Recommendations for Managing Mule Deer Habitat In Wyoming

WGFD Mule Deer Working Group, October 2015 Version 10/16/15

Special Thanks to our Partners

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Introduction

Mule deer have declined in Wyoming and throughout the West over the past 25 years. Multiple factors have likely caused this decline (deVos et al. 2003), but habitat quality and availability have likely had the greatest influence. Several important mule deer habitats such as aspen (*Populus tremuloides*), mixed mountain shrub, and sagebrush steppe are in declining condition as a result of persistent drought, changing plant community structure and composition (succession), noxious and invasive species and fire suppression. Habitats have also been fragmented and are less usable as a result of energy development, exurban residential development, and highway and fence projects (deVos et al. 2003, Sawyer et al. 2009a).

Though landscape-scale restoration and management of mule deer habitats will be needed to sustain mule deer herds at desired levels, the abundance of wildlife and wildlife habitats throughout Wyoming has and will continue to be the result of progressive and adaptive land management and stewardship by private landowners, agriculture producers, state and federal land management agencies, and others. It is important all land managers, whether on public or private land, continue to play a critical role in providing wildlife habitat.

Historically, Wyoming Game and Fish Department (WGFD) has placed highest priority on managing winter ranges used by mule deer and other ungulates based on the assumption these habitats are most limiting to population growth. Nutrition during summer and autumn has an important influence on survival and especially reproduction (Julander et al. 1961, Julander 1962, Pederson and Harper 1978, Mautz 1978). Recent research has established that nutrition during summer and fall periods is critically important for mule deer fawn production and survival (Tollefson et al. 2010, Monteith et al. 2013a). The body condition of does moving from fall or "transition" ranges (habitats at mid-elevation mule deer move through or stop over during fall and spring migration) onto winter range significantly influences fawn survival and recruitment the following year (Bishop et al. 2005, Tollefson et al. 2010). There is also growing evidence improving forage quality on late summer and fall transition range can enhance a population's growth potential by increasing pregnancy rates and overwinter survival of fawns and adults (Lomas and Bender 2007, Bishop et al. 2008). Sawyer et al. (2009b) demonstrated mule deer use stopover sites as they migrate between summer and winter ranges. Deer spend more time at these sites presumably to forage and conserve energy as they progress to winter range. In light of this insight, the WGFD is refocusing emphasis on summer and transition ranges to increase fawn production and survival. Habitat work in these areas may produce the greatest net benefit for deer. The WGFD will also continue habitat work on winter ranges where it has potential to reduce over-winter mortality.

It is generally accepted that quality mule deer habitat includes a mix of early- and mid-succession plant communities, especially those containing higher proportions of preferred browse species. Natural disturbance regimes, including periodic fire, are essential to maintain vegetation in a range of successional stages that are beneficial to mule deer. In addition, mule deer must also be able to use their seasonal habitats effectively. Because migration corridors serve as the critical link between summer and winter ranges, they must be unimpeded by physical barriers (e.g., game-proof fences, roads, etc.) and protected from various forms of development and human disturbance (e.g., housing and energy development).

Most habitat treatments for mule deer are intended to establish a mosaic of early seral plant communities through such actions as prescribed burning, mowing, chaining, discing, and thinning. Treatments typically target older plant communities that are less productive and of lower nutritional value. Other treatments including prescribed or targeted livestock grazing to maintain or enhance vegetation community species composition or application of herbicides to control noxious weeds and other undesired plants (i.e., cheatgrass) can improve habitat conditions for mule deer. To be most effective, habitat treatments should focus on those seasonal habitats and locations having the greatest potential to influence mule deer survival and reproductive success. In general, the nutritional plane of mule deer entering the winter has the greatest influence on their survival through winter and spring, and also has a major effect on health and survival of fawns (Tollefson et al. 2010, Monteith et. al. 2013b).

Funding and planning resources to implement habitat projects is limited. Ideally, available resources should be invested in habitats and locations where the greatest benefits will be realized. Accordingly, emphasis should be placed on important (or historically important) summer/fall transition ranges where there is high potential for successful restoration and improvement. However, opportunities to implement habitat projects are often dependent on local area interest, partnerships, and funding availability. The momentum realized from local efforts may evolve into broader initiatives yielding additional resources that can be channeled into identified statewide priorities.

This document contains habitat management recommendations focused primarily on diet/nutrition for mule deer in Wyoming. These recommendations are provided for use by land management agencies (e.g., the Bureau of Land Management (BLM), United States Forest Service (USFS), Office of State Lands and Investment (OSLI), the Natural Resources Conservation Service (NRCS), and conservation districts, private landowners and others to improve habitats for mule deer to sustain and potentially increase mule deer populations throughout Wyoming.

These recommendations are intended to be used as general guidelines when developing management strategies and projects to improve mule deer habitat. They are not intended to be construed or used as regulatory requirements or standards. It is recognized every management situation, project and geographic site is unique and will, therefore, require unique, adaptive and creative solutions and actions to be successful.

The Mule Deer Diet

Mule deer are highly selective browsers that consume primarily plant "leaders", though they also consume grasses and forbs especially during spring and summer. Leaders are the current year's growth represented by long thin twig-like extensions growing from terminal buds. Annual leaders (including leaves and stems) are much more nutritious and easily digested by mule deer, because they have not yet hardened into fibrous woody material (Figure 1).

Figure 1. *Annual leader growth measurement of sagebrush*

As portions of forage plants mature, cell walls thicken and harden into coarse, woody material. Matter contained within the cells is up to 98% digestible (Short and Reagor 1970). However, the cell wall itself contains components such as cellulose, hemicellulose, lignin, cutin, pectin, and tannin, several of which are indigestible or interfere with digestion. The rough feel and appearance of woody branches that are two years old or older (not current year leader growth) is due to buildup of cell wall material. Some cell wall components can be broken down by the microbes in the stomach and digested while others cannot. For example, lignin, a non-carbohydrate polymer that binds the cell together, is indigestible. As browsing plants mature and senesce, they produce less annual leader growth. Proportionately much more of the plant becomes comprised of woody material. In addition, crude protein declines (Wasley 2004). Dietary crude protein of 7% is considered to be the minimum necessary for maintenance of a positive nitrogen balance (Murphy and Coates 1966). Dietary crude protein levels of 16-17% are necessary for lactation (Verme and Ullrey 1972).

Figure 2. *Cheatgrass invasion post-fire severely degrades mule deer habitat*

Most preferred browse species also lose vigor with age. For example, antelope bitterbrush (*Purshia tridentata*) is, in many places, the most important browse for mule deer. However, leader growth and seed production cease as bitterbrush ages. Seed production and leader growth begin to decline in 60-year old plants (McConnell and Smith 1977). The lack of leader growth has an obvious impact on availability of forage, and lack of seed production significantly reduces recruitment of new plants (Wasley 2004).

Throughout Wyoming the majority of plant communities historically preferred

by mule deer are in late seral stages and are less productive. In addition, the health of associated herbaceous vegetation within the understory has also declined in many areas. Preferred grasses and forbs can be extremely important forage during the late spring and summer months, especially for lactating females, and can be vital in helping mule deer accumulate the necessary fat reserves before entering the winter. Unfortunately, in some areas of the state, much of the herbaceous component has been converted to less desirable grasses and/or invasive weeds [e.g. cheatgrass (*Bromus tectorum*)], and often lacks forb production and diversity (Figure 2).

Mule deer diet varies throughout the year based on nutritional requirements, location on the landscape, and plant availability. Seasonal preferences include high grass use in spring, high forb use in summer and fall, and high shrub use in winter (Figure 3). Mule deer have evolved migratory and non-migratory adaptations for survival. Migratory behavior gives mule deer access to higher quality forage on summer ranges (typically in higher elevation mountains). The advantage of seasonal access to higher quality forage typically offsets energy demand of migration, and migratory herd segments tend to be more productive. Non-migratory deer remain in the same general area year-round and select dietary components seasonally within that area. Plant selection and preference varies seasonally (Table 1). Local habitat biologists likely can provide more specific information about preferred species in your area.

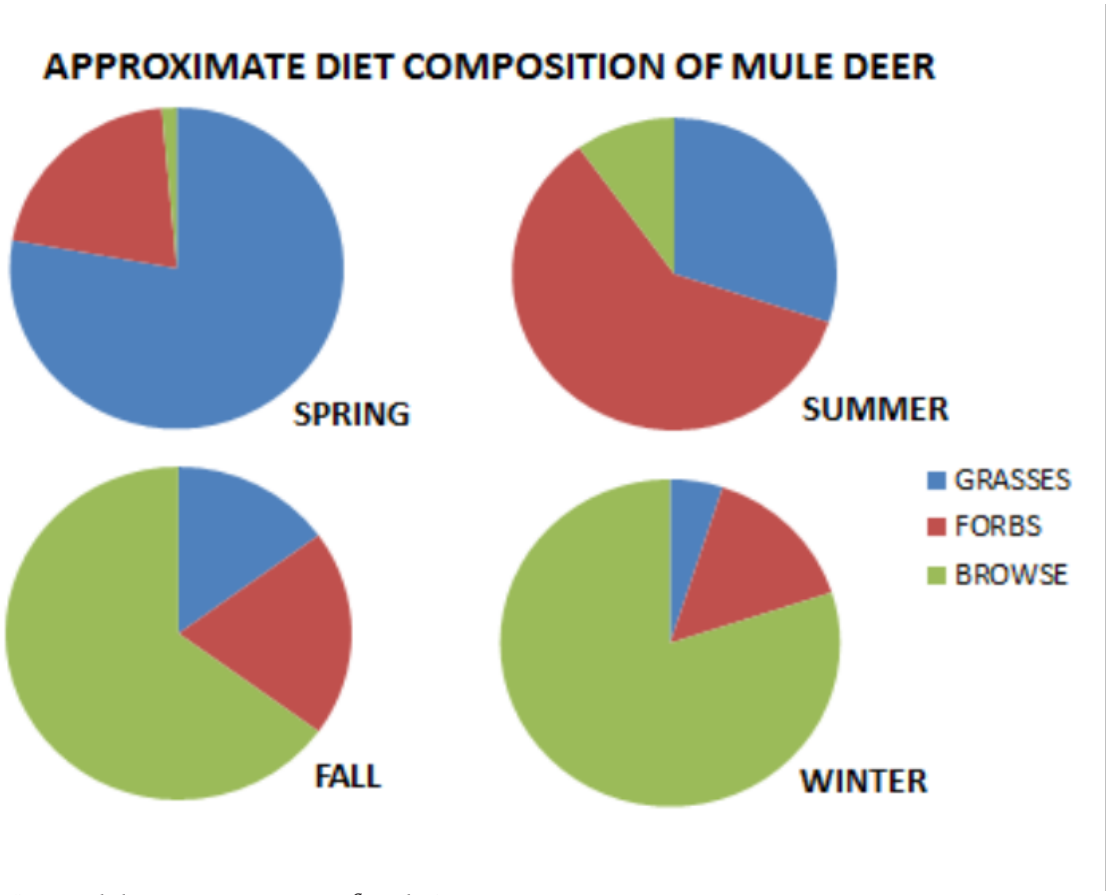

Figure 3. *Seasonal dietary composition of Mule Deer*

Preferred Forage Species Utilized by Mule Deer in Wyoming			
Spring	**Summer**	**Fall**	**Winter**
Bluegrass spp.	Sticky geranium	Aspen	Aspen
Native wheatgrass	Balsamroot	Elderberry	Big sagebrush
Indian ricegrass	Sunflower spp.	Huckleberry	Antelope bitterbrush
Prairie junegrass	Valerian spp.	Chokecherry	True mountain mahogany
Upland sedge	Clover spp.	Serviceberry	Curl-leaf mountain mahogany
Agoseris spp	Fireweed	Gamble oak	Fringed sagebrush
Aster-like forbs	Strawberry	Skunkbush sumac	Buckwheat
Phlox spp.	Vetch spp.	Antelope bitterbrush	Phlox spp.
Biscuitroot	Yarrow	True mountain mahogany	Skunkbush sumac
Clover spp.	Goldenrod	Curleaf mountain mahogany	Winterfat
Penstemon	Bladderpod	Winterfat	Gambles oak
Buckwheat	Cinquefoil	Cottonwood	Rose
Buttercup spp.	Lupine	Willow	Serviceberry
Fescue spp.	Carex spp.		
Needle and thread	Bluegrass spp.		
Native brome	Sagebrush		
	*Sweet clover		
	*Alfalfa		
	*Sanfoin		
	*Small burnet		
	*Cicer milkvetch		
	*Birdsfoot trefoil		
Other Forage Species Utilized by Mule Deer in Wyoming			
Spring	**Summer**	**Fall**	**Winter**
Blue and Sideoats grama	Biscuitroot	Rose	Black sagebrush
Globemallow	Agoseris spp.	Snowberry	Early sagebrush
Balsamroot	Hawksbeard	Kinnikinnick	Silver sagebrush
Cryptantha spp.	Groundsel	Buffaloberry	Silverberry
Wyoming big sagebrush	Aster-like forbs	Bur oak	Chokecherry
Winterfat	Columbine	Wyoming big sagebrush	Gardner's saltbush
Rabbitbrush (var. lanceolatus)	Primrose	Rabbitbrush (var. lanceolatus)	Four-wing saltbush
Timothy	Penstemon	Rocky Mountain maple	Rabbitbrush (var. lanceolatus)
Bentgrass	Prairie coneflower	Cinquefoil	Greasewood
Spike tristetum	Mountain sorrel	Wild Plum	Snowberry
Alkali grass	Paintbrush	Oregon Grape	Ceanothus spp.
Prairie sandreed	Wild carrot	Currant	Willow
Onion grass	Sweet cicely	Silver Sage	Horsebrush
Tufted hairgrass	Wild onion	Hawthorn	Cottonwood
Green needlegrass	Violet	Red osier dogwood	Red osier dogwood
*Orchardgrass	Parsnip spp.		Birdsfoot sagebrush
*Sweet clover	Dotted gayfeather		Indian ricegrass
*Alfalfa	Mertensia spp.		Blue and Sideoats grama
*Sanfoin	Elephant head		Native wheatgrass
*Small burnet	*Blue flax		Idaho fescue
*Cicer milkvetch	*Corn		Bluegrass
*Birdsfoot trefoil	*Sugar beets		Basin wildrye
*Oats	*Soybeans		Goldenweed
*Barley	*Sunflowers		*Winter wheat
*Winter wheat			
*Triticale			

Table 1. *Forage species used by mule deer in Wyoming seasonally. Additional information about each species is available on the USDA PLANTS Database found at http://plants.usda.gov/*

** denotes non-native/introduced species*

Spring

Nutritional quality is critically important for pregnant and lactating does during spring. Does must have access to sources of calcium, protein, and the ability to replenish rumen micro-fauna. An abundant supply and distribution of early forbs, later perennial forbs, and early basal growth of grasses are also essential for *in-vitro* fawn survival during the final two months of gestation. Habitats used by does during the last two months of gestation and early lactation (about mid-April through late June) include lower elevation winter ranges, spring transition and early summer ranges, riparian areas and pasture lands/croplands, but vary regionally. In early spring, basal leaf growth from cool season grasses, early growth of rhizomatous wheatgrasses, and low growing upland sedges are often the first new herbaceous forage available after snow melt (Figure 4). Additionally, shrubs such as big sagebrush (*Artemisia tridentata*) and early new growth of winterfat (*Krascheninnikovia lanata*) are important (Cox et al. 2009, Fox et al. 2009). Native forbs that emerge early have especially high nutritional value during this period. Agricultural lands can also provide important spring habitat and should not be overlooked, particularly during drought periods. Many non-native legumes associated with pastures and rangelands can provide high quality forage in spring.

Figure 4. *Spring meadow habitat used by does during fawning period*

Optimal spring habitat should include a mix of early, mid, and late succession vegetation communities to provide a wide variety of high quality forage, cover, and parturition habitat. These communities should be identified and prioritized as important habitats for mule deer when developing vegetation management strategies. Invasive species including cheatgrass need to be actively and aggressively controlled to prevent shortened fire intervals and competition with important browse and understory species (Clements and Young 1997, Mule Deer Working Group 2007). Treatments including prescribed fire, mechanical or chemical prescriptions, control of exotic and invasive species, prescribed or targeted livestock grazing, and range restoration designed to restore or maintain habitat types that tend to green-up early and provide high nutrition forage in the spring should be a priority (Figure 5).

Figure 5. *Mule deer doe utilizing meadow habitat during spring*

Migration corridors are an important component of habitat used by mule deer in spring and fall. The ability to migrate is essential for mule deer to travel to, and access, important seasonal habitats. Migrations occur as animals travel between winter and summer ranges. Migration allows mule deer to avoid deep snow and other harsh conditions during winter and take advantage of high quality forage during summer. Migrating mule deer may spend 2–4 months migrating and most of that time is spent in distinct "stopover" areas where mule deer follow the vegetation "green-up" and maximize use of nutritious vegetation (Sawyer 2009b). The importance of these "stopover" sites in both spring and fall cannot be overstated. Vegetation conditions at these sites should be assessed and, when appropriate, prescriptions developed to enhance them.

Summer/Fall

Figure 6. *Good quality summer range with tall forbs in close juxtaposition to conifers, which serve as cover*

Figure 7. *High elevation summer range with tall forbs and a mix of aspen and conifers*

During summer, mule deer diets shift to high carbohydrate sources of forage to build up fat reserves for winter. Overwinter survival, pregnancy and birth rates, and survival of fawns the following spring are significantly affected by the quality of forage available the prior summer (Bishop et al. 2005, Tollefson et al. 2010, Monteith et al. 2013a). To meet their dietary needs, deer expend greater time browsing in mesic sites including riparian areas, ephemeral drainages, irrigated and sub-irrigated meadows, aspen, mixed mountain shrubs, tall forbs, and upland mountain meadows (Figure 6). Mesic habitats are extremely important, especially in drier regions, therefore protection and management of these habitats should be a priority. Competition with other wild and domestic ungulates including elk, white-tailed deer, cattle, and domestic sheep is also a management concern (Collins and Urness 1983, Johnson et al. 2000, Beck and Peek 2005). Management practices should emphasize maintaining and increasing understory vegetation, especially the quantity and quality of forbs (Figure 7) (Pederson and Harper 1978, Collins and Urness 1983, Olson 1992, Beck and Peek 2005). Mule deer require an abundant supply and distri-

Figure 8. *Forbs are the primary forage for mule deer in summer months*

bution of forbs and fine stemmed grasses on all summer ranges including the lower elevation meadows and pasture lands to higher elevation aspen parklands, mountain meadows (Figure 8) and riparian areas. Use of aspen and shrub species increases during late summer and into the fall period (Olson 1992).

Agricultural crops (e.g. alfalfa, winter wheat and others) provide high quality forage and are also used throughout these periods, where available. Body condition at the end of fall is an important determinant of subsequent *in-vitro* fawn survival and recruitment (Julander et al. 1961, Pederson and Harper 1978, Lomas and Bender 2007, Bishop et al. 2008, Tollefson et al. 2010). Grass basal re-growth is often selected by mule deer after frost has cured forbs. At this time, mule deer also increase consumption of browse species as they migrate through transition ranges to winter habitats. In many parts of Wyoming, transition ranges are located in higher precipitation zones and support more diverse and productive plant communities as compared to winter ranges. Management practices on transition ranges should promote a diverse suite of species including shrubs (especially deciduous) and herbaceous species in a mix of seral stages. This is achieved through periodic disturbances (such as prescribed fire or mechanical/chemical treatment), control of exotic and invasive species, prescribed or targeted livestock grazing, and range restoration where needed.

Winter

Crucial winter ranges are complexes of topographic and vegetation features that enable mule deer to survive by limiting their metabolic deficit during extended periods of snow cover and cold temperatures (Figure 9). Habitat effectiveness of crucial winter range can be adversely affected by human activities and developments that increase stress on mule deer, displace them from preferred habitats, or become physical or behavioral barriers to unimpeded movements (Sawyer 2009a). Maintaining effective crucial winter ranges

Figure 9. *Winter range where mule deer primarily forage on sagebrush and other shrubs*

is a very high priority addressed through ongoing federal National Environmental Policy Act (NEPA) reviews, county zoning actions, and where opportunities allow, by retrofitting infrastructure that have become migration barriers.

Figure 10. *Winter range dominated by sagebrush, willow and cottonwood*

Browse species make up the majority of mule deer diet in winter (Figure 10). However, forbs and grasses from the prior growing season are an important source of trace elements. Browse quantity and quality is highly dependent on precipitation from April-June of the previous year (Randall 2012). Vigor of browse plants is influenced by their age and the amount of hedging (Figure 11) to which they have been subjected over time (Wasley 2004). Availability of browse during the winter months can be greatly influenced by snow depth and by competition with other ungulates such as pronghorn and elk. Mule deer undergo "controlled starvation" (they lose body mass) during the winter season. Survival of each individual is a tenuous balance between energy expenditure, conservation, and intake. In order to maximize survival rates, late summer, fall transition, and winter ranges should be managed to provide high quality forage. Older aged plants or those excessively hedged provide poor annual leader growth and therefore lower quality

Figure 11. *Severely hedged sagebrush that is providing limited quality forage*

and quantity of forage for mule deer (Wasley 2004). Leader growth is also influenced by such factors as precipitation, soil type, aspect and exposure to sunlight, and competition with other plants. Annual leaders are more digestible (less lignin) and provide significantly higher quality nutrition (i.e., crude protein) than the previous year's stem growth.

Periodic disturbance events maintain shrub stand vigor and age class diversity by setting back succession. Carefully planned treatments such as mowing, aerating or chaining can improve decadent stands in late seral stages (Figure 12). Interseeding additional browse species can also improve nutritional quality several fold for mule deer. It is vitally important to control invasive species and non-native annual grasses such as cheatgrass in conjunction with treatments to prevent unnaturally short fire intervals at lower elevations (Clements and Young 1997, Mule Deer Working Group 2007). Prescribed burning can also be an extremely useful and cost-effective tool to increase vigor and age class diversity in shrub species known to re-sprout. Often mule deer winter range overlaps identified sage-grouse core areas. Burning is discouraged within sage-grouse core areas with less than 12" of annual precipitation (WGFD 2011a).

Figure 12. *Sagebrush seedlings that emerged two years after mowing treatment intended to thin decadent sagebrush*

Areas of known weed infestations should be mapped prior to treatment. In areas with known cheatgrass prevalence, use of prescribed fire should be carefully evaluated. Methods to control weeds post-treatment (i.e. herbicide) should be implemented within the first year.

Several additional plant species (i.e., winterfat, phlox, fringed sage, black sage, and others) are an important supplement to winter diets of mule deer. In many cases deer have been noted to use wind-blown slopes or paw through snow to forage on a variety of low growing plants. Residual forage in harvested agricultural fields is also frequently used in winter months.

Important Vegetation Types – Management Recommendations

The following vegetation types are seasonally important mule deer habitat in Wyoming. Management recommendations and techniques are outlined for each. An additional section describes considerations common to all vegetation types.

1. Riparian
2. Aspen forest
3. Antelope bitterbrush
4. Mountain shrub (serviceberry, chokecherry, etc.)
5. Curl-leaf mountain mahogany
6. True mountain mahogany
7. Mesic sagebrush (mountain big sagebrush, silver sagebrush, three tip sagebrush)
8. Xeric sagebrush (Wyoming big sagebrush, black sagebrush, early sagebrush, greasewood, saltbush, rabbitbrush)
9. Juniper
10. Conifer forest (lodgepole pine, Douglas fir, Engelmann spruce-subalpine fir, ponderosa pine, limber pine, whitebark pine)
11. Recommendations applicable to all types
12. Other vegetation types: tall forb, alpine and wildlife plantings/forage seedings

Figure 13. *Riparian area with adjacent mountain shrub and aspen communities*

Figure 14. *Riparian area in excellent condition with diverse understory*

Riparian

Mule Deer Use: Riparian corridors are disproportionately important relative to their availability on the landscape. These linear habitats provide a diversity of valuable forage (grasses, forbs, and shrubs) and cover during all seasons, but perhaps most importantly during parturition (Figure 13). Riparian areas also serve as travel corridors. Highly nutritious, digestible forage accessible in riparian areas is critical to meet the nutrition demands of late term pregnancy, parturition, and fawn rearing (Figure 14).

Management Considerations: Riparian areas are commonly used by both wildlife and livestock; therefore, balancing forage utilization rates can pose management challenges (Figure 15). Light to moderate utilization rates have little effect on mule deer forage availability, but high use rates, especially in arid landscapes can remove much of the herbaceous cover that is crucial for doe nutrition and parturition cover (Smith and Doell 1968, Jensen et al. 1972). Timing, duration, and intensity of grazing are key factors to consider for maintaining healthy plant communities. Unhealthy riparian areas are characterized by plant communities with reduced species diversity, reduction in preferred species, compacted soils, decreased mulch and litter, decreased water infiltration, increased runoff, lowered water table, decreased plant vigor and production, and a drier microclimate. During drought or when forage is limited, other wildlife and livestock may more extensively utilize browse species and compete directly with deer.

Residential developments in and around riparian zones are increasing in some areas of the state. Disturbances and habitat alteration associated with rural residential developments can impact deer habitat. To maintain functioning deer habitat in and adjacent to riparian areas, conservation easements or set asides for open space in subdivision plans are tools for consideration.

Figure 15. *Example of a high use riparian area. Note lack of willow regeneration and shrub hedging*

Habitat Management Recommendations:

Recommendation 1: When the goal of grazing management is to maintain or improve cover, vigor, and diversity of vegetation within riparian areas for mule deer, changes in season of use may have beneficial impacts. Changes in grazing management should be based upon vegetation present, project goals, and the goals of the livestock operation.

Recommendation 2: Consider types and classes of livestock that are less likely to utilize plants preferred by deer. Different types of animals (sheep, cows, horses, etc.) and classes (cow/calf pairs, yearlings, bulls, etc) use riparian areas differently. Domestic sheep and goats have diets very similar to deer and compete directly for available forage. In recent years, sheep and goats have been used for biological control of invasive plants and noxious weeds in riparian areas. This type of prescribed grazing must be carefully managed to avoid impacting plant species preferred by mule deer.

Recommendation 3: Increase water availability by reducing conifer encroachment.

Recommendation 4: Work with WGFD habitat biologists to identify important riparian areas for mule deer when developing grazing management strategies designed to benefit both wildlife and livestock.

Common Techniques:

- Carefully plan livestock management based on site-specific conditions. Livestock will utilize riparian vegetation differently depending on weather, stage of plant growth, ruggedness/steepness of terrain, time of year, and plant composition and diversity. Timing of grazing and overall stocking rates are very important. Spring grazing of forbs may reduce the amount of nutrition available to mule deer. Consider alternative pastures during winter and late summer to avoid use of riparian woody vegetation. Management practices can include:

    - Fencing (temporary and permanent), compatible grazing systems, alternative watering sources, supplemental feeding, and alternative shelter sources.
    - Placing salt and mineral supplements outside of riparian zones to attain better distribution of livestock and improved forage use in uplands.
    - Improve upland forage resources through livestock management and/or vegetation treatments to redistribute livestock away from riparian areas in spring when stream banks and adjacent meadows are most vulnerable to trampling and compaction.
    - Use riders to herd cattle away from streamside areas to manage use within riparian areas. Experienced riders who understand cattle behavior as well as the vegetation management goals are needed for this approach to be effective. The presence of alternative water sources and strategic placement of supplements will result in even greater benefits when used in combination with riding.

- Create smaller pasture units to improve management of livestock distribution and forage use. This enables livestock to be moved more frequently when pre-determined utilization rates and streambank alteration thresholds are reached. Grazing duration within riparian areas can be more closely controlled with temporary electric fencing to assist with regeneration of key riparian woody species. Because higher stocking densities are often associated with short duration grazing schemes, it becomes especially important to carefully monitor herbaceous use, browsing levels, and stream bank conditions. Tools such as water gaps and riparian pastures provide additional options to regulate livestock distribution and use.

- Monitor use levels on herbaceous and woody species by accepted quantitative and/or qualitative methods.

- In Wyoming, a majority of riparian habitats are on private land and healthy riparian systems are congruent with profitable and sustainable livestock operations. Maintaining those habitats and operations will ensure open spaces and these important mule deer habitats are protected. In addition, conservation easements are valuable to maintain important riparian habitats as open space.

- Restore or enhance riparian corridors devoid of woody cover by planting desirable shrub and tree species such as willow, cottonwood or other suitable endemic shrubs. Protect new plantings from browsing until well established. In the long-term, incorporation of proper grazing management strategies will ensure restoration success.

- Introduction of beavers can be an effective riparian restoration or enhancement technique where compatible with other surface uses. Beaver ponds accumulate sediments, broaden the floodplain, lower the stream gradient, and raise the water table, all of which promote development of a healthy riparian system.

- Control, or eradicate if possible, noxious or invasive species when present, by chemical, biological and/or mechanical methods. Reduce possible impacts to non-target vegetation by spot spraying herbicides.

Aspen Forest

Figure 16. *High quality forage and cover provided by aspen regeneration post wildfire*

Mule Deer Use: Aspen stands often contain a rich diversity of forbs, grasses, and shrubs that provide important forage and cover used by mule deer, especially during summer months. Aspen is also important parturition and fawn rearing habitat (Mackie et al. 1998). Kufeld et al. (1973) identified aspen as the fourth most important food item for mule deer (Figure 16). The understory is frequently dominated by forbs that provide critical forage for pregnant and lactating does (Figure 17).

Management Considerations: Conifer and sagebrush encroachment threatens aspen persistence in many areas throughout Wyoming and the Intermountain West (Figure 18). Aspen are unable to regenerate under a dense evergreen canopy and conifers also compete for available water. Environmental factors contributing to aspen decline include over 100 years of fire suppression and excessive browsing by wild (e.g., elk) and domestic ungulates. New growth on burns or clearcuts is especially palatable. However with excessive use, desirable forbs in the aspen understory can be converted to less palatable species such as coneflower (*Rudbeckia occidentalis*) and mule's ear (*Wyethia amplexicaulis*). In addition to forbs and grasses, aspen understories often include a variety of highly palatable mixed mountain shrubs. Consult the Western Aspen Alliance website (http://western-aspen-alliance.org/) for additional literature and information about aspen management.

Figure 17. *Aspen with diverse productive understory including young aspen plants and many forb and grass species*

Figure 18. *Conifer encroachment in aspen*

Habitat Management Recommendations:

Recommendation 1: Maintain aspen communities as multi-aged stands with roughly 20% young (less than 20 years old), 60% middle (20-60 years old) and 20% older (over 60 years old) age class stands on a landscape scale.

Recommendation 2: Maintain browse levels at less than 30% of terminal leader length on trees less than 10 feet tall (Burton 2004, Rogers and Mittanck 2013).

Recommendation 3: Increase water availability by reducing conifer encroachment.

Recommendation 4: Complete aspen community assessments to prioritize management actions on a watershed scale.

- Prioritize areas for treatment based on the key developed by Campbell and Bartos 2001 (Table 2) to sustain aspen on the landscape.

Key to the risk factors used to prioritize areas with aspen for restoration and conservation actions in the Intermountain West. Assumption: Aspen are present with a density of at least 20 mature trees per acre. Note: Couplet 1 refers to relative cover; couplets 2 to 5 use absolute cover. (Campbell and Bartos, 2001)	
1. a. Conifer species comprise at least half of the canopy cover.	Highest priority
b. Aspen comprises more than half of the total canopy cover.	Go To #2
2. a. Aspen canopy cover is less than 40%; and sagebrush, usually a dominant understory species, exceeds 15% cover.	High priority
b. Not as above.	Go To #3
3. a. Conifer cover (including overstory and understory) exceeds 25%.	Moderate to high priority
b. Conifer cover is less than 25%.	Go To #4
4. a. Aspen regeneration (5 to 15 feet tall) is less than 500 stems per acre.	Moderate priority
b. Aspen regeneration exceeds 500 stems per acre.	Go To #5
5. a. Any two of the following three risk factors are represented: 1—Aspen canopy cover is less than 40%. 2—Dominant aspen trees are greater than 100 years old. 3—Sagebrush cover exceeds 10%.	Low to moderate priority
b. Two of the three risk factors in 5a are not represented.	Go To #6
6. a. One of the three risk factors in 5a is represented.	Low priority
b. None of the risk factors above are represented.	Candidate for properly functioning condition

Table 2. *Key to risk factors used to prioritize aspen areas for management actions*

- Use aerial photography and ground truthing to classify community types (Mueggler 1988) and current age structure within watersheds or project areas. Tree coring can be used to determine ages of live trees. Historic fire frequencies can be identified from fire scars on Douglas fir (*Pseudotsuga menziesii)* or other conifers.

Common Techniques:

- Prescribed fire (Figure 19). Spring or fall prescriptions are preferred to optimize aspen and herbaceous species regeneration. In aspen stands with conifer encroachment, conifer slashing two years pre-treatment will provide fuel to expand the burn window and help to maintain burn control lines.

- Mechanical thinning of live aspen. Removing 30% or more of the canopy/mature trees will stimulate root suckering.

Figure 19. *Prescribed burning to reduce conifer encroachment and increase aspen stand vigor*

- When consistent with management plan objectives, allow naturally ignited fires to burn through late seral aspen communities (opposed to full suppression) to encourage suckering after the disturbance (Figure 20).

Figure 20. *Aspen regeneration one year after the Fontenelle wildfire in western Wyoming*

- Rip through root systems with mechanical equipment (8-10 inches deep, 8-10 yards from parent trees) to stimulate suckering (Shepherd et al. 2006).

- Remove and/or thin conifers through mechanical means (e.g. mulching, cutting) to reduce competition.

- In all treatments it is very important to protect aspen stands from excessive browsing. Temporary exclusion of wildlife and livestock can allow suckers to grow above the browse zone (10 feet) and successfully establish a new age cohort. Jack-strawing, hinging or leaving logging slash in place can deter browsers from the area and protect young stems. A conifer fence (at least 10 ft high) constructed with cut trees is also an effective means to exclude wildlife and livestock.

- Browse rates and species composition can be estimated using the following monitoring techniques: Variable Radius Aspen Circle (Kilpatrick et al. 2003); and Live Dead Index (Keigley et al. 2002).

- Conduct treatments on a larger scale to disperse browsing pressure. Avoid treatments in areas where wildlife or livestock congregate (i.e. near feedgrounds, watering facilities, winter concentration areas, etc.) unless management strategies are in place to ensure suckers can grow above the browse zone.

- Postburn (either by prescription or wildfire) aspen stands should typically be rested or deferred from grazing for two growing seasons to achieve desired conditions by protecting young suckers from browsing and encouraging reestablishment of ground cover. Local variability will dictate longer or shorter deferments.

- Avoid treating stands, or exercise extreme caution, when invasive species are present (Cox et al. 2009). If invasive species are present, consider treatments to control them prior to other treatments to enhance aspen. Maintain an appropriate species composition post-treatment.

Antelope Bitterbrush

Figure 21. *Antelope bitterbrush and mountain big sagebrush community*

Mule Deer Use: Antelope bitterbrush grows predominantly on well-drained sites up to 9,000 ft elevation in Wyoming, and is often found in mixed stands of mountain big sagebrush (*Artemisia tridentata* var. *pauciflora* or var. *vaseyana*) (Figure 21). Mule deer forage on bitterbrush year-round in Wyoming. The parts consumed by mule deer provide between 8% and 14% crude protein depending on the season (Clements and Young 2007). Bitterbrush is particularly attractive browse in spring and fall. This shrub species is frequently a minor component of the landscape and highly selected by mule deer. As a result, it is often heavily hedged, which is problematic because bitterbrush plants require second-year leaders to produce flowers. Consequently, bitterbrush communities often lack recruitment of young plants, and many are becoming old and less productive.

Management Considerations: Restoration efforts have included harvesting bitterbrush seed to grow 2-year old nursery stock for planting. However, cost is high and young plants are especially susceptible to overbrowsing. Prescribed fire varies in effectiveness as a tool to restore or enhance bitterbrush, and the outcome is influenced by genetics, physiological status, fire intensity, and soil moisture after the fire. Prescribed fire impacts (positive and negative) to bitterbrush in Wyoming depend greatly on the intensity of the fire and the amount of time that elapses until a moisture event occurs on the burn location. Excessive herbivory in July and August can greatly diminish seed production and increase seedling mortality. This can perpetuate even-aged, decadent bitterbrush communities (Clements and Young 2001).

Habitat Management Recommendations:

Recommendation 1: Assess antelope bitterbrush community vigor and age structure at a landscape scale based on known areas of seasonal mule deer use. Note flowering plants and seedling establishment or lack of recruitment. Identify percent of the community exhibiting decadent plant characteristics (plants generally >60 years old). The overall assessment should be considered when identifying treatment prescriptions and timelines. The goal of treatments is to restore and sustain a diverse age and size class structure.

Recommendation 2: Only treat stands with >40% of plants in decadent condition (generally >60 years old).

Recommendation 3: Maintain browse levels at <35% of current annual leader growth (A. H. Winward, retired, U.S. Forest Service, personal communication).

Common Techniques:

- Herbicide (tebuthiuron or Spike®) application to thin or remove sagebrush. Application should be at a "thinning" rate based on site-specific soil samples, to give bitterbrush present on the site a competitive advantage. Tebuthiuron applications are typically done in the fall, prior to persistent snow cover. Full activation of the herbicide is not typically seen until year(s) 2-3 following treatment. Changes in livestock grazing in years 2 and 3, to avoid growing season use, may lead to successful establishment of perennial grass and forb cover. This corresponds to sagebrush mortality and the subsequent release of moisture and available nutrients.

- Prescribed burning in early spring or very late fall.

- Restoration. Reseed bitterbrush the first fall after a wildfire or prescribed burn, using recently collected seed. Plant seeds at 1-2 inch depth and in microsites or patches with enhanced moisture, and/or in sites with reduced competition from other plants.

- Mechanical treatments. Treat 30-70% of the shrub community in a mosaic pattern, based on site objectives and pre-treatment conditions. Potential treatments include but are not limited to: mowing/roto beating, aerating (Lawson aerator), chaining, ripping, and harrowing (Dixie harrow). When mowing, the mower deck can be set above low-growing shrubs to selectively remove a portion of the canopy, to lessen competition but maintain a seed source for seedling establishment. The increased litter accumulation associated with mechanical treatments aid with moisture retention and seedling establishment.

Mountain Shrub

Mule Deer Use: Mountain shrubs include serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), elderberry (*Sambucus spp.*), gooseberries/currents (*Ribes spp.*) and snowberry (*Symphoricarpos spp.*) among others. Antelope bitterbrush and mahogany (*Cercocarpos* spp.) are also considered mountain shrubs, but are discussed individually due to their individual importance to mule deer and occurrence across much of Wyoming. Mixed mountain shrub communities can be found in all mule deer seasonal ranges. Where these species occur on winter range, browsing use levels are typically very high. However, vegetation treatments targeting mountain shrubs are most beneficial where these species grow on transition or summer ranges. Mountain shrub species are often a minor component of the landscape (Figure 22), but are highly selected for their forage and nutritional value.

Figure 22. *Mixed mountain shrubs frequently occur in small patches on the landscape*

Management Consideration: In many locations, extreme browsing has prevented seedling establishment and recruitment, resulting in monotypic stands of old and decadent shrubs. Many mountain shrubs are in the Rosaceae (rose) family and require two-year old leaders to produce viable seed. Often, 5-10 years may lapse between environmental conditions that are conducive for successful seed germination. Many of these species will resprout after disturbances. Mountain shrubs grow on mountain slopes, hillsides and in riparian zones dependent on local moisture regimes and soils. Most species in this category require 14 inches of annual precipitation. After forbs and grasses have cured, mountain shrubs become a very important source of forage for mule deer.

In appropriate locations, condition of serviceberry and other shrubs can be improved by prescribed fire, which reduces shrub height and promotes growth of new twigs with higher nutritional content. Prescribed burning may harm serviceberry in harsh (especially very dry) locations where serviceberry occurs at low densities, and in very cold sites where growth post-treatment would be limited by temperature. After burning, new growth has higher crude protein and lower crude fiber compared to unburned plants (Asherin 1973). Annual stem growth (biomass) is also greater on recently burned plants in the absence of heavy browse pressure (Cook et al. 1994). In forested habitat types, serviceberry is actually fire-dependent, and declines where fire exclusion results in canopy closure (Gruell 1983).

The nutritional value of chokecherry is relatively high with 38.8% dry matter digestibility and 8.7% crude protein content (Davis and Welch 1985). Crude protein levels do not appreciably decline as winter progresses. Fire often kills above ground stems and foliage, but plants quickly resprout. After burning, chokecherry plant biomass will increase for at least 5 years, while the density of stems can increase for up to 13 years before stabilizing (Eichhorn and Watts 1984).

Habitat Management Recommendations:

Recommendation 1: Manage herbivory to not exceed 40% of annual leader growth; use above these levels can be detrimental to the vigor and survival of mountain shrub plants.

Recommendation 2: Enhance or maintain age class diversity by implementing management techniques to establish early seral plant communities on the landscape.

Recommendation 3: Consider mechanical treatments or spring burns to stimulate growth of young plants when mountain shrubs have matured into tree-like growth forms or become decadent.

Common Techniques:

- Prescribed burning should be conducted in spring or fall with optimal soil moisture and followed by a period of rest or deferment from grazing until desired vegetative objectives are achieved. Swift moving head fires with low resonance time and low fire intensity are often prescribed to reduce mortality rates.

- Herbicide (tebuthiuron or Spike®) application to thin sagebrush. Application should be at a "thinning" rate based on site-specific soil samples to give non-sagebrush shrubs (i.e., mountain shrubs, bitterbrush) a competitive advantage. Spike® applications are typically done in the fall, prior to persistent snow cover. Full activation of the herbicide is not typically seen until year(s) 2-3 following treatment. Changes in livestock grazing in years 2 and 3, to avoid growing season use, may lead to increased establishment of perennial grass/forb cover. This corresponds to sagebrush mortality and the subsequent release of moisture and available nutrients. Fencing may be necessary to control browsing pressure until young plants become established.

- Mechanical treatments. Treat 30-70 percent of the shrub community in a mosaic pattern, based on site objectives and pre-treatment conditions. Potential treatments include but are not limited to: mowing/roto beating, aerating (Lawson aerator), chaining, ripping, and harrowing (Dixie harrow). Seeding may or may not be incorporated dependent on site specific objectives and whether an adequate seed source is available onsite. Increasing litter will aid with moisture retention and seedling establishment.

- Patch size needs to be considered to assess likelihood of excessive browsing pressure post-treatment and determine how many acres should be treated at any one time to maintain sufficient alternative sources of preferred forage on the landscape.

- Bare root stock can be planted in appropriate sites to increase species diversity after burning.

Curl-leaf Mountain Mahogany

Mule Deer Use: Curl-leaf mountain mahogany *(Cercocarpus ledifolius)* is an evergreen shrub or small tree that occurs in stands ranging from one to several hundred acres in size. It grows in scattered patches and extensive pure stands occur on dry, rocky, slopes between desert steppe and lower conifer communities. Curl-leaf mountain mahogany is highly palatable and nutritious for mule deer and other wildlife, especially during the winter months. Domestic livestock also occasionally use it.

Management Considerations: Curl-leaf mountain mahogany can reach >1,300 years of age (Schultz et al. 1990). Plants are capable of fixing nitrogen, which can improve soils and benefit other plant species. After plants have reached several years of age, they become browse tolerant and can persist on the landscape in spite of significant browsing pressure. However, browse levels are often too high to allow for establishment of new plants (Figure 23 and Figure 24). Seedlings emerge and establish best in shallow litter depths and within open canopies. While seedlings will emerge successfully in deep litter substrates, establishment is rare. Site characteristics that are conducive to seedling emergence are often less conducive to establishment and maturation of plants.

Figure 23. *Curl leaf mountain mahogany with excessive hedging and little regeneration of young plants*

Figure 24. *Curl leaf mountain mahogany with excessive hedging*

Stands with a closed or nearly closed canopy are often devoid of young plants in the understory despite a high seed density (Schultz et al. 1990). Curl-leaf mountain mahogany is often difficult to burn due to insufficient fuel in the understory. When conditions are favorable, burning can be an effective means to remove all live plants from the stand. Some researchers have suggested fire may in-

crease regeneration in decadent or late seral stands, whereas overall stand productivity will decrease with continued protection from disturbance. Resprouting is extremely rare. Prescribed fire treatments should not be conducted to increase regeneration via resprouting as it can take several decades for plants to become reestablished after burning.

Habitat Management Recommendations:

Recommendation 1: Promote seedling establishment and recruitment by thinning stands to create gaps in the canopy. Aerial fire ignition just prior to a late-fall snow event is an effective method for creating a mosaic of openings favorable for seedling establishment. A mosaic of treatment and habitat types is preferred in order to provide optimal foraging, hiding and thermal resources.

Recommendation 2: Plan large treatment areas and distribute them to disperse browsing pressure. It is important to maintain other shrub species within or close to treated sites to protect mahogany seedlings (Cox et al. 2009).

Recommendation 3: Remove conifers and consider site preparation to increase exposure of mineral soils favorable to mahogany seedling germination and growth.

Recommendation 4: Plant seedlings to restore mahogany when entire stands are killed by wildfire and there is little or no seed source.

Recommendation 5: Curl-leaf mountain mahogany plants less than 60 inches tall tolerate utilization rates of up to 50-60% (Garrison 1953).

Common Techniques:

- Prescribed burning during fall can be effective in some instances in areas with relatively higher effective precipitation. Pre-treatment slashing may be necessary to provide a fuel base to achieve needed fire behavior. Adjustments in post-treatment grazing should be considered to allow desired vegetation re-growth and recovery.
- Trees can be selectively removed with chainsaws. Larger stand thinning efforts can be accomplished with heavy equipment such as bulldozers.
- Aerial seeding may be successful depending on understory composition and availability of bare mineral soil.

True Mountain Mahogany

Mule Deer Use: Where it is available, mule deer use true mountain mahogany (*Cercocarpus montanus*) as an important source of forage, concealment, and thermal cover year round, but particularly during fall and winter. True mountain mahogany is a minor component of the landscape in western Wyoming, but is abundant in southeast Wyoming (Figure 25) and portions of the Black Hills. The species grows on mountain slopes and hillsides in shallow calcareous soils. True mountain mahogany readily re-sprouts and regenerates following disturbances, including fire or mechanical treatments.

Figure 25. *True mountain mahogany community on Iron Mountain in SEWyoming*

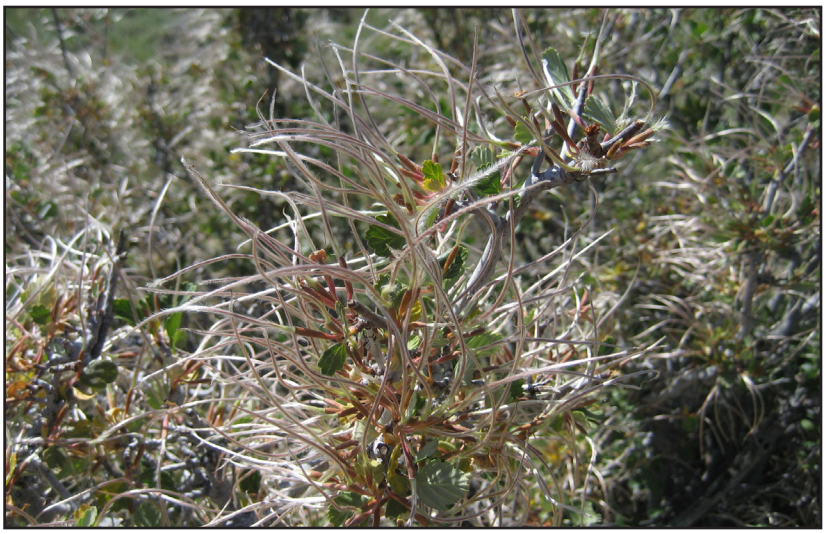

Figure 26. *True mountain mahogany in decadent condition but with good seed production due to recent precipitation*

Management Considerations: Fire suppression and hedging by historically high populations of wild ungulates have inhibited seedling recruitment, resulting in low age class diversity within most stands in Wyoming. True mountain mahogany is a member of the Rosaceae (rose) family, which requires two-year old leaders to produce seed (Figure 26). It is drought tolerant, but when highly stressed may respond by not producing seed for many years (up to 10), which can further limit age class diversity and seedling recruitment. True mountain mahogany is a long-lived species capable of fixing nitrogen in its root nodules, which suggests it fulfills a significant role in maintaining soil fertility.

New growth following treatments contains higher crude protein, is typically more digestible, and more productive. Mule deer will actively select resprouting mahogany (Figure 27) and consume it in greater amounts throughout the year. Older, decadent plants (Figure 28) typically have lower crude protein content, are less digestible, and may contain elevated levels of secondary compounds that interfere with protein digestion.

Figure 27. *Vigorous shrub with good leader growth*

Nutrient levels in treated stands remain elevated up to 5 years, but decline rapidly afterward. Production can remain elevated for 10 years or more in treated shrub stands. Due to high water content and low volatile oil levels, true mountain mahogany plants are often not fully consumed in prescribed fires. Remnant skeletons protect resprouting leaders from excessive browsing (Figure 29). The skeletons also trap and accumulate snow, which provides an additional moisture source that assists regeneration. Fire is not the only treatment alternative. Mechanical treatments such as mowing can produce similar results, though considerably more expensive. Any disturbance that removes the above-ground biomass and leaves the root crown intact can provide desirable results.

Figure 28. *Decadent shrub with poor annual leader growth*

Figure 29. *True Mountain mahogany resprouting from root crown*

Habitat Management Recommendations:

Recommendation 1: Manage herbivory to not exceed 40% of annual leader growth; this level of browsing can be detrimental to the vigor and survival of true mountain mahogany plants (A. H. Winward, retired, U.S. Forest Service, personal communication).

Recommendation 2: Maintain or enhance age class diversity by implementing management techniques that encourage establishment of early seral plants on the landscape.

Common Techniques:

- Prescribed burning in spring or fall can be effective if followed by grazing rest or deferment until vegetative objectives are achieved (typically 2 growing seasons). Properly timed and executed burns result in low shrub mortality rates. Spring burns seem to create a more favorable response in the herbaceous understory.

- If noxious weeds or cheatgrass are present, reduction or eradication by chemical or biological methods should be a priority. If shrub treatments cannot be avoided where cheatgrass is present, follow-up herbicide treatments should be completed within the first year. The treatment plan should include pre-treatment mapping of infested areas.

- An experimental herbicide treatment has been used to produce results that mimic burning. The herbicide mix consists of nine ounces/acre of Plateau® herbicide, 32 ounces of methylated seed oil and 7 gallons of water/acre applied in August or early September. (Please note that this technique is considered experimental and should not be considered routine, however, preliminary results are promising). This treatment is far less expensive than prescribed fire when cheatgrass is present, as both the shrub and invasive weed components are handled by one treatment. An additional benefit is that resprouting mahogany leaders are often semi-protected from herbivory by the residual skeletons of the deceased plants.

Mesic Sagebrush Communities

Figure 30. *Mountain sagebrush community with diverse understory of forbs and grasses*

Figure 31. *Sagebrush, snowberry and a dense understory serve as cover for this mule deer fawn*

Mule Deer Use: In Wyoming, mesic sagebrush communities (annual precipitation greater than 12"), generally grow in the upper elevations of big sagebrush distribution (Figure 30). Mountain big sagebrush dominates in most locations. Associated species often include silver sagebrush (*Artemisia cana*), threetip sagebrush (*Artemisia tripartita*), spiked sagebrush (*Artemisia tridentata* ssp. *spiciformis*), bitterbrush, currant, and snowberry. Deer use mesic sagebrush predominantly during spring, summer, and fall. Higher elevation, colder temperatures, and deeper snow cover make these locations less suitable as winter range. However, the diversity of shrub and herbaceous species present, forage quality and production are characteristically higher in mesic sagebrush sites which deer use as spring/fall transition range, parturition habitat (Figure 31) and summer range.

Management Considerations: Based on Ecological Site Descriptions (ESDs) (USDA-NRCS 2013) of Historic Climax Plant Community (HCPCs), at least 6 grass and 35 forb species should be present in the understory of a functional mountain big sagebrush community. It is important to consider the site potential outlined in the ESD before planning and implementing management actions. A sagebrush canopy cover of 15% or greater may reduce herbaceous production due to resource competition. When a site becomes dominated by dead or decadent plants, the herbaceous component can be released by managed disturbances. Typically, mountain big sagebrush stands respond more rapidly than xeric sites following disturbance. Atypical of other sagebrush species, silver sagebrush and spiked sagebrush resprout after disturbance. Therefore treatments can be more effective and produce results sooner in mesic locations dominated by these species. Sites with a claypan high in the soil profile are typically not suitable for treatment. Habitat requirements of other species should be considered when designing management actions in all sagebrush habitats; including mesic sites (see Sage-Grouse Core Area section).

Habitat Management Recommendations:

Recommendation 1: Maintain sagebrush-dominated plant communities on at least 70% of the sagebrush community, emphasizing mid- to late seral stages and a diversity of age classes.

Recommendation 2: Maintain or improve sagebrush vigor (annual growth and seed production) consistent with the ecological site potential.

Recommendation 3: Increase composition of preferred forage species such as bitterbrush, shrubs and forbs.

Figure 32. *Result of prescribed burn that maintained a mosaic of seral stages on the landscape*

Common Techniques:

- Prescribed burning in spring or fall can be effective if followed by grazing rest or deferment until vegetative objectives are achieved (typically 2 growing seasons). Spring burns on silver sagebrush (resprouting) sites will increase plant coverage, rejuvenate plants, and enhance understory vegetation, whereas fall burns give herbaceous species a competitive advantage. Burn in mosaic patterns to promote diversity and retain nearby seed stock for recolonization (Fig. 32). After a fire, threetip sagebrush can become dominant in mixed stands due to vigorous regeneration; however, a hot fall burn can reduce threetip sagebrush and increase the herbaceous component.

- Mechanical treatments. Treat 30-70 percent of the shrub community in a mosaic pattern based on site objectives and pre-treatment conditions (Fig. 33). The percent treated can be higher on landscapes dominated by sagebrush, but should be lower on landscapes where sagebrush is a small component within other communities. Potential treatments include but are not limited to: mowing/roto beating, aerating (Lawson aerator), chaining, ripping, and harrowing (Dixie

harrow). Seeding may or may not be incorporated dependent on site-specific objectives and whether an adequate seed source is available onsite. Increasing litter will aid with moisture retention and seedling establishment.

Figure 33. *Herbaceous cover improvement two years following Lawson aerator treatment; mountain big sagebrush site. Left side was treated, right side untreated.*

- Herbicide (tebuthiuron or Spike®) application to thin sagebrush. Application should be at a "thinning" rate based on site-specific soil samples to give non-sagebrush shrubs (e.g. bitterbrush) a competitive advantage. Spike® applications are typically done in the fall, prior to persistent snow cover. Full activation of the herbicide is not typically seen until year(s) 2-3 following treatment. Changes in grazing in years 2 and 3, to avoid growing season use, may lead to successful establishment of perennial grass and forb cover. This corresponds to sagebrush mortality and the subsequent release of moisture and available nutrients.

- When consistent with management plan objectives, allow naturally ignited fires to burn to promote younger age classes in a mosaic across the landscape. Also, sagebrush should be managed for spatial heterogeneity so fires are more likely to burn in a patchy pattern and retain seed sources for post-burn re-growth.

Xeric Sagebrush/Salt Desert Shrub

Mule Deer Use: In Wyoming, mule deer winter ranges are predominantly xeric sagebrush systems comprised of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), black sagebrush (*A. nova*), early sagebrush (*A. longiloba*), greasewood (*Sarcobatus vermiculatus)*, saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp., *Ericameria* spp.), and others. In general, these communities grow on well-drained soils with less than 12 inches of annual precipitation, derived mostly from snowfall. Many winter ranges are heavily dominated by Wyoming big sagebrush. These areas are used primarily for foraging once snow depth pushes deer off summer ranges at higher elevations. Salt desert shrub communities occur where soils are more saline (Figure 34 and Figure 35). These areas are frequently dominated by saltbush, winterfat, and greasewood. During winter, mule deer utilize Gardner's saltbush (*Atriplex gardneri*) and winterfat extensively where available.

Figure 34. *Saltbush community with herbaceous production*

Figure 35. *Gardners Saltbush*

Management Considerations: Throughout much of Wyoming, mule deer winter ranges are dominated by older age class shrubs that are hedged excessively and lack recruitment of young plants. Many of these communities also lack a productive understory of native forbs and grasses. Other wildlife (i.e., elk and pronghorn) and livestock (i.e., cattle, sheep, and horses) compete for available forage. Conversion of xeric sagebrush communities to annual grass (cheatgrass) has become a significant problem in many parts of the West, and is increasing in Wyoming.

Greasewood is often associated with saltbushes, rubber rabbitbrush (*Ericameria nauseosa*), budsage (*Artemisia spinescens*) and big sagebrush. However, greasewood can increase and become dominant when particularly saline sites are exposed to excessive disturbance. Greasewood accumulates salt in its leaves and creates a salt-enriched microenvironment under its canopy due to leaching of salt from shed leaves. Since greasewood will re-sprout after disturbance, it is advised to avoid treating greasewood sites in order to avoid expansion of greasewood-dominated communities.

Based on ESDs (USDA-NRCS 2013) of HCPCs, at least 4 grass and 11 forb species should be present in the understory of a functional Wyoming big sagebrush community. It is important to consider the

site potential outlined in the ESD before planning and implementing management actions. A sagebrush canopy of 15% or greater will reduce herbaceous production due to resource competition and is a candidate for treatment. Sites with thin topsoil or a clay layer near the surface (early sagebrush, black sagebrush sites), are not recommended for treatment with fire or mechanical forms of disturbance due to slow recovery potential. Habitat requirements of other species should be considered when designing management actions in all sagebrush habitats (see Sage-Grouse Core Area section).

Habitat Management Recommendations:

Recommendation 1: Maintain sagebrush-dominated plant communities on at least 70% of the landscape, emphasizing mid- to late seral stages and a diversity of age classes.

Recommendation 2: Maintain or improve sagebrush vigor (annual leader growth and seed production), age class diversity and understory vegetation consistent with the ecological site potential (Figure 36 and Figure 37).

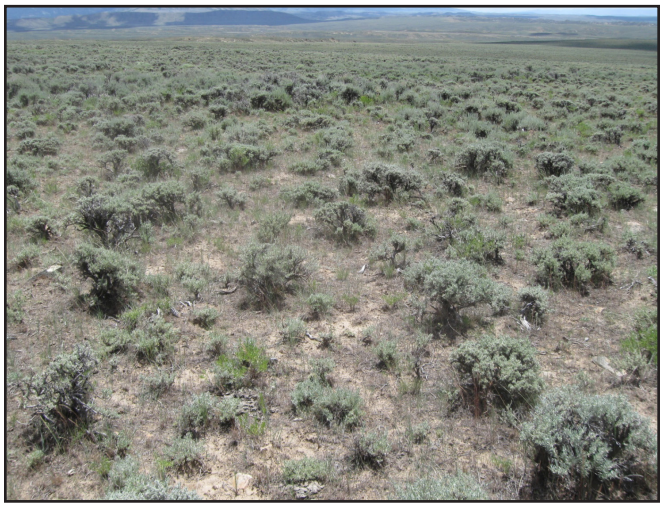

Figure 36. *Wyoming big sagebrush community with good recruitment (three distinct age glasses)*

Figure 37. *Wyoming big sagebrush community with healthy understory and minimal bare ground*

Recommendation 3: Focus treatments on areas with deeper soils or relatively higher moisture (bowls, north/east aspect) to achieve more favorable vegetation response in a relatively shorter time period.

Recommendation 4: Maintain browse levels at less than 35% of annual leader growth on sagebrush species (A. H. Winward, retired, U.S. Forest Service, personal communication).

Recommendation 5: In areas where disturbing sagebrush is not recommended, focus management on removal of invasive and undesirable species.

Recommendation 6: On sites with Gardner's saltbush tailor land management practices to ensure annual growth is available for wintering mule deer.

Recommendation 7: Improve transition ranges and summer habitats to hold animals longer in the fall and reduce pressure on over-browsed winter habitats.

Common Techniques:

Mechanical treatments. Treat 10-50 percent of the shrub community in a mosaic pattern based on site objectives and pre-treatment conditions. The percent treated can be higher on landscapes dominated by sagebrush, but should be lower on landscapes where sagebrush is a small component within other communities. Potential treatments include, but are not limited to: mowing/roto beating, Lawson aerator (Figure 38), chaining, ripping, and harrowing (Dixie harrow). Seeding may or may not be incorporated dependent on site specific objectives and whether an onsite seed source is available. Increasing litter will aid with moisture retention and seedling establishment.

Figure 38. *Lawson aerator provides mechanical disturbance with the option of incorporating seed into the treatment based on-site specific objectives*

- Herbicide (tebuthiuron or Spike®) application to thin sagebrush. Application should be at a "thinning" rate based on site-specific soil samples. This method can have negative impacts to forbs in relatively low precipitation zones. Spike® applications are typically done in the fall, prior to persistent snow cover. Full activation of the herbicide is not typically seen until year(s) 2-3 following treatment. Changes in grazing in years 2 and 3, to avoid growing season use, may lead to successful establishment of perennial grass and forb cover. This corresponds to sagebrush mortality and the subsequent release of moisture and available nutrients.

- Eradicate noxious weeds or cheatgrass (if present) by chemical or biological methods – this must be a priority. Treatments in cheatgrass-infested areas should not be considered without aggressive cheatgrass control.

- Apply herbicide to reduce prickly pear cactus (*Opuntia polyacantha*) competition. The application should be done when the prickly pear cactus is either in full bloom or the flowering bud is prominent. Impacts to non-target forb/shrub communities should be considered prior to application with herbicide.

Juniper

Mule Deer Use: Mule deer use juniper (*Juniperus* spp.) habitats primarily for cover in Wyoming. The cover value of juniper varies depending on availability of alternative cover choices. For example where there is significant topographic relief including ridges, mesas, relatively steep hills, and riparian breaks, mule deer will use these topographic features for cover, reducing their need for vegetative cover. In Wyoming, juniper is found primarily on south and west facing slopes with shallow soils and on relatively flatter areas with deeper soils mixed with sagebrush or other shrub communities. Under extreme conditions, mule deer sometimes use juniper as an emergency food source, however, volatile oil content interferes with digestion and deer may starve on a diet high in juniper content.

Figure 39. *Juniper encroaching sagebrush on deeper soil. Removal would likely improve mule deer habitat*

Management Considerations: Juniper encroachment into sagebrush and grassland communities has increased in recent decades (Figure 39). Fire suppression is widely believed to be a key underlying cause of woodland expansion (Burkhardt and Tisdale 1976). Juniper propagates entirely by seed; consequently seed dispersal by mammals and birds plays an important role in juniper establishment and expansion. This results in drier, less productive sites, therefore tree removal should be a management priority. Altered soil chemistry in juniper-dominated sites can also inhibit herbaceous species that are important forage for mule deer.

Figure 40. *Juniper on steep slopes with shallow soil is not a high management priority*

Habitat Management Recommendations:

Recommendation 1: Reduction of juniper canopy is a management priority where juniper has encroached into sagebrush or mixed mountain shrub communities on deeper soils. However, juniper management is not a priority on shallow, rocky slopes (Figure 40).

Recommendation 2: Where appropriate and necessary, maintain juniper stands as security and thermal cover. Incorporate a mosaic of suitable foraging sites among juniper stands and utilize management techniques to maintain a favorable distribution of both cover and forage availability

Recommendation 3: Maximize nutritional quality of herbaceous forage and browse in the understory.

Recommendation 4: Improve hydrologic function where juniper has encroached into sagebrush and mountain shrub communities. Remove conifers to increase the amount of precipitation reaching the soil surface and to reduce moisture loss from transpiration.

Common Techniques:

- Focus management on sites with deeper soils.
- Mechanical removal. Techniques include mastication, chaining, chainsaws, dozers, feller-bunchers, mulchers, or other types of mechanical implements.
- Prescribed fire. It is often necessary to mechanically pre-treat 25-35% of juniper trees due to lack of fine fuels needed to carry a fire. Stand burning, scattering slash, and pile burning can all be successful techniques depending on conditions.
- Herbicide application. Herbicides are rarely used to directly control juniper in Wyoming. However, they can be applied to control aggressive, undesirable vegetation that may proliferate after juniper removal (e.g. knapweed or cheatgrass).
- Reseeding. Dense, monotypic stands of juniper in late succession usually lack shrubs in the understory and density of grasses and forbs may be insufficient to recolonize the site following juniper removal. If the density of deep-rooted perennial grasses is less than 2 plants per 10 square feet, plan to drill or broadcast seed appropriate species of grasses, forbs, and shrubs.

Conifer Forest

Mule Deer Use: Most conifer forests grow at higher elevations where mule deer spend much of the summer. Conifer habitats are used primarily as escape and security cover, and to a lesser extent, as foraging habitat. In eastern Wyoming, ponderosa pine (*Pinus ponderosa)* forests can also serve as year-round habitat for mule deer. Removal of forest canopy is generally beneficial for deer when a mosaic of cover patches and edge habitats is retained across the landscape.

Management Considerations: Many forests have grown into dense, even aged timber stands due to fire suppression and a decline in logging activity over recent decades. Areas heavily overstocked with mature trees often have closed canopies and far less forage value by comparison to forests with clearings and multiple-age stands. Disturbances (logging, fire, or other disturbances) can encourage growth of shrubs and early seral species that provide forage during summer and fall seasons (Figure 41 and Figure 42). Managers can employ a variety of strategies to improve mule deer habitat within forested areas. After timber removal or harvest and other understory treatments (e.g., slash removal), biomass of herbaceous vegetation increases in response to decreased competition for sunlight, soil minerals, and precipitation. Current Lynx management criteria may significantly constrain forest management alternatives intended to benefit mule deer and other species.

Figure 41. *Excellent herbaceous and shrub response following timber harvest*

Figure 42. *Excellent aspen response following timber harvest*

Habitat Management Recommendations:

Recommendation 1: Plan timber management such that large blocks of older age class stands are retained in a mosaic pattern adjacent to early seral areas.

Recommendation 2: Employ various practices (thinning, timber harvest, burns) to increase production of herbaceous forage and encourage shrub establishment in the understory.

Recommendation 3: Retain sufficient low-growing cover in various locations to provide day bed sites concealed from predators.

Recommendation 4: Manage sites to maintain appropriate species composition post-treatment.

Common Techniques:

- Remove or thin overstory conifers. Forest management strategies include ecologically-compatible clear-cut designs that open the forest canopy over sufficiently large areas to provide quality mule deer forage.
- Uneven-age stand management. Strategies include selective harvest or leaving small gaps (1-2 acres) throughout the stand.

Figure 43. *Wild hollyhock dominates a landscape two years after wildfire burned conifer-encroached aspen*

- Prescribed fire. Trees and slash remaining in the understory after logging should be burned to increase opportunity for establishment of shrubs and herbaceous species (Figure 43).
- Control of noxious and invasive weeds. Monitoring invasive species such as thistle should be a priority following any management activity. Invasive species should be eradicated.

Recommendations Applicable to All Vegetation Types

Recommendation 1: Maintain or improve native species diversity and productivity consistent with the ecological potential of the site (USDA-NRCS 2013).

Recommendation 2: Control cheatgrass. Exercise caution when conducting treatments where cheatgrass or other invasive species are present. Maintain appropriate and desired species composition post-treatment.

Recommendation 3: Develop grazing management strategies to include consideration of all seasonal ranges for mule deer. Rangelands in good or excellent condition are also typically good for mule deer (Holechek et al. 1989, Holechek et al. 1999) (Figure 44).

Figure 44. *Fence line contrast depicting results of differing grazing management*

Recommendation 4: Two growing seasons rest or deferment from grazing is recommended on most sites after disturbance to vegetation, however, the length of rest or deferment is dependent on the site and may require more or less time to recover to desired conditions. Rest or deferment is important in areas burned either by prescribed or wildfire, in order to increase ground cover and give preferred species a chance to establish.

Common Techniques:

- Ensure adequate protections are in place from herbivory in order to prevent unintentional eradication of preferred forage species. Reduce pressure on over-browsed shrubs by improving habitat in adjacent or higher elevation sites to provide animals additional options for accessing high quality forage.
- Consider grazing distribution, timing and intensity to achieve optimal herbaceous species composition and/or objectives of the project. Rest rotation or deferred grazing systems can benefit both mule deer and livestock.
- If necessary, seed desired shrub/forb mixtures in cleared areas prior to snow cover. This may be done alone or in combination with another treatment. A rangeland drill seeder, seed box mounted atop an aerator or broadcast methods can be used. Seed germination increases with

bare soil contact. See "Special Habitat Types: Wildlife Plantings/Forage Seedings" for additional information.

- Control or eradicate noxious weeds and cheatgrass. Avoid treatments on slopes and aspects with high prevalence of cheatgrass when follow-up treatments are not possible or timing hinders treatment. If shrub treatments cannot be avoided, follow-up herbicide treatments should be completed within the first year. The treatment plan should include pre-treatment mapping of infested areas.

Other Habitat Types

Tall Forb

Figure 45. *Tall forb community in mule deer summer range*

Tall forb communities, not to be confused with mountain meadow grass/forb communities, grow in areas with over 30 inches of annual precipitation, in particular on deep loam to clay soils at higher elevations (6,500-10,000 feet) (Figure 45). These communities are typically found in the Wyoming, Salt, Gros Ventre, and Teton mountain ranges and are dominated by forbs such as sticky geranium, tall larkspur and single-flower sunflower. These forbs provide critical summer forage, especially for lactating does. Reynolds (1911) and Ellison (1949), based on their rangeland evaluations, concluded during the early settlement of the western United States grazing by domestic animals, mainly sheep, substantially reduced plant cover and altered species composition. Soils continue to erode in areas with greater than 20% exposure of bare ground (O'Brian et al. 2003). Continued improvement in grazing practices, in concert with active restoration (e.g., seeding/planting tall forbs), is necessary to recover and enhance these tall forb communities. Because of the importance of nutrition during summer and fall periods this habitat type is critically important for mule deer fawn production and survival (Tollefson et al. 2010, Monteith et al. 2013a).

Alpine

Alpine communities are complexes of high-elevation meadows, fell (barren) fields, and rock slopes above timberline. Mule deer use these areas during summer and fall (Figure 46). Grasses and sedges dominate and willow species grow in wetter soils. Vegetation in the alpine zone is remarkably diverse and similar to that growing in the Arctic. Common taxonomic groups include wildflowers, succulents, moss and lichens (Figure 47). Alpine zones provide dependable green forage in summer, even in drier years, due to the high elevation and relatively moister climate. Although these areas are rarely affected by direct anthropogenic disturbances (many are within designated wilderness areas), alpine zones are increasingly threatened by climate change, acid rain and air-born pollution. There is little opportunity (or need) for management actions in these habitats aside from recreation management.

Figure 46. *Doe mule deer in high quality alpine habitat*

Figure 47. *Alpine community (cushion plants)*

Wildlife Plantings/Forage Seedings

Wildlife plantings can benefit mule deer, but need to be designed with consideration given to local ecological conditions. Seedings and plantings are expensive and therefore should be carefully planned to assure they will be effective. Factors to consider include: site objectives, cost, timing, forage availability to coincide with mule deer seasonal use, site preparation, precipitation or irrigation potential, browse levels, seeding or planting method, and post-treatment monitoring and management. Species selected for planting should be adapted to the specific geographic area and readily established. Success rate for shrub establishment is higher when bare rootstock is used. Non-native forbs such as alfalfa (*Medicago sativa*), cicer milkvetch (*Astragalus cicer*), birdsfoot trefoil (*Lotus corniculatus*), sainfoin (*Onobrychis viciifolia*), small burnet (*Sanguisorba minor*) and clover (*Trifolium* spp.) can provide high quality forage for mule deer but are not accepted on most federal lands (Figure 48).

Figure 48. *Sainfoin and falcata alfalfa were inter-seeded with the Lawson aerator to benefit mule deer and sage grouse*

Other Management Considerations

Mule deer habitats are the focus of this document, however, it is recognized land management decisions and practices will be influenced by other species and considerations. The following should be considered when developing habitat management plans and projects for mule deer.

Forest Insects

Insect outbreaks (predominantly mountain pine beetle – *Dendroctonus ponderosae*) are causing dramatic changes to forest vegetation across much of Wyoming, some of which may ultimately benefit mule deer. Many studies have documented a significant increase in understory cover, forest heterogeneity, and species richness following significant insect outbreaks (Stone and Wolfe 1996, Chan-McLeod 2006, Jenkins et al. 2008, Griffin et al. 2011, Griffin and Turner 2012). Herbaceous growth is greatest during the epidemic phase with shrubs and herbaceous species peaking 5-10 years afterward (Chan-McLeod 2006, Jenkins et al. 2008). Herbaceous and shrub growth are also greatest in stands with ≥60% mortality (Stone and Wolfe 1996). Understory biomass can be an order of magnitude greater in beetle killed stands (50-75% mortality) compared to unaffected stands, and increases exponentially with severity of disturbance (Stone and Wolfe 1996). Increased foliar nitrogen levels in post-outbreak understory vegetation, as well as a flush in forbs, can result in greater forage quality for mule deer for up to 30 years (Griffin et al. 2011).

Figure 49. *Beetle killed Engelmann Spruce*

Changes in plant species composition post-outbreak may differ depending on overstory composition pre-outbreak. In lodgepole pine (*Pinus contorta*) forest, understory shrubs and herbaceous plants dominate openings until lodgepole pine saplings reassume dominance (Jenkins et al. 2008). In Engelmann spruce (*Picea engelmannii*) stands following severe outbreaks of spruce beetle (Figure 49), the return to climax spruce dominated communities may take up to several hundred years (Jenkins et al. 2008). Douglas fir stands will experience accelerated growth of shrubs and young conifer regeneration due to improved growing conditions (Hawkes et al. 2003). Intense aspen suckering has been observed in areas where conifer communities had an aspen component prior to insect outbreaks (Kayes and Tinker 2012, Malcom 2012) and following spruce beetle outbreaks in Colorado (Collins et al. 2011), Utah (DeRose and Long 2010, Stone and Wolfe 1996) and Canada (Hawkes et al. 2003).

Management options following insect outbreaks may be limited (and unnecessary), however, mechanical harvesting of dead overstory trees may benefit mule deer in some circumstances (Chan-McLeod 2006). If aspen are present, mechanical cutting of beetle killed trees can stimulate aspen suckering and growth (Collins et al. 2011, Malcolm 2012), similar to the understory response mechanical tree harvesting produces in stands unaffected by forest insects (Stone and Wolfe 1996). Rejuvenation processes can be faster in salvaged stands than in unsalvaged stands (Chan-McLeod 2006). However, salvaging operations can reduce regeneration of shrubs, forbs and grasses due to disturbance created by equipment in the understory (Collins et al. 2011, Malcolm 2012). Effects will vary depending on severity of the attack, type and amount of remaining live vegetation, ecosystem, and surrounding landscape (Chan-McLeod 2006). Pros and cons of management actions within beetle-killed timber need to be balanced based on site-specific objectives.

Sage-Grouse Core Areas

Sage-grouse core areas (Figure 50) overlap important mule deer habitats (primarily winter ranges) throughout much of Wyoming. Management activities that affect suitable sage-grouse habitat within core areas must conform with Wyoming Executive Order (EO) 2015-4 (State of Wyoming 2015). This EO requires new disturbances, when added to preexisting disturbances, shall not exceed 5% of the suitable sage-grouse habitat within each analysis area. Any treatment that reduces sagebrush canopy to less than 15% is considered a disturbance.

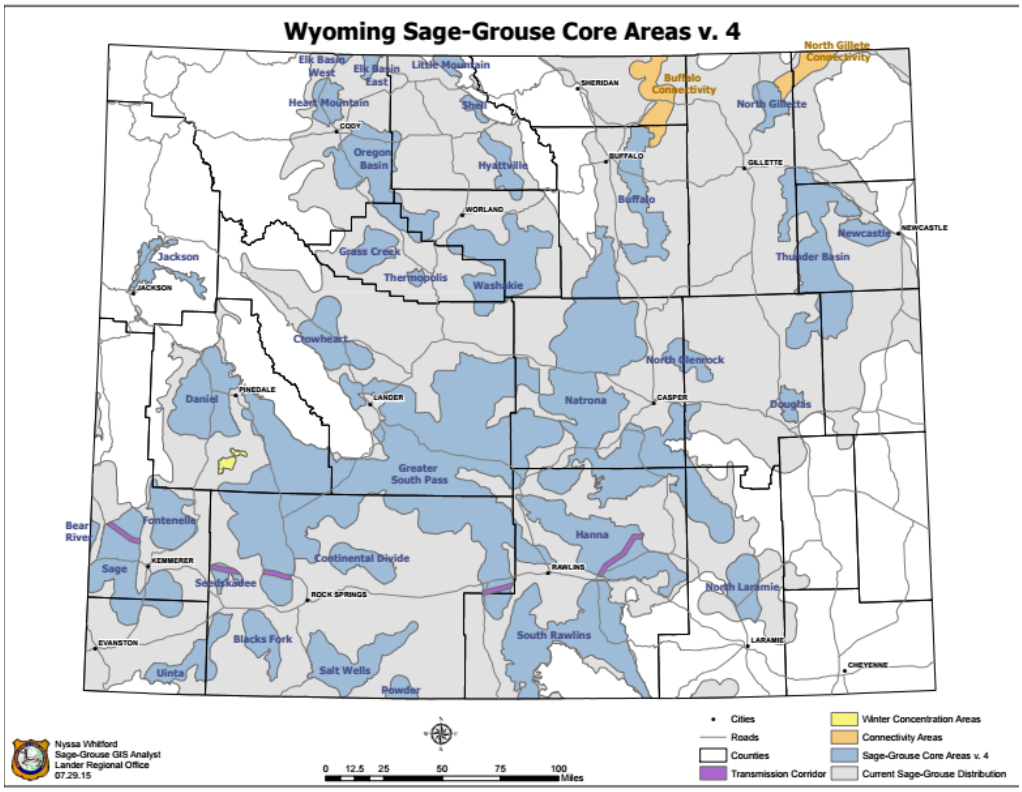

Figure 50. *Wyoming Sage Grouse core areas with Wyoming core (dark green) and connectivity areas (yellow). (State of Wyoming 2015)*

Before proceeding with plans for sagebrush treatments in core areas, managers are encouraged to consider benefits of treatments within spring/fall transition range and summer range, which appear to have greater influence on mule deer survival and reproduction. Many summer and transition habitats are located outside core areas. That said, opportunities exist to improve mule deer habitats within sage-grouse core areas. If appropriate mosaics are incorporated in the implementation design (all treated sagebrush must be within 60m of untreated sagebrush with ≥10% canopy cover), and if cumulative disturbance does not exceed 20% of identified suitable sage-grouse habitat, sagebrush within core areas may be treated under specific guidelines (Wyoming Game and Fish Department 2011). Treatments in general should not be considered within 0.6 mi of an active sage-grouse lek, although an exception may be granted in rare circumstances, with demonstration the treatment will not cause a decline in sage-grouse. Treatment objectives should be clearly defined and may include such parameters such as age class diversity, shrub vigor, grass and forb cover or diversity, removal of encroaching junipers, or elimination of non-native species. The treatment plan should include a post-treatment monitoring program to assess progress toward meeting treatment objectives. Burning is discouraged within sage-grouse core areas with less than 12” of annual precipitation.

Lynx Management

Aspen treatments are frequently a high priority on mule deer summer and fall transition ranges. Habitat treatments on national forest lands in the Northern Rocky Mountains, including Bridger-Teton and Shoshone National Forests in Wyoming, are subject to the objectives, standards, and guidelines in the Northern Rockies Lynx Management Direction (NRLMD) (United States Forest Service 2007), as this document is an amendment to their forest plans. Lynx Analysis Units (LAUs) were established based on the home range size of a female lynx, and underpin the assessment of vegetation disturbance, namely, the conversion of forests to early successional stages (see Ruediger et al. 2000 and Interagency Lynx Biology Team 2013). Wildlife habitat improvement, fuels reduction (fire abatement), and timber sale projects fall into the category of "vegetation management" in the NRLMD. For such projects, restrictions apply to (1) the amount and rate mapped lynx habitat is converted to stand initiation stages, (2) the type of treatment (pre-commercial thinning is prohibited), and (3) treatment of snowshoe hare habitat (adverse effects on snowshoe hare habitat is prohibited).

However, habitat treatment opportunities may occur when treatments are located in Wildland Urban Interface (WUI) areas. Here, although the primary objectives identified (as in a NEPA document) for the project must only be fuels related, habitat improvements for ungulates are a legitimate ancillary benefit. Acreages of lynx habitat affected by treatments within a WUI area are counted against a 6% forest-wide cap.

Because the NRLMD is a forest plan amendment, its standards and guidelines strictly apply to mapped lynx habitat on the Bridger-Teton and Shoshone National Forests. Rigorous biological assessments and Section 7 consultation with the U.S. Fish and Wildlife Service are also required for projects that affect lynx, a federally threatened species under the Endangered Species Act. Although NRLMD standards and guidelines present significant challenges for ungulate habitat and population managers, biologists should look for flexibility (e.g., working in WUIs) within the Direction that provides for treatment opportunities and proactively work with national forest and U.S. Fish and Wildlife Service biologists.

Critical habitat for Canada lynx is designated across much of Western Wyoming. Spatially, this designation is different from lynx habitat mapped under the lynx conservation strategy and the NRLMD. Although lynx critical habitat must be considered in NEPA documents and during Section 7 consultation, the effects of ungulate habitat projects on lynx critical habitat are addressed by identifying how the primary constituent elements of lynx habitat (snowshoe hares and boreal forests, denning habitat, habitat connectivity, and deep fluffy snow) are affected. Thus, although requirements under the NRLMD and the consideration of the primary constituent elements are similar topically, they are strictly separate considerations.

Invasive Species Management

Figure 51. *Cheatgrass invading sagebrush*

Non-native plants have caused significant damage to natural systems throughout the West, including Wyoming. Ecological impacts include; displacement of native plants, reduction in biodiversity, alteration of normal ecological processes such as nutrient and water cycling; increased soil erosion, increased stream sedimentation, and alteration of fire regimes (Cox et al. 2009). Although many invasive species are present in Wyoming, some have proven more problematic due to the extent of infestations and vegetation type conversions (Figure 51). The highest priority species for control through aggressive management include: cheatgrass (Figure 52), spotted knapweed (*Centaurea biebersteinii*) (Figure 53), Russian knapweed (*Acroptilon repens*), leafy spurge (*Euphorbia esula*), salt cedar (*Tamarix pentandra*), Russian olive (*Elaeagnus angustifolia*) and toadflax (*Linaria spp*).

Figure 52. *Cheatgrass invasion of a true mountain mahogany community in winter range*

Management plans should be developed with local landowners, weed and pest districts, and other partners to eradicate or contain these species when they are present in important mule deer habitat. Any treatment or planned disturbance should include proactive measures to prevent new infestations (Figure 54). Presence and distribution of invasive species

should be mapped and areas of high concentrations (e.g. south aspects for cheatgrass) should be excluded from the treatment area. Project funding requests should routinely include a line item to control invasive species post-treatment. If treatment contingencies are not proactively addressed, reacting to an infestation post-treatment can become a significant management and funding challenge. Post treatment monitoring criteria should include trigger points for implementing aggressive control measures. Consult local weed and pest districts or WGFD habitat biologists for technical assistance to handle weed management issues.

Figure 53. *Spotted knapweed invading mule deer habitat*

Figure 54. *Aerial application of herbicide to control cheatgrass*

Summary

The abundance of wildlife and wildlife habitats throughout Wyoming has and will continue to be the result of progressive land management and stewardship by private landowners, agriculture producers, state and federal land management agencies, and others. The scale of habitat restoration and management needed to begin and sustain recovery of Wyoming's mule deer populations is a landscape level effort. From a practical standpoint, resources available to restore, manage, and enhance Wyoming's mule deer habitats are limited. Therefore, those resources should be invested in to attain the greatest net benefit. Summer and fall transition ranges are highest priorities for management in order to maximize fawn production and survival. Habitat diversity on multiple scales is also extremely important. This includes plant species and structural diversity on rangelands, as well as a diversity of community types used by mule deer throughout their seasonal ranges.

Game & Fish is eager to continue working hand-in-hand with land managers on public and private lands throughout the state to best implement the recommendations and practices identified. Certainly, restoring mule deer habitats on a landscape scale will require extensive collaboration and strong partnerships with private landowners, federal and state agencies, and nongovernmental organizations to continue to implement sustainable land use and management programs. To be sustainable, land use practices must adapt to ever-changing environmental, vegetation and habitat conditions. Efforts to adopt more progressive and adaptable land management practices will require long-term monitoring to identify successful practices and techniques. Enhancing mule deer habitats cannot occur without funding, partnerships and sharing of technical data and implementation resources.

Much has been done in Wyoming to improve mule deer habitat over the past 20+ years. It takes a long time for both vegetation and populations to respond to treatments and results are not immediately apparent. Habitat work planned and implemented today is an investment for future generations. There is no quick fix, however, a landscape-level effort focused on creating, enhancing, and sustaining healthy habitats is the first step in the right direction to enhance mule deer populations in Wyoming.

Literature Cited

Asherin, D. A. 1973. Prescribed burning effects on nutrition, production and big game use of key northern Idaho browse species. University of Idaho, Moscow, Idaho. Dissertation. 96 p.

Beck, J. L., and J. Peek. 2005. Diet composition, forage selection, and potential for forage competition among elk, deer, and livestock on aspen-sagebrush summer range. Rangeland Ecological Management. 58:135-147.

Bender, L. C. 2012. Guidelines for management of habitat for mule deer. New Mexico State Cooperative Extension Service. Circular No. 662.

Bishop, C., J. Unsworth, and E. O. Garton. 2005. Mule deer survival amongst adjacent populations in southwest Idaho. Journal of Wildlife Management. 69:311-321.

Bishop, C., G. White, D. Freddy, B. Watkins, and T. Stephenson. 2008. Effect of enhanced nutrition on mule deer population rate of change. Wildlife Monographs. 172:1-28.

Burkhardt, J. W., and E. W. Tisdale. 1976. Causes of juniper invasion in southwest Idaho. Ecology. 76:472-484.

Burton, D. 2004. Aspen Delineation Project. Proceedings: Managing Aspen in Western Landscapes. Cedar City, UT.

Campbell, R. B., and D. L. Bartos. 2001. Aspen ecosystems: objectives for sustaining biodiversity. U.S. Forest Service Proceedings RMRS-P-18. Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Chan-McLeod, A. C. A. 2006. A review and synthesis of the effects of unsalvaged mountain pine beetle attacked stands on wildlife and implications for forest management. BC Journal of Ecosystems and Management. 50:119-132.

Clements, C., and J. Young. 1997. A viewpoint: Rangeland health and mule deer habitat. Journal of Rangeland Management. 50:129-138.

Clements, C., and J. Young. 2001. Antelope bitterbrush seed production and stand age. Journal of Range Management. 54:269-273.

Clements, C., and J. Young. 2007. Restoring antelope bitterbrush communities. Pages 12-16 in M. Cox, editor. 6th Western States and Provinces Deer and Elk Workshop proceedings. Nevada Department of Wildlife, Reno, USA.

Collins, W., and P. Urness. 1983. Feeding behavior and habitat selection of mule deer and elk on northern Utah summer range. Journal of Wildlife Management. 47:646-663.

Collins B., C. Rhodes, R. Hubbard, and M. Battaglia. 2011. Tree regeneration and future stand development after bark beetle infestation and harvesting in Colorado lodgepole pine stands. Forest

Ecology and Management. 47:646-663.

Collins, W., and P. Urness. 1983. Feeding behavior and habitat selection of mule deer and elk on northern Utah summer range. Journal of Wildlife Management. 47:646-663.

Cook, J. G., Hershey, T. J., and L. L. Irwin. 1994. Vegetative response to burning on Wyoming mountain-shrub big game ranges. Journal of Range Management. 47: 296-302

Cox, M., D. W. Lutz, T. Wasley, M. Fleming, B. B. Compton, T. Keegan, D. Stroud, S. Kilpatrick, K. Gray, J. Carlson, L. Carpenter, K. Urquhart, B. Johnson, and C. McLaughlin. 2009. Habitat guidelines for mule deer: Intermountain West Ecoregion. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies.

Davis, J. N., Welch, B. L. 1985. Winter preference, nutritive value, and other range use characteristics of *Kochia prostrata*. The Great Basin Naturalist. 45: 778-783.

DeRose, R. J., and J. N. Long. 2010. Regeneration response and seedling band dynamics on a *Dendroctonus rufipennis*-killed *Picea englemannii* landscape. Journal of Vegetation Science. 21:377-387.

de Vos Jr., J.C., M.R. Conover, and N.E. Headrick. 2003. Mule Deer Conservation: Issues and Management Strategies. Berryman Institute Press, Utah State University, Logan.

Eichhorn, L. C. and C.R. Watts. 1984. Plant succession on burns in the river breaks of central Montana. Proceedings, Montana Academy of Science. 43: 21-34.

Ellison, L. 1949. Establishment of vegetation on depleted subalpine range as influenced by microclimate. Ecological Monographs 19: 97-121.

Fox, L. B., A. A. Arsenault, C. E. Brewer, L. H. Carpenter, B. Jellison, J. A. Jenks, W. F. Jensen, T. W. Keegan, D. J. Kraft, D. W. Lutz, C. L. Richardson, B. D. Trindle, A. P. Schmidt, and T. S. Stivers. 2009. Habitat guidelines for mule deer: Great Plains Ecoregion. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies.

Garrison, G. A., 1953. Effects of clipping on some range shrubs. Journal of Range Management. 6:309-317.

Griffin, J., M. Turner, and M. Simard. 2011. Nitrogen cycling following mountain pine beetle disturbance in lodgepole pine forests of Greater Yellowstone. Forest Ecology and Management. 261:1077-1089.

Griffin, J. and M. Turner. 2012. Changes to the N cycles following bark beetle outbreaks in two contrasting conifer forest types. Oecologia. 170:551-565.

Gruell, G. E. 1983. Fire and vegetative trends in the northern Rockies: interpretations from 1871-1982 photographs. Gen. Tech. Rep. INT-158. Intermountain Forest and Range Experiment Station U.S. Department of Agriculture, Forest Service. Ogden, UT.

Hawkes, B., S. W. Taylor, C. Stockdale, T. L. Shore, R. I. Alfero, R. Campbell, and P. Vera. 2003. Impact of mountain pine beetle on stand dynamics in British Columbia. T. L. Shore, J. E. Brooks, and J. E. Stone, eds., pages 177-199 in Mountain Pine Beetle Symposium: Challenges and Solutions. Canadian Forest Service, Pacific Forestry Center, Kelowna, British Columbia.

Holechek, J. L., R. D. Pieper, and C. H. Herbel. 1989. Range Management Principles and Practices. Prentice Hall, Englewood Cliffs, NJ. 501 pp.

Holechek, J. L., H. Gomez, F. Molinar, and D. Galt. 1999. Grazing studies: What have we learned. Rangelands. 21:12-16.

Interagency Lynx Biology Team. 2013. Canada lynx conservation assessment and strategy. 3rd edition. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Forest Service Publication R1-13-19, Missoula, MT. 128 pp.

Jenkins, M., E. Hebertson, W. Page, and C. A. Jorgensen. 2008. Bark beetles, fuels, fires and implications for forest management in the Intermountain West. Forest Ecology and Management. 254:16-34.

Jensen, C. H., A. D. Smith, G. W. Scotter. 1972. Guidelines for grazing sheep on rangelands used by big game in winter. Journal of Range Management. 25:346-352.

Johnson, B., J. Kern, M. Wisdon, S. Findhold, and J. Kie. 2000. Resource selection and spatial separation of mule deer and elk during spring. Journal of Wildlife Management. 64:685-697.

Julander, O. 1962. Range management in relation to mule deer habitat and herd productivity in Utah. Journal of Range Management. 15:278-281.

Julander, O., W. L. Robinette, and D. A. Jones. 1961. Relation of summer range condition to mule deer herd productivity. Journal of Wildlife Management. 25:54-60.

Kayes, L., and D. Tinker. 2012. Forest structure and regeneration following a mountain pine beetle epidemic in southern Wyoming. Forest Ecology and Management. 263:57-66.

Keigley, R. B., M. R. Frisina, and C. W. Fager. 2002. Assessing browse trend at the landscape level part 1: prelminary steps and field survey. Rangelands. 24:28-33.

Kilpatrick, S., D. Clause, and D. Scott. 2003. Aspen response to prescribed fire, mechanical treatments, and ungulate herbivory. U. S. Forest Service Proceedings RMRS-P-29, pages 93-102. USFS Rocky Mountain Research Station. Fort Collins, Colorado, USA.

Kufeld, R. C., O. C. Wallmo, and C. Feddema. 1973. Foods of the Rocky Mountain mule deer. USDA Forest Service Research. Paper RM-111. Fort Collins, Colorado.

Lomas, L., and L. Bender. 2007. Survival and cause-specific mortality of neonatal mule deer fawns, north-central New Mexico. Journal of Wildlife Management. 71:884-894.

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. Montana Fish, Wildlife and Parks. Helena, Montana. 180pp.

Malcom, K. 2012. From death comes life: recovery and revolution in the wake of epidemic outbreaks of mountain pine beetle. USFS Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Mautz, W. W. 1978. Nutrition and carrying capacity. *In:* Big Game of North America. Edited by Schmidt and Gilbert. Stackpole, PA. Pages 321-348.

McConnell, B. R. and J. G. Smith. 1977. Influence of grazing on age-yield interactions in bitterbrush. Journal of Range Management. 30:91–-93.

Monteith, K., T. Stephenson, V. Bleich, M. Conner, B. Pierce, and T. Bowyer. 2013a. Risk-sensitive allocation in seasonal dynamics of fat and protein reserves in a long-lived mammal. Journal of Animal Ecology. 82:377-388.

Monteith, K. L**.,** R. A. Long, V. C. Bleich, J. R. Heffelfinger, P. R. Krausman, and R. T. Bowyer. 2013b. Effects of harvest, culture, and climate on trends in size of horn-like structures in trophy ungulates. Wildlife Monographs 183.

Mueggler, W. F. 1988. Aspen community types of the Intermountain Region. Gen. Tech. Rep. INT-250. U.S. Department of Agriculture Forest Service, Intermountain Research Station, Ogden, Utah, USA.

Murphy D. A. &Coates J. A. 1966 Effects of dietary protein on deer. Transactions of the North American Wildlife and Natural Resource Conference. 31: 129–139.

Mule Deer Working Group. 2007. The Wyoming Mule Deer Initiative. Wyoming Game and Fish Department. Cheyenne, Wyoming.

O'Brien, Renee A.; Johnson, Curtis M.; Wilson, Andrea M.; Elsbernd, Van C. 2003. Indicators of rangeland health and functionality in the Intermountain West. Gen. Tech. Rep. RMRS-GTR-00. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 13 p.Olson, J. 1992. Mule deer habitat requirements and management in Wyoming. Department of Renewable Resources, University of Wyoming, Laramie, Wyoming.

Pederson, J., and K. T. Harper. 1978. Factors influencing productivity of two mule deer herds in Utah. Journal of Range Management. 31:105-110.

Randall, J. E. 2012. Pinedale Region winter range shrub hedging and age class data. Unpublished data. Wyoming Game and Fish Department, Pinedale, Wyoming.

Reynolds, R V. R 1911. Grazing and floods: a study of conditions in the Manti National Forest, Utah. U.S. Forest Service Bulletin 91. 16 pp.

Rogers, P.C and C. M. Mittanck. 2013. Herbivory strains resilience in drought-prone aspen landscapes of the western United States. Journal of Vegetation Science. 25:1-13.

Ruediger, Bill, Jim Claar, Steve Gniadek, Bryon Holt, Lyle Lewis, Steve Mighton, Bob Naney, Gary Patton, Tony Rinaldi, Joel Trick, Anne Vandehey, Fred Wahl, Nancy Warren, Dick Wenger, and Al Williamson. 2000. Canada lynx conservation assessment and strategy. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Missoula, MT

Sawyer, H. M., M. J. Kauffman, and R. M. Nielson. 2009a. Influence of well pad activity on winter habitat selection patterns of mule deer. Journal or Wildlife Management. 73: 1052–1061.

Sawyer, H., M. J. Kauffman, R. M. Nielson, and J. S. Horne. 2009b. Identifying and prioritizing ungulate migration routes for landscape-level conservation. Ecological Applications. 19: 2016-2025.

Schultz, B. W., P. T. Tueller, and R. J. Tausch. 1990. Ecology of curlleaf mahogany in western and central Nevada: community and population structure. Journal of Range Management. 43:13-20.

Shepperd, W. D., P. C. Rogers, D. Burton, and D. L. Bartos. 2006. Ecology, biodiversity, management and restoration of aspen in the Sierra Nevada. Gen. Tech. Rep. RMRS-GTR-178. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Short, H.L., and J.C. Reagor. 1970. Cell Wall Digestibility Affects Forage Value of Woody Twigs. Journal of Wildlife Management. 34:964-967.

Smith, A. D. and D. Doell. 1968. Guides to allocating forage between cattle and big game on winter range. Utah Division of Fish and Game. Publication 68-11. Salt Lake City, UT.

State of Wyoming. 2015. Office of Governor Mead. State of Wyoming Executive Department Executive Order. Greater Sage-Grouse Area Protection. 2015-4.

Stone, W., and M. Wolfe. 1996. Response of understory vegetation to variable tree mortality following a mountain pine beetle epidemic in lodgepole pine stands in northern Utah. Plant Ecology, 122:1-12.

Tollefson, T., L. Shipley, W. Meyers, D. Keisler, and N. Dasgupta. 2010. Influence of summer and autumn nutrition on body condition and reproduction in lactating mule deer. Journal of Wildlife Management. 74:974-986.

U.S. Department of Agriculture-Natural Resources Conservation Service [USDA-NRCS]. 2013. Ecological Site Information System <https://esis.sc.egov.usda.gov>. Accessed 16 August 2013.

United States Forest Service. 2007. Northern Rockies lynx management direction record of decision. Washington D.C., USA

Verme, L. J., and D. E. Ullrey. 1972. Feeding and nutrition of deer. p. 275-291. *In* Digestive physiology and nutrition of ruminants, vol. 3: practical nutrition. D. C. Church, ed. Oregon State University Bookstores, Corvallis, Oregon.

Wasley, T. 2004. Nevada Mule Deer Population Dynamics: Issues and Influences. Nevada Department of Wildlife, Reno, Nevada.

Wyoming Game and Fish Department. 2011. Wyoming Game and Fish Department protocols for treating sagebrush to be consistent with Wyoming Executive Order 2011-5; Greater Sage-Grouse Core Area protection. Cheyenne, Wyoming.