Montana Fish, Wildlife & Parks

Big Game Winter Range Recommendations for Subdivision Development in Montana: Justification and Rationale

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Foreword

Wildlife biologists across Montana recognize the value of big game winter range; it is finite, biologically important, and likely to be lost without careful planning and resource management. In fact, there is no seasonal range more important to big game than winter range, and no bigger permanent threat to winter range—especially in western Montana—than housing development.

This paper, assembled by a 30-year MFWP veteran with extensive big game habitat experience, summarizes the effects of housing development on big game winter range and then outlines a set of recommendations designed to minimize impacts to this critical habitat. As Montana continues to grow, these recommendations will aid biologists, land managers, developers, and others in *their decision-making. I also believe that following these recommendations will have long-term benefits for Montana's big game wildlife.*

There is no doubt that in the future, Montana will need additional houses and subdivisions that provide safe neighborhoods and help keep our economy strong. However, in order to conserve Montana's tremendous natural beauty and abundant wildlife, we must make careful and thoughtful decisions about where those new developments are located and how they are placed on the land.

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This professional paper outlines the justification and rationale behind MFWP's big game winter range recommendations for subdivision development. Big game animals that will primarily benefit from these standards include mule and white-tailed deer, elk, moose, antelope, bighorn sheep, and mountain goats.

Background

Winter range is the yearly habitat anchor for Montana's big game. It is where deer, elk, moose, antelope, and other hooved animals return year after year to spend the tough winter months when snow and cold drive them from their summer haunts (see Figure 1). For millennia, big game animals have migrated from summer and fall ranges to winter ranges. Winter ranges are usually found at low elevations, where cover, food, and security are available and conditions are less harsh than in other areas. In winter, big game rely heavily on the thick layers of fat they accumulated during summer. But their winter range is just as important as the fat they bring with them.

Figure 1. *Elk on undeveloped functional winter range.*

Winter ranges are often on private lands in mountain valleys, on foothills, or along rivers and streams. Although it's the most important seasonal range that big game occupies during the year, it is usually the most limited in size of all the seasonal ranges. For example, the forested Bowser white-tailed deer's winter range in northwest Montana occupies only 2 percent of the population's year-round home range (Dusek et al. 2006).

Winter ranges are not found everywhere. These areas must have the right combination of elevation, slope, aspect, and vegetation. Animals commonly migrate 5 to 30 miles or more to get to winter range. Some deer and elk come from as far away as 100 miles or more, while some antelope that winter in north-central Montana migrate over 250 miles from Saskatchewan to avoid the harsher Canadian winters (Williams et al., in prep). Because spring, summer, and fall ranges are often miles from winter range, permanent habitat alterations like subdivisions on winter range can impact reproduction, population size, and migration patterns. This in turn may affect a deer hunter's chance at a buck or a wildlife photographer's opportunity for a prize image, many miles away and many months later.

Lastly, winter ranges are the most threatened by human encroachment because of their proximity to valley floors, foothills, rivers, and streams. What big game animals need to make it through the winter is access to these key wintering areas and de facto permission to share the landscape with humans. Wildlife managers know that, in the long run, we must protect big game winter ranges to ensure that our grandchildren will be able to enjoy Montana's rich and varied big game herds, the associated human recreational opportunities, and the state's ability to manage big game into the future.

Winter ranges vary in character across the state depending on regional climate, weather patterns, and vegetation. East of the Continental Divide and in some places west of the Divide, particularly in southwest Montana, elk winter range is typically south- and west-facing open grassland foothills adjacent to timber used for bedding. Mule deer winter range shares many of these same characteristics, but may not be as strongly tied to nearby timber and usually has a stronger shrub component, such as sagebrush, bitterbrush, or mountain mahogany. White-tailed deer typically winter either in areas associated with low-elevation agricultural lands and valley bottoms with associated brush and trees for cover, or in dense forests with a canopy cover that provides good snow intercept. There are, of course, exceptions to these broad generalizations, which underscores the importance of area-specific surveys and analyses.

Much of Montana west of the Continental Divide, particularly in the northwest, is dominated by a conifer overstory and is strongly influenced by maritime weather patterns that generate a lot of snow. Consequently, the winter ecology of elk and deer in this part of Montana is different from other areas of the state with less snow and more grass. In these forested, high-snow locations, elk and deer winter range is typically below 5,000 feet elevation. They prefer areas with a conifer overstory, particularly Douglas fir, which provides snow intercept as well as forage; and a shrubby understory, often of young conifers, mountain maple, willow, and rose, which elk also eat. Arboreal lichen, often called "Old Man's Beard" or "Bear Hair," is also an important food item associated with the conifer forest. Because canopy cover and understory are important structural components of this type of winter range, thinning and removing forest vegetation may compromise its value.

Eastern Montana is a vast, wide landscape—Big Sky country. Here, even to the practiced eye, big game winter ranges may not look much different than the surrounding terrain. Yet, visual similarities aside, animals traditionally use only certain areas as winter range. Antelope prefer more open habitats and avoid areas that collect snow (Yoakum 2004). Mule deer prefer topography such as coulees and more rugged terrain (Wood 1989). For both of these species, sagebrush is extremely important for food and cover. Elk winter range in eastern Montana is generally found in the more rugged breaks habitat. Here, junipers and ponderosa pines offer vegetative cover. Agricultural lands along the river bottoms are typically the winter homes for white-tailed deer throughout the state.

The number of animals on a winter range varies depending on time and space. The use of winter range can vary from year to year for a variety of reasons, including annual variations in habitat quality, animal population fluctuations, and winter severity that concentrates animals differently from year to year. Habitat quality can vary because of things such as slope, aspect, elevation, and vegetation and winter conditions like snow depth, wind, and temperature. The vegetation can vary due to fires, logging, weed infestations, forest encroachment or succession, etc. Animal populations themselves go up and down because of hunting by humans, predators, diseases, weather, natural population cycles, and other reasons. Winter severity markedly affects the number of animals using a winter range and often determines whether animals will be spread out over the landscape or concentrated within a small "core" or "critical" winter range area. In a 13-year study of white-tailed deer in northwest Montana, researchers found that during severe winters deer density on "critical" winter range was 530 deer per square mile; during the mildest years it was 116 (Dusek et al. 2006). This should not be interpreted to mean that the entire deer population could survive by protecting only the "critical" winter range, because in many cases deer do not choose to go there *except* during severe conditions (Dusek et al. 2006), and other areas that we might be tempted to call "marginal" are vitally important to the population in most years. Moreover, as big game populations fluctuate from low numbers to high, the more marginal areas become more important for supporting the increase (Pac et al. 1991; Mackie et al. 1998). If deer were forced to use these relatively small "critical" winter ranges repeatedly, these areas would soon be hopelessly degraded by heavy deer browsing year after year. In the final analysis there is one important point: *All* winter range is important to the long-term survival of big game populations.

When evaluating winter range it is necessary to consider the potential of the winter range to support animals, not just the number that may currently be there. A visit during the wrong time or season, or during a population low or a mild winter, can give a very wrong impression of the value and potential of the property as winter range. All too often biologists, consultants, developers, and decision-makers visit and evaluate properties proposed for subdivision during just one or perhaps a few trips, often during the summer. Because lands proposed for development are private, MFWP does not conduct systematic winter surveys unless the area is unforested and can be surveyed from the air. Moreover, MFWP has neither the funding nor the staff to survey all known, suspected, or mapped winter ranges. This inability to survey winter ranges year after year makes it difficult for MFWP biologists to "prove" or document that big game use specific areas as winter range in any given year, and underscores the importance of site-specific information.

Impacts from Development on Big Game Winter Range

When settlers first came to Montana, they found that the valleys and mountain foothills were the best places to build homesteads, farms, and ranches, and later, roads, cities, and subdivisions. These same valleys and foothills were also big game winter range. Consequently, we have already lost a significant amount of the functional winter range that was present when Europeans first arrived. But within the last three or four decades, a significant new threat to remaining winter range has emerged: the trend to build houses and subdivisions away from towns and out in the country where homes, roads, driveways, and the impacts they cause beyond their immediate footprint can greatly reduce functional winter range (see Figure 2) (Gude et al. 2006a).

Figure 2. Dispersed housing development severely impacts winter range. *The cumulative effects of one subdivision, then another, and another, with houses and roads on 5- to 20-acre lots spread across the landscape have essentially eliminated this once-functional elk and mule deer winter range in Montana's Bitterroot Valley.*

We are, after all, talking about wildlife. One half of the word "wildlife" is the word "wild," and land use changes that make an area less wild make it less suitable for wildlife. When people build a subdivision on winter range, they remove the de facto permission for big game to occupy the land.

This paper addresses impacts of and recommendations for subdivision development on big game winter range. But it is important to point out that exurban and rural development other than subdivisions is also a major, perhaps *the* major, contributor to winter range loss and fragmentation. Subdivision regulations and review do not apply to properties divided into parcels larger than 160 acres, family conveyances, mining claims, boundary adjustments, or homes built on parcels already platted. Such properties may be in big game winter range, and, as explained later, one house situated in the wrong place can have a greater impact than several houses placed thoughtfully on the landscape. Only careful land use planning on a landscape scale will address the loss of winter range in the long term.

Big game winter range across Montana is seriously threatened. By far the greatest and most significant threat to big game winter range is development—housing development in the western part of Montana and energy development in the east. Subdivisions and housing development have long been recognized as *the* primary threat to wildlife in western Montana. In 1998 the Montana Chapter of The Wildlife Society identified subdivisions and land use as the number one issue facing Montana wildlife in the near future. This observation is supported by many scientists. For example, Glennon and Kretser (2005, p. viii) noted:

> The effects to wildlife from development consist of varying types and intensities of impacts including: ecosystem fragmentation, edge effects and nest predation, creation of source-sink dynamics, disruption of wildlife dispersal and movement patterns, effects associated with roads, changes in community composition and structure, effects associated with domestic pets, effects associated with recreation in the surrounding area, human-wildlife conflicts, and cumulative impacts.

Montana's Comprehensive Fish and Wildlife Conservation Strategy (MCFWCS, 2005) recognizes human population growth/development/subdivision as a conservation concern in all 11 of the Terrestrial Conservation Focus Areas (specific geographical areas of Montana that are in greatest need of conservation) in western Montana and in all the community types in greatest need of conservation (habitats, along with their related fish and wildlife, that are in greatest need of conservation throughout Montana regardless of location) in the state.

MFWP's individual species plans also recognize the threat posed by subdivisions. The Elk Management Plan (MFWP 2005, p. 44) speaks to the "…permanent loss of habitat through housing development" and states that "FWP will not support any habitat management that it perceives as detrimental to the long-term health of the soil, water and vegetation or that permanently reduces the amount of elk habitat." It also points out (p. 43), as then–MFWP Director Jeff Hagener indicated in the May–June 2003 issue of *Montana Outdoors,* "[M]FWP does not have authority over land use, but our ability to conserve Montana's fish and wildlife depends on habitat just as the species themselves do. That's why we constantly seek to involve those who do have authority over land—both private property owners and land management agencies—to join with us in our shared task of ensuring the future abundance of Montana's wildlife treasures." The Montana Bighorn Sheep Conservation Strategy (2010, p. 72) notes that:

> Habitat deterioration, loss, and fragmentation are the greatest threats to the maintenance and viability of wildlife habitats and populations. Most impacts on wildlife habitats are human induced. The ability to influence human activities that negatively affect wildlife habitats is one of the major challenges facing wildlife and land managers today.

Among the major habitat issues facing bighorn sheep in Montana, first on the list (ibid.) is "residential and resort developments." Also listed is "human disturbance on critical lambing and winter ranges." Human development was an issue for 46 percent of the bighorn sheep populations in the state.

The published scientific literature has long recognized the threat of exurban development and subdivisions (Connolly and Wallmo 1981; Curran 1990; Werther 1999; Lyon and Christensen 2002; Lutz et al. 2003; Mule Deer Working Group 2003; O'Gara and Yoakum 2004; Hayden et al. 2008; many others). Theobald et al. (1997, p. 26) noted that "…residential development causes extensive changes in land use and cover that constitute the foremost threat to intact, high quality wildlife habitat." E.O. Wilson (1992, p. 253) identified habitat destruction as one of the four "mindless horsemen of the environmental apocalypse" and as the primary cause of biodiversity loss in recent time. McIntyre and Hobbs (1999), Odell and Knight (2001), Odell et al. (2003) and others have likewise considered human-caused changes to the environment, such as housing development and subdivisions, to be a major factor in landscape alteration.

Studying white-tailed and mule deer in the Gallatin Valley, Vogel (1989, p. 410) found that in relation to an increase in density of housing and the associated increase in human activity, "The most important response was decreased use of the developed area by deer." Significantly, he also found (ibid.) "a pronounced effect of houses at low housing densities," with deer use falling precipitously as housing density increased from one house per 640 acres to one house per 60 acres. Deer use continued to decline at higher housing densities, but at a lower rate. This has also been the experience of many other biologists and is the reason for additional concern when subdivisions are proposed in undeveloped wildlife habitat. Not only are the effects of the new houses much greater when undeveloped and remote rural landscapes are subdivided, but it "opens the door" to further development.

Developers may describe the designation of "open space" within a proposed subdivision as suitable wildlife habitat. However, often these are areas between houses or are developed for recreational uses such as golf courses, trail systems, and other activities. Because of their small size and location, such open spaces are seldom functional winter range. As Glennon and Kretser (2005, p. ix) wrote, drawing on the work of Maestas et al. (2001):

> A common misconception of exurban development is that, because most of the matrix remains in the original habitat type, effects to wildlife are minimal. Several studies have provided evidence to the contrary and demonstrated that it cannot be assumed that because most of the land within exurban developments remains undeveloped, it is suitable for all species that would occur there in the absence of houses.

Big game winter range is particularly vulnerable to the impacts of exurban development because big game animals need large, contiguous blocks of unfragmented habitat. Some recommended buffers between houses, human activities, and winter range can be found in Appendix I.

There is a need for a common language when discussing housing density issues (Theobald 2004). Development of subdivisions invariably and necessarily involves the concept of housing density. However, there is confusion and no consistent terminology among the various "players" in the subdivision review process, including land use planners, local governments, laypersons, developers, biologists, etc. as to classifications of housing density. Many community and neighborhood plans and zoning districts consider housing densities of one house per 5 to 20 acres as "rural residential." Others, using definitions based on U.S. Census Bureau criteria, have described densities of one house per 1 to 10 acres as "suburban," one per 10 to 40 acres as "exurban," and more than 40 acres per house as "rural" (Theobald 2005; Gude et al. 2008; Brown et al. 2005; Kretser et al. 2008). Studying the effects of housing on deer habitat use, Vogel (1989) considered one house per 64 acres as a "high" density and one house per 20 acres as a "very high" density. Consequently, even though the word "rural" in a definition implies an open landscape with room for wildlife, many areas classified as "rural" are not functional winter range for big game, and the word "suburban" may be more apropos. This fact underscores the need to try to look at the landscape from the standpoint of a big game animal rather than a human, and led McIntyre and Hobbs (1999, p. 1290) to note that "how an organism experiences landscape alteration, is of more significance in conservation biology than the human perspective." Until there are universally understood and used terms and definitions regarding housing densities and big game winter range issues, discussions between developers, biologists, and others need to be sure to incorporate language describing what is actually proposed to occur on the landscape.

The effects of subdivision on winter range go far beyond the footprint of houses and roads. Subdivisions can affect the way that wintering big game uses habitat a mile or more away (McIntyre and Hobbs 1999; Sime 1999; Appendix I). People walking, hiking, biking, skiing, and jogging, or driving their cars, 4-wheelers, ATVs, or snowmobiles can negatively affect wildlife. And with people come their pets. Dogs, especially dogs that are allowed to run loose, commonly chase, harass, injure, and kill big game animals, and can range up to three to five miles from the nearest house (Sime 1996; Sime 1999; Sime and Schmidt 1999). Even dogs barking within a subdivision can affect wildlife 200 or more yards away (Brent Brock, Craighead Institute, pers. comm.). Dogs can also form semi-feral packs that roam the countryside only to return home later. Evidence suggests that county regulations or subdivision covenants that restrict dogs from running loose are ineffective and often not enforced (Sime 1996; Sime 1999; Sime and Schmidt 1999). Dogs at large invariably come with development. To address this issue, some local jurisdictions, such as San Miguel County in Colorado, have prohibited dogs within half a mile of big game winter range (San Miguel County 2010).

Houses, roads, people, dogs, and other human activity often limit or preclude big game use of winter range. Glennon and Kretser (2005) advocated research to determine appropriate "building effect" distances. A number of studies have shown that elk change their distribution and habitat use more in response to humans than to wolves (Gude et al. 2006b; Proffitt et al. 2009; Proffitt et al. 2010). Cleveland (2010), studying elk use of a winter range in the Wildland/Urban Interface (WUI) near Missoula, found that elk preferred areas at least three-quarters of a mile from houses. Likewise, it has been shown that elk can be disturbed and move away from cross-country skiers that are over a mile away (Cassirer et al. 1992) and from ATV traffic two-thirds of a mile away (Wisdom et al. 2004). In a study in the Gallatin Valley, Vogel (1989) found more white-tailed deer in areas at least half a mile from houses than in areas closer to development. Because big game animals live significantly off their stored fat reserves during winter, if they are harassed or disturbed, they burn fat more quickly and have a lower chance of surviving the winter. The negative effect of disturbing big game on winter range is well known (Geist 1971; Lyon 1979; Parker et al. 1984; Cassirer et al. 1992), and is the primary reason winter ranges on MFWP wildlife management areas are closed during the winter. Another complicating factor is that the effects of new subdivisions on big game populations are not fully realized immediately after "build-out," or even within a few years of build-out. Instead, it may take many years and generations for animal populations to respond to development as individual animals die, find other areas, or adapt. As a result, the actual total impact of a development on winter range may not be fully realized for decades (McIntyre and Hobbs 1999; Hansen et al. 2005).

If given a choice, big game will avoid houses (Vogel 1989; Storm et al. 2007; Cleveland 2010). Consequently, where development is placed on winter range makes a significant difference (Duerkson et al. 1996). Subdivisions placed in unfragmented blocks of winter range and not adjacent to other development and infrastructure have a much greater negative impact on wildlife than do new houses situated next to existing development. Developing new subdivisions and housing in relatively remote and unfragmented areas is commonly known as "leapfrog" or "spotfire" development. Vogel (1989, p. 410) found "a pronounced effect of houses at low housing densities," noting that white-tailed deer use declined drastically (by 63 percent) when the number of houses in a 640-acre section increased from just one house to two. One of the most significant impacts of leapfrog development is that it paves the way for further new development. As a result, these developments often lead to cumulative impacts on unfragmented blocks of winter range; such cumulative impacts can rapidly and seriously compromise these important wildlife habitats.

Cumulative effects need to be assessed. Glennon and Kretser (2005, p. 26) noted that "The most critical aspect of the effects of exurban development on wildlife may be their cumulative impact." Cumulative effects can be described as the "tyranny of small decisions made singly," a premise first offered by the economist Alfred Kahn (1966) and noted in an ecological context by others (Odum 1982; Cocklin et al. 1992). If big game populations are to be protected long-term in Montana, any evaluation of a proposed subdivision must consider likely future cumulative effects from future development on big game winter range (Odum 1982). Continued application of "small decisions made singly" with regard to subdivisions and development eventually results in isolated relic winter range patches with little connectivity to other habitat and a generally highly modified matrix (Theobald et al. 1997; McIntyre and Hobbs 1999; Glennon and Kretser 2005; Hansen et al. 2005). Small populations of big game may still manage to survive, but often in conflict with humans and only if the remaining winter range is not developed further.

Habituation of big game is a big problem. When housing reaches the point when there are no "undeveloped" areas left, big game can no longer choose to avoid houses and either must adapt or leave. Species vary in their ability to adapt. White-tailed deer seem to do so quite easily and can even live in town. Mule deer are less adaptable than whitetails, but are also known to live in towns. Antelope are less adaptable than mule deer, and elk are the least adaptive of all. One of the impacts of human development on big game is that these animals may habituate to people, and the habituation of wildlife creates new problems. Kretser et al. (2008, p. 289) found "exurban landscapes contain the highest concentrations of reported human-wildlife interactions."

Just because deer are observed living in town does not mean that development is not a problem for deer. This statement may surprise people who see deer and elk in and around a subdivision. Although the animals appear to be fine, appearances can be deceiving, since even "habituated" deer react behaviorally and physiologically to humans, traffic, and dogs (Sibbald et al. 2001; Taylor and Knight 2003). Habituation of big game to development is a problem for at least six important reasons: (1) it "cheapens" people's perception of big game; (2) big game often come into conflict with people; (3) it can change the ecology and native habitat use of a big game population; (4) it can severely limit wildlife management options; (5) it can impact hunting and other wildlife-related recreational opportunities over a large area, including the big game's entire year-round home range; and (6) such negative interactions with wildlife may undermine people's attitudes toward conservation.

Humans perceive wildlife around subdivisions much differently than animals that are “wild” and farther away from homes (Lonner 1991; Glennon and Kretser 2005; Hayden et al. 2008; Theobald et al. 1997; Thompson and Henderson 1998). Instead of being valued as a treasured natural resource, habituated animals are seen as less wild, and often become unwanted nuisance animals. Although people may enjoy wildlife, if big game is accruing more costs than benefits, society generally loses tolerance for them (Kretser et al. 2009; Leong 2010). Under these circumstances, big game animals are seen as neighborhood pests that eat flowers, damage fences, defecate on lawns, tear up landscaping, cause traffic accidents, and even threaten humans. People with such views are less likely to support other wildlife conservation efforts (International Association of Fish and Wildlife Agencies 2004). Also, these animals can attract predators such as mountain lions, which can cause additional human-wildlife conflicts and possible safety concerns for subdivision residents (Hickman 2004). Unfortunately, once big game animals become established, it is not easy or inexpensive to keep unwanted problem animals away from a subdivision.

A subtle and often unrealized aspect of rural subdivisions is that they can change the year-round ecology of big game, causing animals over time to abandon nearby traditional winter ranges and become residents, potentially year-round residents, in and around subdivisions (Berger 2007; Haggerty and Travis 2006; Hebblewhite et al. 2006; Hurst and Porter 2008; Klopper et al. 2005; McClure and Bissonette 1996; Thompson and Henderson 1998; Whittaker and Knight 1998). Once this occurs, these habituated animals go from being “Wild Wild” animals “in areas where there is little or no evidence of influence by man,” to “Mild Wild” (Lonner 1991, p. 4). When they become residents in and around developments, big game may also abandon their yearly migration to spring, summer, and fall ranges. When big game populations quit migrating between seasonal ranges, they often no longer provide the hunting and other recreational opportunities that they did before the residential development occurred (Harden et al. 2005).

Helena, Missoula, and Fort Benton all have habituated urban and suburban deer populations that have grown to unacceptable numbers. Deer densities within the Helena and Missoula city limits (about 230 and 156 deer per square mile, respectively, MFWP pers. comm.) are comparable to numbers on good-quality native deer winter range, but are certainly unacceptable in town. Deer, elk, and other wildlife that cause problems in urban and suburban environments often require MFWP to respond or become involved, thus diverting money and personnel away from other important conservation activities. MFWP is funded primarily by licenses bought by hunters and anglers. Essentially, hunters end up paying MFWP staff to respond to wildlife problems in subdivisions. In addition, these hunters also “pay” a second time because of the reduced opportunity to hunt due to development and the subsequent aggregation of deer in “refuges.” Consideration should be given to establishing a subdivision wildlife impact fee levied on developers and earmarked for addressing “problem” wildlife issues.

Subdivisions limit the tools available to manage wildlife populations. The most effective tool for managing big game populations is hunting, particularly hunting with rifles. But hunting is usually not a viable option in and around subdivisions because of safety reasons and covenant restrictions. Additionally, some subdivision residents may oppose hunting in general, and nearly all residents do not want animals dying on or near their property (Thompson and Henderson

1998). MFWP's elk plan (MFWP 2005, p. 45) also recognizes that "development may hinder effective harvest and population control."

Conserving Big Game Winter Range Threatened by Subdivision Development
Development and subdivisions on big game winter range may render this critical habitat as unsuitable for big game use, unsuitable for big game management, or both. Such subdivisions often convert functional undeveloped winter range into a series of disconnected and unusable habitat fragments. Functional undeveloped winter ranges are large unfragmented landscapes of suitable habitat where big game can live in a natural wild state during the winter (generally November through April). The characteristics of functional winter range include the following factors: (1) animals can use the habitat undisturbed; (2) animals can move easily to and from summer range; (3) animals do not create conflicts with people and domesticated pets; (4) traditional human use and enjoyment of the animals is maintained; and (5) all options for effective big game management, including hunting with rifles, can be employed if desired.

MFWP's objectives for conserving big game winter range faced with subdivision are similar to those championed by other authors (e.g., Glennon and Kretser 2005):

- Minimize habitat fragmentation.
- Minimize the loss of functional habitat.
- Maintain the animal's ability to travel freely between winter range patches and other seasonal ranges.
- Maintain MFWP's ability to manage wildlife effectively and as non-habituated herds.
- Minimize the potential for subdivisions to lead to problematic concentrations of big game.
- Minimize wildlife-human conflicts.

Early discussions with MFWP are important when developing in or near big game winter range. Before laying out any lot boundaries and designing other features for a subdivision proposed in big game winter range, the developer or landowner should consult with a local MFWP wildlife biologist to discuss the type, topography, vegetation, and other features of the particular winter range and a subdivision design that could minimize impacts. Such consultations would not only result in a more wildlife-friendly design but could also save costly and time-consuming redesign efforts.

The effect of subdivision on big game winter range needs to be evaluated at the local level, not at the hunting district or larger level. By law, all counties and communities in Montana must evaluate proposed subdivisions based on seven criteria, two of which are the effects the subdivision will have on wildlife and wildlife habitat. For this evaluation to be meaningful for big game winter range, it needs to be done at a local level (Mule Deer Working Group 2003). For example, a proposed subdivision west of Kalispell will not likely affect deer or elk in the Swan Valley. But depending on the size of the winter range and the size of the subdivision, it could certainly have a significant impact on local deer and elk herds. These animals may range widely during other seasons, but their winter range is relatively restricted. Too often, the effects of a subdivision on big game are evaluated at too broad a scale to be relevant to the local herds.

The case for clustering. As pointed out above, functional winter range requires large undeveloped blocks of land and associated movement corridors. Realizing the importance of winter range, some local jurisdictions in the Rocky Mountain West, like San Miguel County in Colorado and Jackson Hole, Wyoming, have adopted half-mile buffers around mapped big game winter range, disallowing any development. However, this approach is not applied consistently or everywhere in the West.

Exurban lands are traditionally developed by subdividing them into a grid of parcels ranging from 5 to 40 acres. From an ecological perspective, this dispersed type of development effectively maximizes the individual influence of each home on the land (Lenth et al. 2006). As mentioned earlier, a single house situated in the wrong place can have a greater impact than several houses clustered together so that houses are within the "zone of influence" of each other and the entire cluster is placed thoughtfully on the landscape near and adjacent to existing development. Similarly, Vogel (1989) found a significant impact on white-tailed deer use of winter range when housing densities went from one house per 32 acres to one house per 20 acres. If development is planned on or near big game winter range, the best option for wildlife is to build the houses and roads on a small portion of the landscape near and adjacent to existing development and leave as much land as possible undisturbed, unfragmented, and protected (see Figure 3).

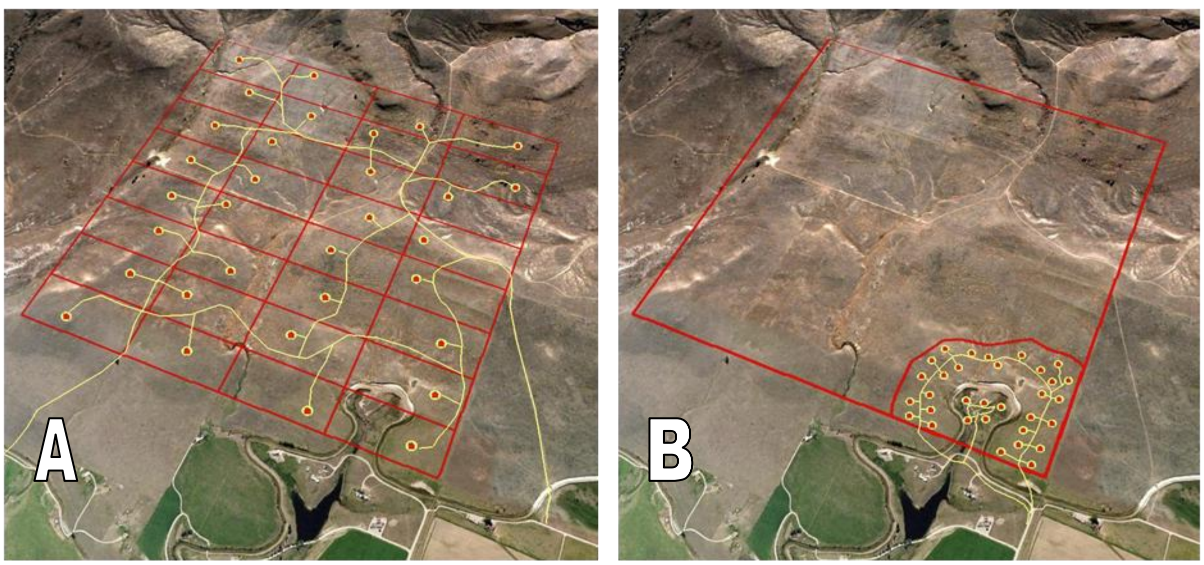

Figure 3. *Examples of traditional development of thirty-two 20-acre lots spread across 640 acres of winter range (A), and a "clustered" design (B) of the same 32 houses on 2-acre lots on 10% of the property, 64 acres, situated in a corner near existing development. Clustering homes as shown in B obviously impacts winter range much less than dispersed development in A.*

As noted, it is important that new development be placed adjacent to existing development. Odell and Knight (2001) advocate this type of clustering, and Wait and McNally (2004, p. 205) speak to the importance of clustering homes in one corner of a larger property, thereby reducing impacts to wildlife and "maintaining the open spaces residents want while reducing the per-unit cost." Additionally, the developable acres can be developed with more houses at a higher density with no or little additional impact on the winter range. As Figure 3B illustrates, clustering houses on a 640-acre section can leave significant winter range open, undeveloped, and either adjacent to or well connected to other nearby functional winter range. In "conservation development" planning where wildlife is not an explicit consideration, houses may often be clustered in the middle of the parcel, away from existing development, and thus severely fragment the functional wildlife habitat.

Planners, biologists, and others are advised to carefully review proposed subdivisions touted as "cluster" developments. "Ecologically"-based cluster development as advocated here may differ in important ways from definitions of cluster development adopted by local jurisdictions or from the concepts of cluster development held by individuals or developers. As an example, a Montana subdivision proposed in 2006 had 643 lots spread across 393 acres of undeveloped winter range (average 1.6 acres per lot), with no provision for conserving other acreage as undeveloped open space, yet it was promoted as a "clustered" development.

The percentage of undisturbed habitat can be a guide to maintaining big game winter range and an indicator of habitat quality. McIntyre and Hobbs (1999) provide a framework for conceptualizing human effects on landscapes. The authors point out that human modification of habitat occurs at multiple levels, and the degree to which habitat is modified may be more instructive than the simple habitat/non-habitat distinction that characterizes much of the fragmentation literature. These authors propose four states that describe a continuum of landscape alteration:

(1) **intact:** more than 90 percent of original habitat remaining, high connectivity, and low modification of remaining habitat;
(2) **variegated:** 60 to 90 percent of original habitat remaining, generally high connectivity for most species, and low to high degree of modification of remaining habitat;
(3) **fragmented:** 10 to 60 percent of original habitat remaining, generally low connectivity, and low to high degree of modification of remaining habitat; and
(4) **relictual:** less than 10 percent of the original habitat remaining, no connectivity, and a generally highly modified matrix.

The Washington Department of Fish and Wildlife (2009) also supports the concept of using the percentage of undisturbed habitat across the landscape as a useful indicator of habitat composition and configuration. This indicator can provide a surrogate measurement for other important parameters such as the amount of edge habitat, proximity to homes, and the amount of available habitat. It can also reflect the extent of habitat connectivity (With 2002). "Sensitive animals, such as neotropical migrant songbirds and raptors, require 65 to 95 percent of undisturbed vegetation (Berry et al. 1998; Stratford and Robinson 2005). Many species of mammals and amphibians are expected to do well where natural vegetation covers over 80 percent of the landscape (Kilpatrick and Spohr 2000; Grinder and Krausman 2001; Riley et al. 2003)" (WDFW 2009, p. 4 of Chapter 3). Montana's big game animals are wide ranging, with large spatial requirements including intact, functional, undeveloped winter range. MFWP biologists across the state urge careful land use planning and resource management to maintain winter range (see Foreword). If development must occur in winter range, it should be located as far from undeveloped winter range as possible, placed as close to existing development as possible, and clustered into as small a footprint as possible.

Suggested Subdivision Standards for Development in Big Game Winter Range
The following steps and criteria are recommended to avoid or minimize the negative impacts of subdivisions on big game winter range.

Recommended Approach to Subdivision Design. In designing the proposed subdivision, the subdivider is encouraged to follow the four steps outlined below. Local MFWP wildlife biologists are encouraged, when contacted by the subdivider or the subdivider's representative, to make time for the consultation described in subsections b. and c. (below).

a. Consult MFWP's Crucial Areas Planning System (CAPS) and/or other publicly available sources of wildlife habitat information, for a preliminary indication of whether the property proposed for subdivision may be located in or adjacent to big game winter range.

b. Consult with the local MFWP wildlife biologist, or other professionally trained biologist, to verify the preliminary assessment. If consulted, the MFWP biologist should provide the subdivider with a written determination of whether or not the property proposed for subdivision is located in or adjacent to big game winter range.

c. If the biologist determines that the property proposed for subdivision is located wholly or partially within big game winter range, consult further with the biologist for site-specific information and recommendations on minimizing the impacts of the subdivision on big game species and big game winter range. MFWP recommendations may include suggestions for avoiding or strictly limiting the placement of subdivision design features in winter range. Or, based upon site-specific conditions and the extent of existing development located adjacent to or near the proposed subdivision, MFWP may recommend that strict restrictions on the location of subdivision design features are not necessary. In offering recommendations, the MFWP biologist should take into account the wildlife and habitat data compiled by the subdivider, any field reviews completed by other professionally trained biologists, MFWP's own wildlife and habitat data, and any other applicable biological information.

d. Incorporate the biologist recommendations into the design of the proposed subdivision.

Subdivision Design Standards. Whether or not the subdivision design approach recommended above is completed, the following standards pertain to any subdivision development proposed on property that contains or lies adjacent to big game winter range:

a. Cluster the subdivision design features on as small a footprint as possible, as far from winter range as possible, and as close to existing development as possible (e.g., other houses, roads, residential utilities).

b. Locate areas of proposed open space immediately adjacent to existing winter range or open space on adjacent lands, in order to maintain the functional connection with other open space and winter range on public and private lands.

c. Provide or maintain linkage within a winter range patch, between isolated patches of winter range, or between summer range (or other seasonal habitat) and winter range. Recommended linkage widths are a minimum of one (1) mile for elk and one-half (1/2) mile for other species. For white-tailed deer, mule deer, and moose, linkage should be along riparian corridors where present.

   The local MFWP wildlife biologist may recommend the number of linkages needed to maintain wildlife movement, and whether or not site-specific circumstances justify a reduced linkage width (e.g., topography and/or natural vegetation may limit line of sight distances and sufficiently alleviate noise between linkage habitat and development activity to allow undisturbed movement of wildlife).

References

Berger, J. 2007. Fear, human shields and the redistribution of prey and predators in protected areas. *Biology Letters* 3:620–23.

Berry, M.E., C.E. Bock, and S.L. Haire. 1998. Abundance of diurnal raptors on open space grasslands in an urbanized landscape. *The Condor* 100:601–8.

Brown, D.G., K.M. Johnson, T.R. Loveland, and D.M. Theobald. 2005. Rural land-use trends in the conterminous United States, 1950–2000. *Ecological Applications* 15:1851–63.

Cassirer, E.F., D.J. Freddy, and E.D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. *Wildlife Society Bulletin* 20:375–81.

Cleveland, S.M. 2010. Human predation risk and elk behavior in heterogeneous landscapes. M.S. Thesis. University of Montana, Missoula, MT. 101 pp.

Cocklin, C., S. Parker, and J. Hay. 1992. Notes on cumulative environmental change I: Concepts and issues. *Journal of Environmental Management* 35(1):31–49.

Connolly, G.E., and O.C. Wallmo. 1981. Management challenges and opportunities. Pages 537–45 in Mule and black-tailed deer of North America. O.C. Wallmo, ed. Wildlife Management Institute, University of Nebraska Press, Lincoln, NE. 605 pp.

Curran, R.P. 1990. Biological resources and diversity of the Adirondack Park. Technical Report 17, Vol. 1. The Adirondack Park in the 21st Century, State of New York.

Duerkson, C.J., D.L. Elliot, N.T. Hobbs, E. Johnson, and J.R. Miller. 1996. Managing development for people and wildlife: A handbook for habitat protection by local governments. American Planning Association PAS #470/471. Chicago, IL.

Dusek, G., A. Wood, S. Hoekman, C. Sime, and J. Morgan. 2006. White-tailed deer studies in the Salish mountains, northwest Montana. Montana Fish, Wildlife & Parks, Wildlife Division. Helena, MT.

Geist, V. 1971. Is big game harassment harmful? *Oil Week* 14(June):12–13.

Glennon, M., and H. Kretser. 2005. Impacts to wildlife from low density, exurban development: Information and considerations for the Adirondack Park. Wildlife Conservation Society, Adirondack Communities and Conservation Program. Technical Paper No. 3. 53 pp.

Grinder, M.I., and P.R. Krausman. 2001. Home range, habitat use, and nocturnal activity of coyotes in an urban environment. *Journal of Wildlife Management* 65(4):887–98.

Gude, P.H., A.J. Hansen, R. Rasker, and B. Maxwell. 2006a. Rates and drivers of rural residential development in the Greater Yellowstone. *Landscape and Urban Planning* 77:131–51.

Gude, J., R.A. Garrott, John J. Borkowski, and Fred King. 2006b. Prey risk allocation in a grazing ecosystem. *Ecological Applications* 16(1):285–98.

Gude, P., R. Rasker, and J. van den Noort. 2008. Potential for future development on fire-prone lands. *Journal of Forestry* June 2008:198–205.

Hagener, M.J. 2003. Our Point of View: Plans must address habitat. *Montana Outdoors* May–June 2003.

Haggerty, J.H., and W.R. Travis. 2006. Out of administrative control: Absentee owners, resident elk and the shifting nature of wildlife management in southwestern Montana. *Geoforum* 37:816–30.

Hansen, A.J., R.L. Knight, J.M. Marzluff, S. Powell, K. Brown, P.H. Gude, and K. Jones. 2005. Effects of exurban development on biodiversity: Patterns, mechanisms, and research needs. *Ecological Applications* 15(6):1893–1905.

Harden, C.D., A. Woolf, and J. Roseberry. 2005. Influence of exurban development on hunting opportunity, hunter distribution, and harvest efficiency of white-tailed deer. *Wildlife Society Bulletin* 33(1):233–42.

Hayden, J., G. Ardt, M. Fleming, T.W. Keegan, J. Peek, T.O. Smith, and A. Wood. 2008. Habitat guidelines for mule deer: Northern forest ecoregion. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies. USA.

Hebblewhite, M., E.H. Merrill, L.E. Morgantini, C.A. White, J.R. Allen, E. Bruns, L. Thurston, and T.E. Hurd. 2006. Is the migratory behavior of montane elk herds in peril? The case of Alberta's Ya Ha Tinda elk herd. *Wildlife Society Bulletin* 34:1280–94.

Hickman, G. 2004. Findings and Recommendations of the Urban Wildlife Working Group, September 2004. Montana Fish, Wildlife & Parks. 187 pp. Accessed December 31, 2011, at: http://fwp.mt.gov/fwpDoc.html?id=8426.

Hillis, J.M., M.J. Thompson, J.E. Canfield, L.J. Lyon, C.L. Marcum, P.M. Dolan, and D.W. Cleery. 1991. Defining elk security: The Hillis Paradigm. In Elk Vulnerability—A Symposium. Montana State University, Bozeman, MT, April 10–12, 1991.

Hurst, J.E., and W.F. Porter. 2008. Evaluation of shifts in white-tailed deer winter yards in the Adirondack region of New York. *Journal of Wildlife Management* 72(2):367–75.

International Association of Fish and Wildlife Agencies. 2004. Potential costs of losing hunting and trapping as wildlife management tools. Animal Use Issues Committee, IAFWA, Washington, DC.

Kahn, A.E. 1966. The tyranny of small decisions: Market failures, imperfections, and the limits of economics. *KYKLOS* 19:23–45.

Kilpatrick, H.J., and S.M. Spohr. 2000. Movements of female white-tailed deer in a suburban landscape: A management perspective. *Wildlife Society Bulletin* 28(4):1038–45.

Kloppers, E.L., C.C. St Clair, and T.E. Hurd. 2005. Predator-resembling aversive conditioning for managing habituated wildlife. *Ecology and Society* 10.

Kretser, H.E., P.J. Sullivan, and B.A. Knuth. 2008. Housing density as an indicator of spatial patterns of reported human-wildlife interactions in northern New York. *Landscape and Urban Planning* 84(3–4):282–92.

Kretser, H.E., P.C. Curtis, J.D. Francis, R.J. Pendall, and B.A. Knuth. 2009. Factors affecting perceptions of human-wildlife interactions in residential areas of northern New York and implications for conservation. *Human Dimensions of Wildlife Management.* 14(2):102–18.

Lenth, B.A., R.L. Knight, and W.C. Gilgert. 2006. Conservation value of clustering housing developments. *Conservation Biology* 20(5):1445–56.

Leong, K.M. 2010. The tragedy of becoming common: Landscape change and perceptions of wildlife. *Society & Natural Resources* 23(2):111–27.

Lonner, T.N. 1991. Elk vulnerability and the biomodulator. Pages 2–5 in A.G. Christensen, L.J. Lyon, and T.N. Lonner, compilers. Proceedings of a symposium on elk vulnerability. Montana State University, Bozeman, MT.

Lutz, D.W., M. Cox, B.F. Wakeling, D. McWhirter, L.H. Carpenter, S. Rosenstock, D. Stroud, L.C. Bender, and A.F. Reeve. 2003. Impacts and changes to mule deer habitat. Pages 13–61 in J.C. deVos Jr., M.R. Conover, and E. Headrick, eds. Mule deer conservation: Issues and management strategies. Jack H. Berryman Institute Press, Utah State University. Logan, UT. 240 pp.

Lyon, L.J. 1979. Habitat effectiveness for elk as influenced by roads and cover. *Journal of Forestry* 77(10):658–60.

Lyon, L.J., and A.G. Christensen. 2002. Elk and land management. Pages 557–81 in E.I. Toweill and J.W. Thomas, compilers and eds. North American elk: Ecology and management. Wildlife Management Institute, Smithsonian Institution Press, Washington, DC and London. 962 pp.

Mackie, R.J., D.F. Pac, K.L. Hamlin, and G.L. Dusek. 1998. Ecology and management of mule deer and white-tailed deer in Montana. Technical bulletin, Federal Aid Project W-120-R, Montana Fish, Wildlife and Parks, Helena, MT. 180 pp.

Maestas, J.D., R.L. Knight, and W.G. Gilgert. 2001. Biodiversity and land use change in the American mountain west. *Geographical Review* 91(3):509–24.

McClure, M., and J.A. Bissonette. 1996. Valley deer in Cache County: A search for management solutions. Paper presented at the Annual Meeting of the Utah Chapter of The Wildlife Society. Logan, UT. March 1, 1996.

McIntyre, S., and R. Hobbs. 1999. A framework for conceptualizing human effects on landscapes and its relevance to management and research models. *Conservation Biology* 13:1282–92.

Montana Fish, Wildlife & Parks. 2005. Final Elk Management Plan. Montana Fish, Wildlife & Parks, Helena, MT.

Montana Fish, Wildlife & Parks. 2010. Bighorn Sheep Conservation Strategy. Montana Fish, Wildlife & Parks, Helena, MT.

Montana Fish, Wildlife & Parks. 2010. Crucial Areas Planning System (CAPS). Montana Fish, Wildlife & Parks, Helena, MT. Accessed December 31, 2011, at: http://fwp.mt.gov/fishAndWildlife/conservationInAction/crucialAreas.html

Montana's Comprehensive Fish and Wildlife Conservation Strategy, Executive Summary. 2005. Montana Fish, Wildlife & Parks, Helena, MT.

Mule Deer Working Group. 2003. Mule deer: Changing landscapes, changing perspectives. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies. 30 pp.

Odell, E.A, and R.L. Knight. 2001. Songbird and medium-sized mammal communities associated with exurban development in Pitkin County, Colorado. *Conservation Biology* 15(4):1143–50.

Odell, E.A., D.M. Theobald and R.L. Knight. 2003. Incorporating ecology into land use planning: The songbirds' case for clustered development. *Journal of the American Planning Association* 69(1):72–82.

Odum, W.E. 1982. Environmental degradation and the tyranny of small decisions. *BioScience* 32(9):728–29.

O'Gara, B.W., and J.D. Yoakum. 2004. The future. Pages 809–832 in B.W. O'Gara and J.D. Yoakum, eds. Pronghorn ecology and management. Wildlife Management Institute, University Press of Colorado, Boulder, CO. 903 pp.

Pac, D.F., R.J. Mackie, and H.E. Jorgensen. 1991. Mule deer population organization, behavior, and dynamics in a northern Rocky Mountain environment. Final Report, Federal Aid Project W-120-R-7-18. Montana Fish, Wildlife & Parks, Helena, MT. 316 pp.

Parker, K.L., C.T. Robbins, and T.A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. *Journal of Wildlife Management* 48(2):474–88.

Proffitt, K., J. Grigg, R.A. Garrott, and K.L. Hamlin. 2009. Elk behavioral responses to predation risk: Contrasting effects of wolves and human hunters. *Journal of Wildlife Management* 73:345–56.

Proffitt, K., J. Grigg, R.A. Garrott, K.L. Hamlin., J. Cunningham, J.A. Gude, and C. Jourdonnais. 2010. Changes in elk resource selection and distributions associated with a late-season elk hunt. *Journal of Wildlife Management* 74(2):210–18.

Riley, S.D., R.M. Sauvajot, T.K. Fuller, E.C. York, D.E. Kamradt, C. Bromley, and R.K. Wayne. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. *Conservation Biology* 17(2):566–76.

San Miguel County. 2010. San Miguel County Land Use Code, Article 5: Standards. Section 5–407 B. Deer, Elk and Bighorn Sheep Winter Concentration Area/Severe Winter Range. Accessed December 31, 2011, at: http://www.sanmiguelcounty.org/departments/planning/index.html.

Sibbald, A.M., R.J. Hooper, I.J. Gordon, and S. Cumming. 2001. Using GPS to study the effect of human disturbance on the behaviour of red deer stags on a highland estate in Scotland. Pages 39–44 in Tracking Animals With GPS: An International Conference Held at the Macaulay Land Use Research Institute, Aberdeen, March 12–13, 2001.

Sime, C.A. 1996. Population ecology of white-tailed deer in northwestern Montana. Job Progress Report, Montana Fish, Wildlife & Parks, Helena, MT. Federal Aid Project W-100-R-3.

Sime, C.A. 1999. Domestic Dogs in Wildlife Habitats. Pages 8.1–8.17 *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The

Wildlife Society. 307 pp. Accessed January 9, 2012, at: http://joomla.wildlife.org/Montana/images/Documents/toc.pdf.

Sime, C.A., and E. Schmidt. 1999. Off-site impacts of rural subdivision on wintering white-tailed deer in northwest Montana: Could man's best friend be wildlife's worst enemy? In 2001, A Space for Wildlife Odyssey: A Symposium on Living in the Western Landscape. March 8–10, 1999, Bozeman, MT. Abstract available.

Storm, D.J., C.K. Nielsen, E.M. Schauber, and A. Woolf. 2007. Space use and survival of white-tailed deer in an exurban landscape. *Journal of Wildlife Management* 71(4):1170–76.

Stratford, J.A., and W.D. Robinson. 2005. Distribution of neotropical migratory bird species across an urbanizing landscape. *Urban Ecosystems* 8:59–77.

Taylor, A.R., and R.L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications* 13(4):951–63.

Theobald, D.M. 2004. Placing exurban land-use change in a human modification framework. *Frontiers in Ecology and the Environment* 2(3):139–44.

Theobald, D.M. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. *Ecology and Society* 10(1):32. Accessed December 31, 2011, at: http://www.ecologyandsociety.org/vol10/iss1/art32/.

Theobald, D.M., Miller, J.M., and N.T. Hobbs. 1997. Estimating the cumulative effects of development on wildlife habitat. *Landscape and Urban Planning* 39(1):25–36.

Thompson, M.J., and R.E. Henderson. 1998. Elk habituation as a credibility challenge for wildlife professionals. *Wildlife Society Bulletin* 26(3):477–83.

Vogel, W.O. 1989. Response of deer to density and distribution of housing in Montana. *Wildlife Society Bulletin* 17(4):406–13.

Wait, S., and H. McNally. 2004. Selection of habitats by wintering elk in a rapidly subdividing area of La Plata County, Colorado. Pages 200–209 in W.W. Shaw, L.K. Harris, and L. VanDruff, eds. Fourth international symposium on urban wildlife conservation, Tucson, AZ.

Washington Department of Fish and Wildlife. 2009. Landscape planning for Washington's wildlife: Managing for biodiversity in developing areas. 88 pp + app. Olympia, WA.

Werther, G.F.A. 1999. Global processes, emerging patterns of societal change, and the future challenges to wildlife management. Pronghorn Antelope Workshop (1998) Proc. 18:1–6.

Whittaker, D., and R.L. Knight. 1998. Understanding wildlife responses to humans. *Wildlife Society Bulletin* 26:312–17.

Williams, J., J. Berger, R. Ridgeway, K. Aune, and S. Knapp. In prep. The Conservation of Montana Wildlife Migrations.

Wilson, E.O. 1992. The diversity of life. W.W. Norton & Company, New York, NY.

Wisdom, M.J., A.A. Ager, H.K. Preisler, N.J. Cimon, and B.K. Johnson. 2004. Effects of off-road recreation on mule deer and elk. Pages 31–550 in Jennifer Rahm, ed. Transactions of the 69th North American Wildlife and Natural Resources Conference. March 16–20, 2004, Spokane, WA. Wildlife Management Institute. Washington, DC.

With, K.A. 2002. Using percolation theory to assess landscape connectivity and effects of habitat fragmentation. Applying landscape ecology in biological conservation. K.J. Gutzwiller. New York, NY, Springer-Verlag: 105–30.

Wood, A.K. 1989. Comparative distribution and habitat use by antelope and mule deer. *Journal of Mammalogy* 70(2):335–40.

Yoakum, J.D. 2004. Habitat characteristics and requirements. Pages 405–45 in B.W. O'Gara and J.D. Yoakum, eds. *Pronghorn Ecology and Management.* Wildlife Management Institute. Washington, DC.

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Appendix I. Examples of big game winter range parameters taken or estimated from a sampling of scientific studies

Species	Study	Findings	Housing buffers	Movement corridor width between developments	Notes
Elk	Hillis et al. 1991	A “security area” during hunting season was at least 250 acres buffered by half a mile from open roads, and it comprised at least 30% of a larger analysis area. A 250-acre circle plus a half-mile buffer gives a circle of 1,500 yards radius.	1,500 yards		This size provided security for ~60% of radio-collared elk based on 3 study areas in Montana.
Elk	Cassirer et al. 1992	75% of elk moved away from cross-country skiers <709 yards away. Skiers would have to stay >1,853 yards away to avoid disturbing elk.	709–1,853 yards		A 2-year study on the YNP northern range; data used here are for “non-habituated” elk.
Elk	Cleveland 2010	Elk selected areas greater than 1,600 meters (1,744 yards) from houses and moved quickly through areas that were <750 meters from houses.	1,744 yards	1,500 meters (1,635 yards) or 2 times the distance that elk began moving quickly past houses.	A 3-year study in the North Hills near Missoula using GPS collars among a herd of ~300 elk
Elk	Wisdom et al. 2004	Elk ran away from ATV traffic that was 1,000 meters (1,090 yards or 2/3 mile) away one-quarter of the time. They ran away about half the time when ATVs were 500 meters away.	1,090 yards		A treatment/ control study done at Starkey Experimental Station, OR, under highly controlled conditions with radio-instrumented elk and people
Mule deer	Taylor and Knight 2003	Mule deer flushed 70% of the time when 390 meters (425 yards) from people hiking off trail.	425 yards		Antelope Island State Park, Utah
White-tailed deer	Vogel 1989	Deer use dropped significantly between 1 house/32 acre and 1 house/20 acres.	214 yards		A 3-year study of the effects of housing on deer in the Gallatin Valley