9. Record what, when, where, and how rehabilitation efforts were implemented.
10. Monitor effectiveness of rehabilitation annually and update GIS and record keeping and share rehabilitation experiences with other natural resource agencies.

Human Encroachment

Background

Human activity impacts mule deer and their habitat in numerous ways, most of which are negative. Many of our daily activities and infrastructure development that we often consider benign is actually detrimental to mule deer. Impacts can be direct (e.g., vehicle collisions, fence entanglement, drowning in canals or impoundments), or more frequently, indirect (e.g., habitat loss to development, impediments to migration, disturbance). Current and ever-increasing levels of human encroachment clearly limit the potential for restoring mule deer populations to levels observed in the mid-20th century. Nevertheless, opportunities exist for conservation and management actions that can reduce impacts of human encroachment or restore habitat values and thereby maintain or increase mule deer numbers and associated public and ecological benefits.

Issues and Concerns

Habitat Loss

Because of the appealing nature of landscapes occupied by wildlife, humans are increasingly moving to these habitats to live (Glennon and Kretser 2005, Hansen et al. 2005). In other cases, development in wildlife habitat is simply a response to exploding human populations and socioeconomic trends in western states and provinces (Glennon and Kretser 2005, Hansen et al. 2005). Occupation of this mule deer habitat brings with it construction of homes, fencing, roadways, and other supporting infrastructure, such as stores, health facilities, and other buildings.

These homes and communities are often located in habitat that fills critical wildlife needs during periods of migration or winter stress. When people move into mule deer habitat, the resultant development destroys many of the features that initially drew people to those habitats. This is the greatest impact of human disturbance on wildlife populations. During the mid 1990s alone, this development occupied 5.4 million acres of open space in the West (Lutz et al. 2003). Nicholson et al. (1997) found that mule deer avoided human developments in all seasons.

A major concern for mule deer is encroachment upon, and development within, important habitat. A primary example of this is the impact of land development on winter range – this long-term habitat change is one of the most pervasive impacts to mule deer habitat. Many winter ranges are on lower elevation valley sides on sunny aspects; exactly the areas desired for human occupation. Impacts of development often reach well beyond actual acreage covered by buildings, roads, and other infrastructure (Glennon et al. 2005, Hansen et al. 2005). In many cases, fences around these structures further exclude deer from usable resources.

Amount of habitat lost through road and railroad construction varies based upon size and type of construction. Reed (1981a) estimated interstate, rural, and county highways usurp 45, 12, and 7 acres of land/mile of road, respectively. Ubiquitous travel networks through mule deer habitat on public forest and rangelands result in further loss of thousands of acres of habitat across the range of mule deer. Gaines et al. (2003), through a literature review to document effects of linear recreation routes on focal wildlife species, listed displacement distances from roads for focal ungulate species including mule deer. Similarly, development of water impoundments and distribution systems eliminate habitat once available to deer. Quarries, mines, and energy development and their associated transportation and distribution systems also remove land area from the total habitat base although reclamation programs can convert some of this land back to usable habitat (see section on Energy and Mineral Development). More recently, several western states and provinces have witnessed construction of “high-fenced” facilities designed to contain privately owned ungulates. These facilities can effectively eliminate hundreds or even thousands of acres of mule deer habitat and block access to additional mule deer habitat. Since 2001, >7,000 acres of occupied mule deer habitat were usurped by high-fenced facilities in east- and south-central Idaho alone (IDFG, unpubl. data).

Where development is unavoidable, “mitigation,” through acquisition or management of land elsewhere, is sometimes employed to offset past habitat losses. However, it is important to recognize that replacement acreage or quality may not match that of lost habitat and existing land already providing wildlife values. This led Reed (1981a:522-523) to comment: “Hence the concept of compensation or mitigation becomes an absurdity as wildlife habitat continues to be whittled away.”

Habitat Conversion

Conversion of natural habitats to agricultural lands can

Figure 30. Homes and communities often are located within habitats that fulfill critical needs of mule deer. However, human occupation and development may provide some advantage to local populations. Photo courtesy Ronald F. Billings, Texas Forest Service/Bugwood.org)

have mixed impacts on mule deer populations depending on extent of conversion, crops produced, and landowner tolerance. Extensive conversions of large areas to crops that provide little forage or cover will likely reduce deer numbers significantly or displace deer completely (e.g., expansive grain farming in Alberta). Conversely, crops that produce usable forage interspersed with adequate cover and native habitat can support unnaturally high density deer populations, provided landowners are amenable. However, differences in landowner tolerance within a local area or changes in ownership can lead to substantial conflicts and a need for intensive management actions. These situations likely result in increased cost:benefit ratios relative to management of intact systems.

Human activity has the ability to alter habitat suitability through direct alteration of habitat characteristics, thereby influencing habitat quality. Although some human activity and man-made structures may seem innocuous, most reduce capability of the land to support deer, often through cumulative effects. Glennon et al. (2005) reported that exurban developments can result in disruption of animal movement patterns and spatial distribution, alteration of community structure with reduced diversity and abundance, introduction of invasive and exotic plant species and general habitat degradation.

In addition to directly usurping habitat, development of human communities often alters adjacent habitat as well. Shrub habitats providing food and cover may change to pasture or manicured lawns. Native shrubs and forbs may be replaced by ornamental plants. People frequently bring domestic dogs and livestock that may compete with, or harass, wildlife, or jeopardize wildlife through disease transmission. Domestic dogs are especially a problem on winter ranges when free roaming dogs chase deer resulting in increased energy expenditures at a time when deer already experience substantial weight loss. Improper use of off-highway vehicles (OHVs) can alter habitat characteristics by destroying vegetation, compacting soil, and increasing erosion (USFS 2005).

However, human occupation may provide some advantages to local wildlife populations (Tucker et al. 2004). Wildlife in some developed areas may acquire more water from artificial sites (e.g. ponds) and enhanced forage (e.g., lawns, plantings, golf courses, agricultural fields) than in surrounding areas (Fig. 30). However, McClure et al. (1999) found that urban deer exhibited lower fawn recruitment than rural deer. They speculated the lower recruitment rate was a result of urban deer clustering around areas of concealment vegetation resulting in incomplete use of available forage. Reduced numbers of natural predators in these areas can also reduce mortality for wildlife. Enhanced forage conditions and decreased predation may result in unhealthy densities of wildlife that will be susceptible to diseases or parasites. Improved forage and decreased predation notwithstanding, increased housing density can result in decreased mule deer abundance (Vogel 1989).

Inevitably, some individuals will feed deer and other wildlife in developed areas, leading to a number of negative consequences. Concentrating deer at feed sites can lead to aggressive behavior among deer and toward humans, as well as promoting disease and parasite transmission. Also inevitably, some people in the area will suffer unacceptable damage to ornamental plants, gardens, and other property, at times leading to widespread unrest in a community. An insidious side-effect of such situations is creation of opinions that deer are nuisance wildlife, similar to Canada geese (*Branta canadensis*) in many developed areas across the U.S. This devaluation of deer in the public eye will only increase difficulty in developing public support for mule deer and management of natural habitats (Lutz et al. 2003).

Figure 31. Road and railway corridors fragment mule deer habitat and may impede migrations. Managers should look for opportunities to include deer crossing structures during any new construction or modification of existing roads and railways. (Photo courtesy Digiology)

Although mule deer are often observed negotiating fences with apparent ease, fencing can create significant barriers or impediments to normal deer movement and increase energy demands. Fence permeability obviously varies with fence design, but all fences affect deer to some extent. Fences along major highways are often designed to completely exclude ungulates and therefore block movements and eliminate migration corridors, effectively isolating some populations. Adult deer may be able to jump over net-wire or 5-6 strand, barbed-wire fences, but fawns are generally unable to negotiate such structures until several months old.

Negative impacts of low permeability fences are readily discernible, but even the more permeable fences create problems for deer. Negotiating virtually any fence requires more time and energy than that of unrestricted movement. In some cases, deer may spend several minutes walking back and forth along a fence to find a potential crossing point. Fences on slopes exacerbate problems because functional fence height increases significantly for deer on the downhill side (Wasley 2004), and deep snow can make an otherwise permeable fence impassable. Crossing fences also carries risks of injury that might later compromise an animal's ability to avoid predators or function normally. Because of climate patterns and topography in the Northern Forest Ecoregion, mule deer populations may display lengthy migrations (Heffelfinger et al. 2003) along which individual animals may encounter dozens of fences. Many arterial roads have fences on both sides thereby increasing the difficulty of the road crossing. The cumulative impact of repeated fence crossings can only increase energy costs and risk of injury, and potentially increase predation risk, particularly for fawns.

Road and railway development (Fig. 31) can limit mule deer access to important habitats as well. The most obvious negative impact on habitat suitability is the elimination of linkages between important habitats. These impacts may be the result of actual development or road proliferation and improvement. Roadways, railways, and associated fences fragment habitat and impede movements for migratory herds (Lutz et al. 2003). Further, mule deer have demonstrated limited ability to alter migration to avoid impediments (Wasley 2004). Construction of a 4-lane, divided highway in southeastern Idaho was implicated in isolation and reduction of a previously migratory deer herd (Hanna 1982).

Recognition and understanding of impacts of transportation systems on wildlife populations have increased dramatically in the past decade (Forman et al. 2003). In fact, highway-associated impacts have been characterized as one of the most prevalent and widespread forces affecting natural ecosystems and habitats in the U.S. (Noss and Cooperrider 1994, Trombulak and Frissell 2000, Farrell et al. 2002). These impacts are especially severe in western states where rapid human population growth and development are occurring at a time when deer populations are depressed. Human population growth has resulted in increased traffic volume on highways, upgrading of existing highways, and construction of new highways, all serving to further exacerbate highway impacts to mule deer and other wildlife. Some highway transportation departments have used overpasses and underpasses for wildlife to mitigate highways as impediments.

Of all the impacts associated with highways, the most important to mule deer and other wildlife species is attributable to barrier and fragmentation effects (Noss and Cooperrider 1994, Forman and Alexander 1998, Forman 2000, Forman et al. 2003). Highways alone act as barriers to animals moving freely between seasonal ranges and to special or vital habitat areas. This barrier effect fragments habitats and populations, reduces genetic interchange among populations or herds, and limits dispersal of young. These all serve to ultimately disrupt processes that maintain viable mule deer herds and populations. Furthermore, effects of long-term fragmentation and isolation render populations more vulnerable to influences of stochastic events, and may lead to extirpations of localized or restricted populations of mule deer. Other human activity impacts directly tied to increased roadways include increased poaching of mule deer, unregulated off-highway travel, and ignition of wildfires. Roads also serve as corridors for dispersal of invasive plants that degrade habitats (White and Ernst 2003).

Past efforts to address highway impacts were typically approached as single-species mitigation measures (Reed et al. 1975). Today, the focus is more on preserving ecosystem

Figure 32. Mule deer can adapt to development of habitat, but deer population health may be affected. In Utah, fawn:doe ratios were substantially lower in an urban setting than a rural setting (McClure et al. 1999) (Photo courtesy Terry Spivey, USDA Forest Service/Bugwood.org)

Figure 33. Even fences less than 8 feet may disrupt movement, increase energy consumption, or result in deaths from entanglement. (Photo courtesy Tom Keegan, IDFG)

integrity and landscape connectivity benefiting multiple species (Clevenger and Waltho 2000). Farrell et al. (2002) provided an excellent synopsis of strategies to address ungulate-highway conflicts. Several states in the U.S. have made tremendous commitments to early multi-disciplinary planning, including Washington (Quan and Teachout 2003) and Colorado (Wostl 2003); some receive funding for dedicated personnel within resource agencies to facilitate highway planning. Florida's internet-based environmental screening tool is currently a national model for integrated planning (Roaza 2003). To be most effective, managers must provide scientifically credible information to support recommendations, identifying important linkage areas, special habitats, and deer-vehicle collision hotspots (Endries et al. 2003).

There is a tremendous need for states and provinces to complete large-scale connectivity and linkage analyses to identify priority areas for protection or enhancement in association with highway planning and construction. Such large-scale connectivity analyses, already accomplished in southern California (Ng et al. 2004), New Mexico, Arizona, and Colorado, serve as a foundation for improved highway planning to address wildlife permeability needs. Similar efforts are underway in Idaho, Oregon, and Montana. More refined analyses of wildlife connectivity needs, particularly to identify locations for passage structures are of tremendous benefit, and run the gamut from relatively simple GIS-based "rapid assessment" of linkage needs (Ruediger and Lloyd 2003) to more complex modeling of wildlife permeability (Singleton et al. 2002). Strategies for maintaining connectivity may include land acquisition (Neal et al. 2003) or conservation easements.

Structures designed to promote wildlife permeability across highways are increasingly being implemented throughout North America, especially large, bridged structures (e.g., underpasses or overpasses) designed specifically for ungulate and large predator passage (Clevenger and Waltho 2000, 2003). Transportation agencies are increasingly receptive to integrating passage structures into new or upgraded highway construction to address both highway safety and ecological needs (Farrell et al. 2002). However, there is an increasing expectation that such structures will indeed yield benefit to multiple species and enhance connectivity (Clevenger and Waltho 2000). Scientifically-sound monitoring and evaluation of wildlife response are needed to improve future passage structure effectiveness (Clevenger and Waltho 2003, Hardy et al. 2003).

Displacement through Disturbance

In addition to loss of habitat, human activity can lead to changes that significantly reduce capacity of the land to support mule deer. Extensive research has documented that wildlife modify their behavior to avoid activities they perceive as threatening, (e.g., elk avoidance of roads with larger traffic volumes). However, this avoidance is generally temporary, and once the disturbance is removed, wildlife returns to their prior routine. Although avoidance behavior is very common, research has rarely evaluated population-level responses such as decreased fitness, recruitment, or conception as a direct result of disturbance. Direct and frequent disturbance of Coues white-tailed deer (*O. v. couesi*) during breeding season did not result in any population-level responses (Bristow 1998). However, Shively et al. (2005) attributed declines in elk calf:cow ratios to experimental disturbance during the peak calving period and Noyes et al. (2001) observed changes in conception dates and pregnancy rates possibly associated with archery hunting during breeding season.

Information regarding responses of deer to roads and vehicular traffic is scarce and imprecise (Mackie et al. 2003). Perry and Overly (1977) found main roads had the greatest impact on mule deer, and primitive roads the least impact. Further, they indicated roads through meadow habitats reduced deer use, whereas roads through forested habitat had less effect. Johnson et al. (2000) surmised that proximity to roads and trails has a greater correlation with deer distribution than does mean road density. Off-road recreation is increasing rapidly on public lands. The U.S. Forest Service estimated OHV use increased 7-fold during the past 20 years (Wisdom et al. 2005a). Use of OHVs has a greater impact on avoidance behavior than does hiking or horseback riding (Wisdom et al. 2005a), especially for elk.

Some white-tailed deer in the eastern U.S. have apparently acclimated to relatively high densities of people and disturbance. Similarly, mule deer are commonly observed in close association with human developments in many areas (Fig. 32); however, these deer may represent relatively small proportions of overall populations existing in a more natural environment. In northeastern Utah fawn:doe ratios and densities of mule deer in an urban setting were 30-40% lower than for rural counterparts (McClure et al. 1999). Domestic dogs are a common component of human developments and can cause additional disturbance to deer, particularly when allowed to freely roam. Dog harassment of deer is most likely to occur, and be most detrimental, during winter when deer are concentrated on winter range. Repeated harassment when deer are in negative energy balance and hindered by snow further depletes energy reserves necessary for survival.

In and of themselves, disturbance factors have generally not been implicated in lower mule deer population performance. However, given the nutritional and energy requirements of deer, it seems reasonable to assume such factors could work insidiously with a number of other factors to negatively impact deer.

Direct Mortality

Direct loss of deer and other wildlife due to collisions with motor vehicles is a substantial source of mortality affecting populations. Romin and Bissonette (1996) conservatively estimated that > 500,000 deer of all species are killed each year in the U.S. Schwabe and Schuhmann (2002) estimated this loss at 700,000 deer/year, whereas Conover et al. (1995) estimated > 1.5 million deer-vehicle collisions occur annually. In addition to effects on deer populations, wildlife-vehicle collisions annually cause many human injuries and deaths. Conover et al. (1995) estimated collisions resulted in 29,000 human injuries and 200 deaths annually. Further, deer-vehicle collisions result in substantial loss of recreational opportunity and revenue associated with deer hunting, and damage to property is tremendous (Reed et al. 1982, Romin and Bissionette 1996). Deer-vehicle collisions are a particularly severe problem on winter ranges to which deer populations historically have migrated in concentrated densities (Gordon and Anderson 2003). In areas of high deer concentrations, feeding of deer by well-meaning individuals can exacerbate the problem if animals cross highways to travel between feed sites and cover. The problem of collisions is further compounded by the dramatic explosion of human residential and other development within mule deer winter range in the Northern Forest Ecoregion. Temporary warning signs have been demonstrated to be effective in reducing collisions during brief-duration migration events (Sullivan et al. 2004).

Lesser amounts of direct mortality can be attributed to entanglement with fencing, but fences certainly cause thousands of deer mortalities each year (Fig. 33). Fencing may further increase deer-vehicle collisions in situations where deer become confined to roadways by adjoining fences (Wasley 2004). An often-overlooked aspect of fence-related mortality derives from reduced ability to escape predators, particularly for fawns, when escape routes are blocked or escape is hindered by fences (Hölzenbein and Marchinton 1992).

Canals and reservoirs also cause direct mortality of mule deer. Canals with steep sides or those lined with concrete or other hard surfaces can trap deer that fall into them, eventually leading to drowning. Drowning also occurs when deer break through ice while attempting to cross reservoirs.

Although usually not considered a significant source of overall mortality, free-ranging and feral dogs certainly kill deer. Under some circumstances, such as periods of heavy snow on winter ranges, predation by dogs can be a serious problem (Boyles 1976, Lowry 1978).

Guidelines

Planning and Coordination

1. Engage the public early in an informed planning process of human-related developments.
2. Develop and maintain interagency coordination in land planning activities to protect important habitats and reduce negative impacts to mule deer.
3. Encourage land and wildlife management agencies to play a proactive role in state, county, and city planning, zoning boards, weed control boards, and with developers.

Figure 34. Wildlife underpasses provide permeability for travel corridors, allowing seasonal use of an area, and movement through the area during migrations. To encourage use, locate structures near existing deer travel corridors and away from human activity. (Photo courtesy Wayne Wakkinen, IDFG)

4. Assess existing human influences (human impact footprint) on mule deer habitat using GIS and disturbance bands. Use information developed to maintain or improve mule deer habitat (Gaines et al. 2003, Wisdom et al. 2005b).
5. Identify important habitats, seasonal use areas, migration routes, and important populations of mule deer. Discourage development, including recreation sites, and reduce road densities and other infrastructure if possible in these areas.
6. Coordinate with agricultural producers to consider wildlife needs in selection of crops, locations, and rotations. Identify acceptable wildlife use.
7. Analyze linkages and connectivity of habitats to identify likely areas for impact hazards as new roads or railroads are developed or altered for higher speed and greater traffic volume.
8. Coordinate with agencies responsible for regulating high-fenced, private wildlife facilities. Strive to locate facilities outside of mule deer habitat, particularly important winter ranges or migration corridors.
9. Consider approaching state and federal transportation agencies for funding of positions to coordinate road planning and mitigation issues.

Minimizing Negative Effects of Human Encroachment

1. Develop consistent regulations for OHV use.
2. Develop and maintain interagency coordination in enforcement of OHV regulations.
3. Designate specific areas and times (seasonal use restrictions) for activities such as OHV use that disturb habitat or deer.
4. Cluster homes and recreational activities to maintain or create large blocks of undisturbed habitat. Direct new development toward previously disturbed areas (clumped rather than dispersed distribution) (Glennon and Kretser 2005, Gaines et al. 2003).
5. Seasonally separate humans and mule deer at critical periods (Gaines et al. 2003).
6. Through education, modify human behaviors to reduce recreational effects on mule deer (Gaines et al. 2003).
7. Encourage use of native vegetation in landscaping human developments to minimize loss of usable habitat.
8. Examine records of deer-vehicle collisions to identify major impact areas and evaluate need for wildlife passage structures. Consider railroads, canals, and other impediments to natural movement when evaluating need for passage structures.
9. Along highway segments where high levels of deer-vehicle collisions have been documented, encourage appropriate regulatory agencies to address the problem. Solutions could include:
   - Seed unpalatable plants in highway rights-of-way to decrease attractiveness.
   - Reduce highway speed limits.
   - Encourage carpooling, development of public transportation systems, use of flex-time and other practices that reduce vehicle trips at times or seasons of elevated deer-vehicle collisions.
   - Construct overpasses and underpasses along wildlife corridors known to be mule deer travel routes (Fig. 34). In the case of canals, construct escape ramps to reduce drowning mortality.
   - Provide ungulate-proof fencing to direct wildlife to right-of-way passage structures or away from areas of numerous deer-vehicle collisions.
10. Monitor activities that may unduly stress deer at important times of the year. Reduce or regulate disturbance if deemed detrimental. When applicable, encourage enforcement of regulations regarding dogs running at large or chasing wildlife and wildlife harassment by snowmobiles and OHV's.
11. Enhance alternate habitats to mitigate for habitat loss, including key seasonal components impacted by habitat loss.
12. Encourage use of wildlife-friendly (permeable) fencing in appropriate areas to minimize habitat fragmentation and direct mortality. Evaluate existing fences for purpose and need; remove redundant fences and retrofit needed fences to allow greater wildlife passage. Ensure all fences meet standards for wildlife passage.
13. Coordinate with agencies to provide private landowner incentives, such as conservation easements, for protecting habitat.
14. Consider purchase of important mule deer habitat subject to likely development or other detrimental use. If necessary, land can be resold with appropriate conservation easements or deed restrictions.
15. Work with conservation groups (e.g., Mule Deer Foundation, Rocky Mountain Elk Foundation) to leverage

funds for management, mitigation, or land acquisition projects.

16. Develop informational brochures and internet resources describing methods and activities for reducing impacts of human development. Widely distribute materials to a variety of individuals or groups including county and city planning departments, homeowner associations, conservation groups, livestock associations, developers, state and federal agencies, extension agents, 4-H clubs, automobile associations, recreation groups, etc. Potential items to include are cleaning vehicles and equipment to reduce spread of invasive weeds, wildlife-friendly fence design, value of native vegetation, methods for reducing deer-vehicle collisions, control of dogs, negative impacts of feeding ungulates, etc.

Wildlife Passage Structures

1. To maximize use by deer and other wildlife, passage structures should be located away from areas of high human activity and disturbance. For established passage structures in place for more than 10 years, Clevenger and Waltho (2000) found structural design characteristics were of secondary importance to ungulate use compared to human activity.
2. Locate passage structures in proximity to existing or traditional travel corridors or routes (Fig. 34, Singer and Doherty 1985, Bruinderink and Hazebroek 1996), and in proximity to natural habitat (Foster and Humphrey 1995, Servheen et al. 2003, Ng et al. 2004).
3. Spacing between passage structures should accommodate local factors such as known deer crossing locations, deer-vehicle collision "hotspots," high deer densities adjacent to highways, proximity to important habitats, etc.
4. Where appropriate and available, use models and other tools to assist in location of passage structures (Clevenger et al. 2002, Barnum 2003, Claar et al. 2003).
5. Passage structures should be designed to maximize structural openness (Reed 1981b, Foster and Humphrey 1995, Ruediger 2001, Clevenger and Waltho 2003, Ng et al. 2004). The openness ratio (width x height/length) should be >0.6 (Reed et al. 1979), and preferably >0.8 (Gordon and Anderson 2003). Reductions in underpass width influence mule deer passage more than height (Clevenger and Waltho 2000, Gordon and Anderson 2003).
6. Underpasses designed specifically for mule deer should be >20 feet wide and 8 feet high (Forman et al. 2003, Gordon and Anderson 2003). Gordon and Anderson (2003) and Foster and Humphrey (1995) stressed the importance of animals being able to see the horizon as they negotiate underpasses (Figs. 35). Mule deer make minimal use of small passage structures such as livestock and machinery box-culverts (Gordon and Anderson 2003, Ng et al. 2004).

Figure 35. Level terrain near the entrance of this wildlife structure encourages use by wildlife and allows wildlife to see through the structure from either end. (Photo courtesy Wayne Wakkinen, IDFG)

Figure 36. Ungulate-proof fencing can reduce collisions, improving human safety and mule deer survival. Care, however, must be taken to avoid blocking migration routes, or fragmenting habitat for mule deer or other wildlife species. (Photo courtesy of Wayne Wakkinen, IDFG)

Figure 37. Locate wildlife passage structures to take advantage of terrain features. Steep terrain restricts the entrance way of this passage structure. Also note the use of fencing and boulders to guide deer movements. (Photo courtesy Wayne Wakkinen, IDFG)

7. Conditions that mimic natural conditions within underpasses, such as earthen sides and use of natural vegetation, promote use by ungulates (Dodd et al. 2007). In Banff National Park, Alberta, deer strongly preferred (10 times more use) crossing at vegetated overpasses compared to open-span, bridged underpasses (Forman et al. 2003).
8. Use ungulate-proof fencing in conjunction with passage structures to reduce deer-vehicle collisions (Fig. 36, Clevenger et al. 2001, Farrell et al. 2002). Caution should be exercised when applying extensive ungulate-proof fencing without sufficient passage structures to avoid creating barriers to deer movement.
9. Where possible, fences should be tied into existing natural passage barriers such as large cut slopes, canyons, and rock outcroppings (Fig. 37, Puglisi et al. 1974).
10. When fencing is not appropriate to reduce deer-vehicle collisions, alternatives include enhanced signage to alert motorists (Farrell et al. 2002), Swareflex reflectors (with generally inconclusive results [Farrell et al. 2002]), deer crosswalks (Lehnert and Bissonette 1997), and electronic roadway animal detection systems (RADS, Huijser and McGowen 2003).

Energy and Mineral Development

Background

The Northern Forest Ecoregion supports an active energy and mineral industry. A wide variety of economically and strategically important minerals and gemstones are mined in this ecoregion. Energy developments and energy reserves including traditional oil and gas deposits, coal-bed methane, wind energy, and hydropower all contribute to economic well-being of this area. However, many energy and mineral developments have adversely impacted significant mule deer habitats in the region.

All disturbances to the landscape constitute an impact at some level (Fig. 38). Severity of the impact to mule deer depends upon the amount and intensity of the disturbance, specific locations and arrangements of the disturbance, and ecological importance of affected habitats. Small, isolated disturbances within non-limiting habitats are of minor consequence. However, larger-scale developments that limit abundance and productivity of mule deer are of significant concern to managers because such impacts cannot be relieved or absorbed by surrounding, unaltered habitats. Like human encroachment, impacts associated with energy and mineral development have the potential to affect ungulate population dynamics, both directly and indirectly (Sawyer et al. 2002).

Impacts to mule deer from energy and mineral developments can include: 1) direct loss of habitat, 2) physiological stresses, 3) disturbance and displacement, 4) habitat fragmentation and isolation, and 5) other secondary effects (Tessman et al. 2004). Each of these, alone or in conjunction with others, has the potential to significantly influence whether deer can maintain some reasonable existence in the developed area or must abandon it altogether.

Hydroelectric power generation is particularly important in the Northern Forest Ecoregion. For example, there are approximately 55 major hydroelectric facilities in the Columbia River Basin, providing 60-70 percent of all electricity in the Pacific Northwest. Two of these dams in Montana caused the loss of nearly 22,000 acres of important winter and spring habitats for mule deer (Casey et al. 1984, Yde and Olsen 1984). Throughout the remainder of the United States portion of the Columbia Basin, over 55,000 acres of quality habitat for mule and black-tailed deer were lost to hydropower development (Ashley 1996).

Issues and Concerns

Direct Loss of Habitat

Direct loss of habitat results primarily from construction and production phases of development. The presence of reservoirs, mines, well pads, roads, pipelines, compressor stations, and outbuildings directly removes habitat from use. Production activities require pervasive infrastructure and depending upon scale, density, and arrangement of the developed area, collateral loss of habitat could be extensive (USDI 1999). Hydroelectric dams inundate mule deer habitat, removing these habitat resources and blocking important migratory corridors for periods that can exceed 100 years - longer than most other mineral and energy developments. Reservoirs and relocation of associated infrastructure, such as roads, can create movement barriers causing loss of other traditional use areas in addition to those inundated (Yde and Olsen 1984).

Other forms of development may have shorter impact periods. For example, a disturbed area may be minimally reclaimed within a 3-5 year period after construction, but a fully productive habitat with proper species composition, diversity, and age could require up to 20 years. Even so, working surfaces will be needed for continued operations, representing an even greater long-term habitat loss (USDI 1999). Additionally, reclamation may not return the land to its original form and function. Reclamation laws typically limit the amount of erosion allowed on the land, favoring mild slopes, yet mule deer are behaviorally adapted to prefer rough terrain (Geist 1981).

Physiological Stress

Physiological stresses occur when energy expenditures by an animal are increased due to alarm and avoidance

movements. These are generally attributed to interactions with humans or activities associated with human presence (traffic, noise, pets, etc.). During winter months, this could be particularly important because deer are already operating at an energy deficit. In addition, diversion of energy reserves can be detrimental for other critical periods during the life cycle such as gestation and lactation. Kuck et al. (1985) suggested, in a simulated mine disturbance experiment, increased energy costs of movement, escape, and stress caused by frequent and unpredictable disturbance may have been detrimental to elk calf growth, but found no evidence of lower survival. These impacts could ultimately have population effects through reduced production, survival, and recruitment (USDI 1999). Loss of low elevation spring ranges along valley floors can force deer to subsist on lower nutritional winter ranges for longer periods, potentially resulting in a lower reproductive rate (Yde and Olsen 1984) and possible eventual degradation of these winter ranges due to overuse.

Disturbance and Displacement

In addition to direct, long-term habitat loss, reservoirs associated with hydroelectric facilities displace individual deer. Such displacement can cause them to subsist on adjacent marginal habitats or concentrate at higher densities in other occupied habitat. Increased travel by humans within development areas is the primary factor leading to avoidance of the developed area by wildlife. These avoidance responses by mule deer (indirect habitat loss) extend the influence of each development to surrounding areas. Zones of negative response can reach 1.7-2.2 miles from active well pads, and deer did not acclimate to disturbance through time (Sawyer et al. 2006).

During all phases of development, roads tend to be of significant concern because they often remain open to unregulated use. This contributes to noise and increased human presence within the development area. Rost and Bailey (1979) found an inverse relationship to habitat use by deer and elk with distance to roads. This displacement can result in under-use of the habitat near disturbances, while overuse may occur in nearby locations. This has the added potential for creating depredation problems with adjoining properties. Added consequences from human presence include, but are not limited to, mortality and injury due to vehicle collisions, illegal hunting, and harassment from a variety of increasing recreational activities.

Habitat Fragmentation and Isolation

Associated with displacement is the greater impact of fragmentation (Fig. 39). Meffe and Carroll (1997) suggested the largest single threat to biological diversity is the outright destruction of habitat along with habitat alteration and fragmentation of large habitats into smaller patches.

As stated earlier, road networks have a cumulative effect when considering total amount of habitat that is effectively lost. This is especially evident in their contribution to habitat fragmentation. According to the Montana Cooperative Elk-Logging Study (Lyon et al. 1985), road densities of 2 miles/mile^2 reduce habitat effectiveness for elk by about 50 percent.

Should development occur within or proximate to migration corridors, isolation may result. Isolation could lead to adverse genetic effects such as inbreeding depression and decreased genetic diversity. Without an ability to move into or from areas critical to normal needs or life stages (e.g., fawning areas, winter range, etc.) local extirpation could ultimately result.

Habitat fragmentation creates landscapes made of altered habitats or developed areas fundamentally different from

Figure 38. Human encroachment causes a variety of impacts to mule deer. In addition to direct habitat loss, disturbance and displacement are common impacts of energy and mineral development. (Photo Courtesy Terry Spivey, USDA Forest aservice/Bugwood.org)

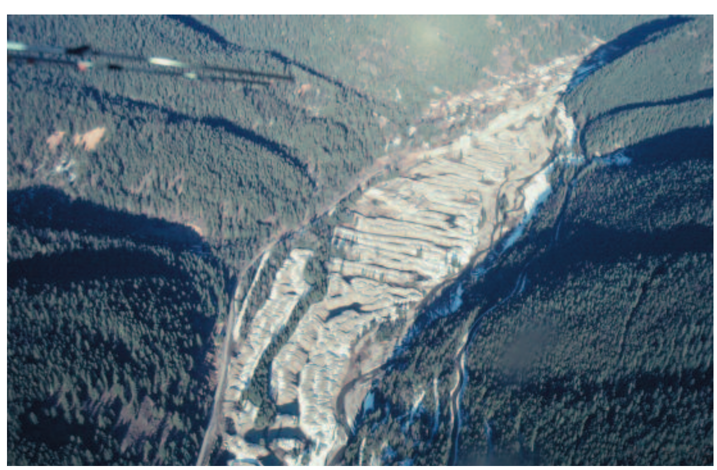


Figure 39. Mining may affect movement patterns and fragment mule deer habitat, as evidenced here by dredge mining for gold in northern Idaho. (Photo courtesy of IDFG)

those shaped by natural disturbances that species have adapted to over evolutionary time (Noss and Cooperrider 1994). These changes manifest themselves as changes in vegetative composition, often resulting in an increase of weedy and invasive species. This, in turn, changes the type and quality of the food base as well as the structure of the habitat (less cover, more edge, etc.). As a result, less high-quality forage is typically available, while changes in vegetative structure may increase rates of predation.

Use of migration corridors also depends on factors such as aspect, slope, and weather. Therefore, when planning developments, it is critical to consider impacts to these corridors and how to mitigate them to facilitate migration of mule deer (Merrill et al. 1994). Flexibility in movement across ranges can be ultimately reflected in the survival and productivity of the deer population and likely enhances their ability to recover from population declines.

Secondary Effects

Secondary effects may be as significant as those direct effects described above. Activities associated with support and service industries linked to development can aggravate adverse impacts. These impacts are similar to those that occur during construction and operations, only intensified. Vehicular traffic to support operations would likely increase significantly. Additional human presence resulting from increased support industries and community expansion will contribute to human-wildlife interactions.

Roads, pipelines, and transmission corridors not only directly remove habitat, but also have the potential to contaminate ground and surface water supplies. Noxious weeds can infiltrate the roadside impact zones and bring negative impacts such as non-native bacteria, viruses, insect pests, or chemical-defense compounds with toxic or allergenic properties. These changes can affect both aquatic and terrestrial habitat productivity.

All these events can increase the amount of area rendered unavailable to mule deer and other wildlife. Finally, inadequate interim mitigation or final reclamation practices have the potential for rendering the area useless to wildlife unless careful consideration is given to planning and implementing a quality reclamation program.

Guidelines

To minimize impacts of energy and mineral development activities upon deer and their habitat, several recommendations are provided for consideration and implementation. These requirements were developed for general application from a number of sources, and should be implemented regardless of the habitats or species present in an area of development activity.

Planning and Coordination

1. Consult the responsible wildlife management agency early in the process, prior to submission of permitting requests. Identify all proposed areas for a phased operation, as well as crucially important habitats and wildlife and areas that should be avoided. The agency should also be consulted concerning the total number of active facility locations within sensitive areas at any given time.
2. Coordinate the configurations of development areas among companies that will be operating in the same area. This includes the use of a phased operational plan that requires 1) delineation of geographical areas for the phased operation, 2) reclamation of each individual area when operations cease prior to opening operations in a new area, 3) clustering of drilling pads, roads, and facilities in a way that minimizes the area of disturbance, even when multiple companies are involved.
3. Where large blocks of public land will be leased, planning should occur such that the sale of new leases in the block coincides with objectives to maximize surface spacing of down-hole drilling pads. For example, in the United States, lease areas may be comprised of several drilling blocks (e.g., 640 acre/block). Regulating authorities should allow only 1 drilling pad/block, but there could be several drilling blocks grouped into a contiguous lease. While 1 block is being drilled out, the next pre-selected drill pad should have all of the necessary clearances done in advance to development. Because pad sites could be pre-selected before leasing, all necessary environmental impact analysis could be completed and reported in an applicable environmental document. This would allow moving the rig onto a new location with minimal down time.
4. Plans should incorporate the most current and best technology that will benefit fish and wildlife. For example, installation of remote monitoring equipment will reduce the number of trips required to monitor or service well sites.
5. Pipelines and powerlines should be pre-planned so they are adequate to carry projected resources from all facilities planned for an area, and coordinated with other infrastructure construction, such as locating lines in access roads, to minimize disturbance.
6. Plans should accommodate timing restrictions that prevent or reduce activities during critical seasonal periods for birds, mammals and other sensitive species. The responsible wildlife management agency staff should be consulted for the specific timing restrictions for areas of development.

Road Construction

1. Use existing roads, as well as associated infrastructure, if they are sufficient and not within environmentally sensitive areas. Coordinate any new road construction

and use among companies operating in the same area. For example, construct roads, powerlines, pipelines, and other infrastructure in a common corridor, but ensure that mule deer can easily cross the corridor by limiting corridor width, installing passage devices, or other mitigation measures.

2. Construct the minimum number and length of roads, and to a standard no higher than necessary to accommodate their intended purpose, while protecting the habitat.
3. Locate and construct all structures crossing intermittent and perennial streams such that they do not decrease channel stability nor increase water velocity. Stream approaches should be at right angles whenever possible to minimize stream disturbance.
4. Locate roads below ridgelines or behind topographic features (knolls, rises) to minimize the zone of visual and auditory effect.

Traffic

1. Frequency of use and speed of vehicles should be minimized. A speed limit of 30 mph for light-duty vehicles and 25 mph for heavy-duty vehicles should be strictly enforced on development access roads (excluding existing roads managed under municipal or state authority).
2. Develop a travel plan that minimizes the amount of vehicular traffic needed to monitor and service facilities and limit traffic volume during high wildlife use seasons and hours. Prohibit traffic completely in certain areas critical to wildlife. The responsible wildlife management agency staff should be consulted to assist with identification of times and critical wildlife areas.
3. Where possible, use pipelines to transport condensates off well sites, or install larger capacity storage tanks so that impact from truck traffic is minimized.

Wells and Drilling

1. Locate well pads in the least environmentally sensitive areas, well away from riparian habitats, streams, or drainages; below ridge lines; and away from important sources of forage or cover, reproductive habitats, winter habitats, calving areas, and brood-rearing habitats of fish and wildlife. The responsible wildlife management agency staff should be consulted to assist with identification of critical fish and wildlife areas.
2. Disturb the minimum area (footprint) necessary in order to drill and operate a well. This includes drilling the maximum number of wells possible from the same pad using horizontal (directional) drilling technologies.
3. Well spacing should be maximized using directional drilling from single pads. For example, if technology will allow a given unit of land (e.g. 640 acres) to be directionally drilled from 1 well pad in a manner that will result in effective recovery of most of the hydrocarbons, then that surface spacing should be required. If operators were using 10-acre spacing, 64 down-hole pads would be required along with significantly increased roads and support facilities. There are circumstances where larger surface spacing is not possible. Technology exists that will allow industry to layer special data to determine the location from which directional drilling can be optimized. If closer spacing is requested, industry should submit justification for this closer spacing.
4. Directional drilling might initially be more expensive. However it does offer opportunities for industry to reduce costs such as
   - Reducing the number of pads, which with consultation with the responsible wildlife management agency, might overcome timing restrictions due to breeding, migration and wintering because wildlife can more readily habituate to the reduced presence.
   - Busing or van transporting of crews, which should reduce truck use and associated costs.
   - Reducing administrative downtime for the rig while on location.
   - Reducing the number of compressor stations needed to keep pipelines flowing.
   - Piping water to the drilling pad and installing water re-use systems.
   - Installing more efficient computer operations, thereby reducing the number of operators and onsite visits that are required.
5. Where existing leases have intermingled ownership of small acreages, administrative arrangements should be made so that 1 company could drill out all the leases from 1 pad.
6. Once drilling has started on a pad, drilling should continue until all wells needed to recover the hydrocarbons from that pad are completed while observing any seasonal restrictions.
7. The practice of drilling a few wells now and then later returning to drill more wells on that pad should not be permitted.
8. Use drilling technology that avoids stripping or removing vegetation. Temporarily crushing or shearing vegetation during drilling activities is more preferable than completely removing vegetation.
9. Use mats to protect topsoil during drilling and pumping.

Stream Habitats and Riparian Corridors

1. No drilling activity or disturbance should be permitted within 500 feet of the outer edge of a riparian area, wetland, or stream. The responsible wildlife management agency should always be consulted when any stream disturbing activities are planned.
2. Use of water for drilling, hydrostatic testing, reclamation, dust abatement, or any other purpose should be made in a manner that minimizes impacts to fish and wildlife.
3. Design drill pad sites to drain excess storm water and other fluids into a properly sized and lined reserve pit

with adequate capacity to intercept and hold excess precipitation. The pit should be lined with a suitable, impermeable barrier to eliminate possible contamination of soil and groundwater.

4. Minimize the number and length of roads, pipelines, power-lines, and other facilities that are located adjacent to intermittent or perennial streams or riparian and wetland areas. Pipelines that must parallel streams or riparian and wetland areas should be sited outside the 100-year floodplain. Pipelines that must cross an intermittent or perennial stream should be constructed by boring underneath the stream rather than trenching or crossing. If crossing must occur, the crossings should be constructed at right angles to all riparian corridors and streams to minimize the area of disturbance. Any pipeline crossings of a stream or riparian and wetland area should be protected against surface disturbances and damage to the pipeline, particularly at both sides of the crossing. Pipelines should be equipped with automatic shut-off valves.
5. Hydrostatic test waters released during pipeline construction could cause alterations of stream channels, increased sediment loads, and introduction of potentially toxic chemicals or invasive species into drainages. Avoid discharging hydrostatic test waters directly into streams or intermittent drainages. Intermittent drainages have significant potential to deliver sediment and toxins to live streams, particularly in northern forests where annual spring runoff is predictable. De-water temporary sedimentation basins in a manner that prevents erosion.
6. Avoid stripping riparian canopies or stream bank vegetation. Temporarily crushing or shearing streamside woody vegetation during crossing construction is more preferable than completely removing vegetation.

Ancillary Facilities

1. Locate facilities, including tanks, transfer stations, shops, equipment shelters, utility towers, etc., in the least environmentally sensitive areas, well away from riparian habitats, streams, or drainages; below ridge lines; and away from important sources of forage or cover, reproductive habitats, winter habitats, calving areas, and brood-rearing habitats of fish and wildlife. The responsible wildlife management agency staff should be consulted to assist with identification of critical fish and wildlife areas.
2. Use existing facilities, utilities, roads, and pipeline corridors and bury power lines and pipelines in or adjacent to roads when possible.
3. Minimize all noise. All compressors, vehicles, and other sources of noise should be equipped with effective mufflers or noise suppression systems.

Human Activities and Secondary Effects

1. All employees or contractors must receive initial environmental awareness training during orientation and follow up training throughout development activities to instruct them concerning these stipulations and other environmental requirements. Their understanding must be comprehensively reviewed in a manner that will identify and correct any deficiencies.
2. Employees, contractors, and guests (except security and public safety personnel) should not be allowed to carry firearms while on site during working shifts, or to use motorized access that would otherwise be restricted to the public for the pursuit or taking of game.
3. Wildlife law enforcement officers should have unrestricted access to all areas of development.

Pollutants, Toxic Substances, Dust, Erosion and Sedimentation

1. Employ erosion control practices and sediment retention structures to prevent sediment transport off-site.
2. Staging, refueling, and storage areas should not be located in riparian zones or on flood plains. Keep all chemicals, solvents, and fuels ≥1,000 feet away from streams, intermittent drainages, and riparian areas.
3. Avoid exposing or spilling hydrocarbon products on the surface.
4. Use dust abatement procedures, including application of environmentally compatible chemical suppressants.

Monitoring and Environmental Response

1. The appropriate wildlife management agency should immediately be notified of potential fish or wildlife problems or concerns.
2. Closely monitor and catalogue conditions or events that may indicate environmental problems. Such conditions or events might include chemical spills or leaks, detection of multiple wildlife mortalities, sections of roads with frequent and recurrent wildlife collisions, poaching and harassment incidents, severe erosion into tributary drainages, migration impediments, wildlife entrapment, sick or injured wildlife, or other unusual observations.
3. Use aerial photography and GIS technologies to monitor the annual extent of disturbance, document the progression and footprint of disturbances, and determine success of reclamation efforts, and report these products to the appropriate wildlife management agency.

Weeds

1. Regularly monitor all roads and facilities for occurrence of weeds and maintain the ability to immediately control noxious and invasive plants that occur along roads, on development sites, or adjacent to other facilities.
2. Clean and sanitize all equipment, including vehicles brought in from other regions. Seeds or sprigs of noxious plants are commonly imported by equipment and mud clinging to equipment, boots etc.

Interim and Final Reclamation

The responsible management agency should be promptly notified in writing when interim or final reclamation has been completed for each development and afforded an opportunity to review the conditions.

1. All documents that refer to reclamation or restoration should adopt a definition of reclamation that includes requirements to restore, not only the landscape and habitats to as close as possible to original condition, but also fish and wildlife communities. This distinction is critical because reclamation of the landscape does not always equate to healthy populations of fish and wildlife communities.
2. A photographic and site inventory record of all development sites should be maintained prior to, during, and after development and provided to the responsible management agency.
3. Fish and wildlife monitoring surveys should be conducted throughout the development area prior to, during, and after activities.
4. Compliance with reclamation standards should be enforced and companies should be required to correct reclamation that does not meet established standards, including restoration of healthy fish and wildlife communities.
5. As soon as practicable, all new facilities should be reclaimed and restored to as close as possible to their original state. Interim reclamation includes grading, topsoil replacement, and hydro-seeding with native (certified weed-free) seed mixtures. Topsoil depth should be varied to encourage establishment and maintenance of diverse woody and herbaceous vegetation. Although native plant species are generally desired, use of non-native species can be a valid mule deer habitat management option. Site-specific conditions, including invasive species, need to be considered prior to any vegetation management actions. This process should continue until satisfactory interim reclamation is established.
6. As soon as practicable, following cessation of activities at a development site, final reclamation should be completed. Final reclamation should include abandonment, removal, and reclamation of all facilities such as structures, roads, power-lines, pipelines, well pads, ponds, ditches, and other disturbance to surface features that altered the original landscape.
7. The area should be returned to as close as original condition as possible. Photographic records should be used to help guide and monitor this process. Reclamation should include re-planting a mixture of forbs, grasses, and shrubs that are native to the area in order to achieve numeric standards of cover, composition, and diversity that are commensurate with the ecological site. Final reclamation should include confirmation that fish and wildlife communities occur at levels similar to pre-development. The reclamation process should include monitoring and adjustments until suitable reclamation has been achieved, including potential offsite mitigation for fish and wildlife communities and their habitats.
8. Reclamation plans should include topographic and habitat features that provide topographic and vegetative diversity reflecting pre-disturbance conditions. Features should be constructed to match similar features found in the surrounding area. Examples of such features may include but are not limited to, rock piles, ledges, steep slopes, escarpments, moisture catchment basins, small depressions, and brush piles.

Bonding

A reclamation bond should be set at an amount equal to 125% of the developer's reclamation responsibilities at the end of the project or at a level that is adequate to cover the company's liability for final reclamation of the entire facility, including fish and wildlife populations. This bond should be reviewed and adjusted on an annual basis.

SUMMARY

The Northern Forest Ecoregion spans western North America from the Yukon to southern California, and from Manitoba, nearly to the Pacific Ocean. The habitats used by mule deer within this area are highly complex and are affected substantially by man's activities. Major influences on mule deer habitat within the Northern Forest Ecoregion include man's modifying the natural fire regime, altering forest structure and composition through timber harvest activities, usurping native plant communities by allowing proliferation of non-native invasive plants, encroaching upon mule deer habitat with development, and developing energy and mineral resources within mule deer habitat. The complexity within this ecoregion dictates that local conditions are considered carefully in the application of these broad guidelines.

Efforts to curb wildland fires have been largely successful during the past century, resulting in the loss of early seral stage forest and loss of landscape complexity. Conversely, increases in invasive annual grasses have lead to greater intensity and frequency of fires in some plant communities, resulting in catastrophic destruction of mule deer habitat.

Forest practices too have a mixed impact on mule deer habitat. Logging, for example, can improve forage quantity and quality for mule deer. On the other hand, logging of winter range can be catastrophic for mule deer if snow-interception provided by inter-locking canopies is compromised. The impacts of forest management must be carefully analyzed at both landscape and local scales.

A threat to mule deer ranges, often overlooked and closely associated with man's activities, is the impact of non-native invasive plant species. Numerous such plant species are spreading at an accelerated rate on public and private lands throughout the ecoregion. As the name implies, invasive plants often invade native plant communities and replace species that are important as mule deer forage or cover. Land and wildlife managers must work together to proactively counter the proliferation of invasive plant species before they become dominant on the landscape.

Human encroachment within mule deer habitat is a large and growing concern. Humans have discovered that many of the geologic, topographic, and habitat factors that characterize this ecoregion are attractive for a wide variety of human uses. Human activities that usurp and preclude mule deer occupation are the most detrimental. These include urban and suburban developments and associated impacts like lawns, golf courses, and highways. However, human recreational activities can also be a concern, especially when large numbers of people are involved. Important habitats may not be lost directly but become unavailable because of real or perceived habitat suitability.

The most promising approach involves positive influence over land management planning and zoning decisions so they better consider wildlife habitat values. Regarding those activities for which land and wildlife agencies have authority, restricting and/or regulating human uses must be considered to minimize impacts on crucial habitats. Seasonal restrictions aimed at protecting key habitats may be most effective. Increased roads and recreational vehicles negatively influence distribution of mule deer and may render otherwise suitable habitats unsuitable for mule deer. Recreational pursuits must also be managed to provide areas free of constant human activity.

A growing concern in the Northern Forest Ecoregion is mineral and energy development. For decades, mineral and energy developments have occurred throughout the ecoregion. However, the growing national need for energy is now focusing development of these resources in the West. Recent research has shown that large-scale and intensive developments are detrimental to mule deer. Mule deer managers must be involved from the beginning of a project, especially so during the initial stages of planning and development. Approaches involving staged and phased developments would be less detrimental than unplanned and poorly planned developments. In many situations, associated impacts such as roads, traffic patterns, noise, and human activities may be more detrimental to mule deer than the well or mining pit.

As described in the preceding pages, the mule deer manager must be accomplished in all things related to humans and their demands upon the land base. To do this effectively, the manager must be well-informed biologically, ecologically, and in the realm of human-dimensions. It is hoped that guidelines provided in this document will aid the manager in meeting this need.

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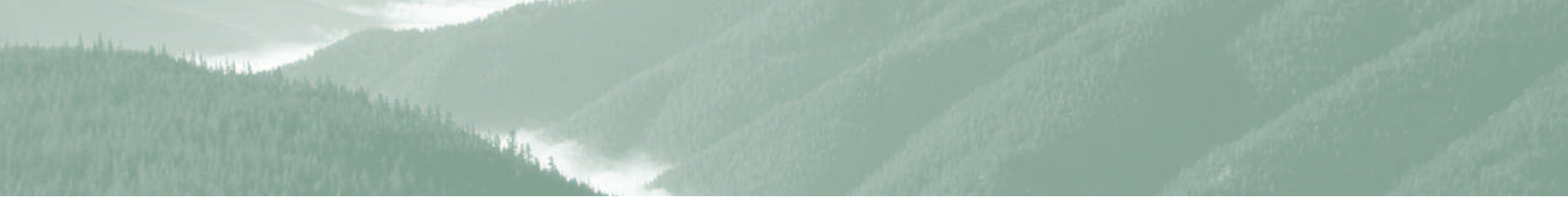

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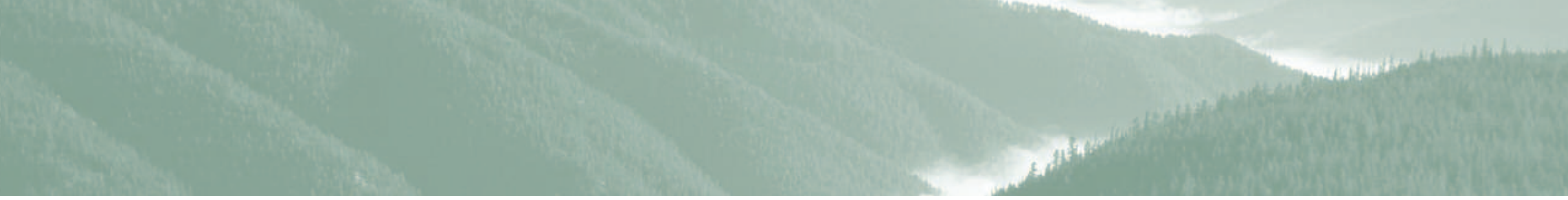

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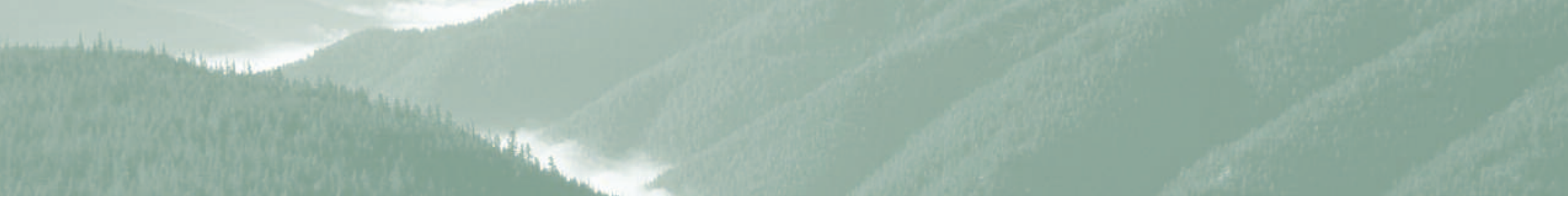

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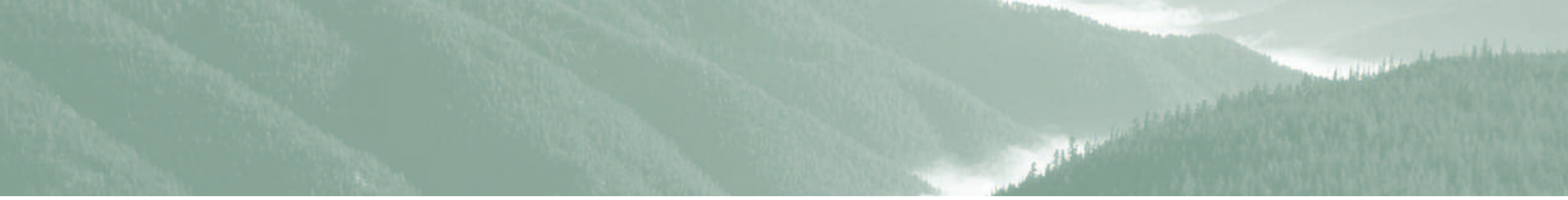

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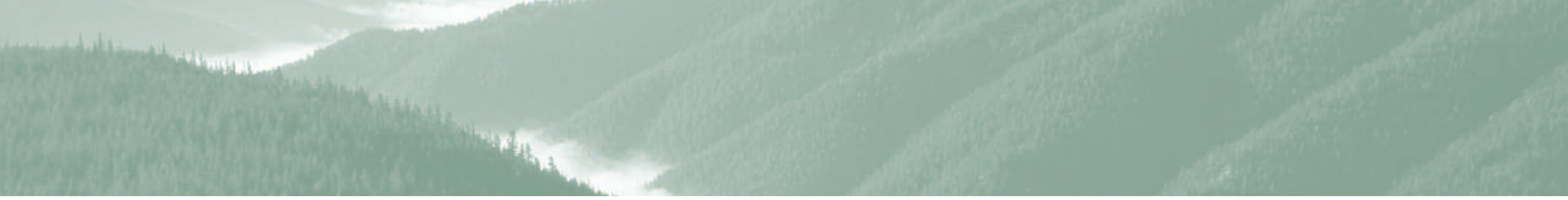

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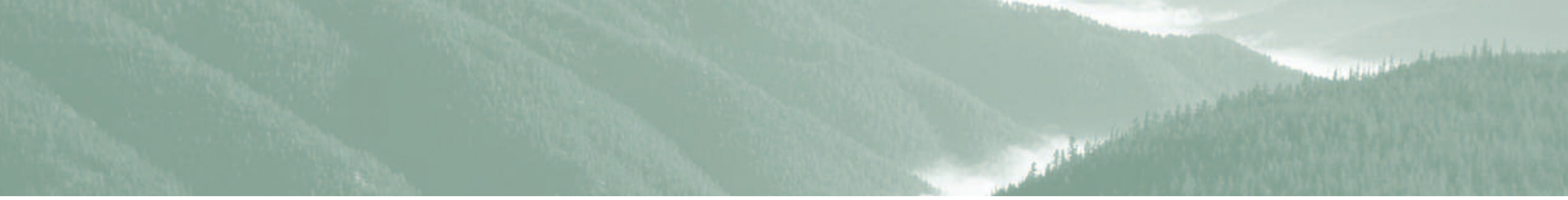

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Appendix A.

Alphabetical listing by category of common names (scientific names) of species cited in the text.

Trees and Shrubs

Aspen, Quaking (*Populus tremuloides*)
Bitterbrush, Antelope (*Purshia tridentata*)
Ceanothus, Redstem (*Ceanothus sanguineus*)
Cedar, Western Red (*Thuja plicata*)
Douglas-fir (*Pseudotsuga menziesii*)
Fir (*Abies* spp.)
Fir, Subalpine (*Abies lasiocarpa*)
Hemlock (*Tsuga* spp.)
Juniper, Western (*Juniperus occidentalis*)
Larch (*Larix* spp.)
Mountain-mahogany, Curl-leaf (*Cercocarpus ledifolius*)
Ninebark (*Physocarpus* spp.)
Pine (*Pinus* spp.)
Pine, Lodgepole (*Pinus contorta*)
Pine, Ponderosa (*Pinus ponderosa*)
Poplar, Balsam (*Populus balsamifera*)
Rabbit-brush (*Chrysothamnus* spp.)
Rose, Wild (*Rosa acicularis*)
Sagebrush (*Artemisia* spp.)
Serviceberry (*Amelanchier* spp.)
Snowbrush (*Ceanothus velutinus*)
Spruce (*Picea* spp.)
Willow (*Salix* spp.)

Forbs and Grass

Cheatgrass (*Bromus tectorum*)
Fescue (*Festuca* spp.)
Knapweed, Spotted (*Centaurea maculosa*)
Wheatgrass (*Agropyron* spp.)

Animals

Bear, Black (*Ursus americanus*)
Cattle, Domestic (*Bos taurus*)
Deer, White-tailed (*Odocoileus virginianus*)
Deer, Coues White-tailed (*Odocoileus virginianus couesi*)
Deer, Mule (*Odocoileus hemionus*)
Coyote (*Canis latrans*)
Elk (*Cervus elaphus*)
Goose, Canada (*Branta canadensis*)
Lion, Mountain (*Puma concolor*)
Wolf, Gray (*Canis lupus*)

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- Montana Department of Fish, Wildlife and Parks
- Nebraska Game and Parks Commission
- Nevada Department of Wildlife
- New Mexico Department of Game and Fish
- North Dakota Game and Fish Department
- Oklahoma Department of Wildlife Conservation
- Oregon Department of Fish and Wildlife
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