

# WILD UNGULATE USE OF AREAS IN SOUTHWESTERN MONTANA AFTER FOURTEEN YEARS OF NATURAL RECOVERY FROM SMELTER IMPACTS<sup>1</sup>

by

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**Abstract:** During 1994, fourteen years after the closure of the Anaconda smelters in southwestern Montana, two seasonal wild ungulate fecal pellet group surveys were conducted along stratified random belt transects within three areas in close proximity to the smelters and at a more distant reference area. Vegetation patterns on the proximal sites had been altered by emissions during the 96 years of continuous smelter operation. The densities of mule deer (*Odocoileus hemionus hemionus*) and Shiras moose (*Alces alces shiras*) droppings on all of the affected areas were either greater, or no different than on the reference area. Seasonal dropping densities of Rocky Mountain elk (*Cervus elaphus nelsoni*) on the affected area farthest removed from human activities, were either significantly greater or no different than on the reference area. On the two affected areas closest to human activities, elk dropping densities were significantly lower than on the reference area in three of the four comparisons. Thirty-three percent of the ANOVA comparisons of seasonal dropping densities on the affected areas were significantly greater than on the reference area, 50% were not significantly different, and 17% were significantly less. The median horizontal diversity index of land cover types was greater (95% CI) on the affected areas than on the reference site. The mosaic of seral communities that has developed on the affected areas since closure of the smelter appears to have produced levels of big game use which are comparable to those on the reference area, except where elk are influenced by human activities.

Additional Key Words: natural recovery, smelter, wild ungulate, Montana.

## Introduction

### Preamble/Site History

The use of smelter-impacted habitats by big game is not a subject area that has been well studied or documented even though the smelting of mined ore is a long-standing world-wide practice that has been affecting the habitats of wildlife for over a hundred years (Haywood 1907, Kataev et al. 1994). In Montana, the development of large rich mineral deposits, and the intensive mining and smelting of ores, has been occurring since the late 1800s. Much historical mining-related activity was centered around the Town of

Anaconda in southwestern Montana where several smelters and stacks were constructed and operated over a period of 96 years between 1883 and 1980. The tallest of the stacks (Washoe Smelter, Figure 1) operated for 78 years and, early in its history, produced over one million pounds of emissions per day (Haywood 1907). Emissions included metals such as copper, lead, zinc, cadmium, and arsenic, as well as sulfur dioxide.

The deleterious effects of smelter emissions on vegetation have been well documented by authors in several countries (Archibold 1978, Conroy and Kramer 1995, Franzin 1984, Gordon and Gorham 1963, Jordon 1975, Winterhalder 1995a, Yan and Miller 1984). Smelter emissions at Anaconda, in concert with many years of fire, logging, and overgrazing, resulted in significant vegetation loss and erosion on upland areas within several kilometers of the stacks (Oswald 1981). Following logging, on-going grazing and sustained exposure to smelter emissions retarded the recovery of vegetation and kept much of it in a disturbed, relatively unproductive condition (Keammerer 1995). Logging, usually in the form of clear-cutting, began in the early 1880s and continued at a high intensity for more than 20

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years. In addition, fire after clear-cutting often removed the slash and litter layer, which contributed to accelerated soil erosion (Vogel and Swartz 1910-1912). Grazing of the uplands area has occurred for 100 years and, by 1976, impacts were evident, particularly along riparian areas. Although the seasonal prevailing winds in the Anaconda area are from the southwest and west (Gechaus 1974), the magnitude and extent of vegetation damage caused by smelter emissions in the Anaconda area were significantly affected by complex wind drift patterns created by mountainous topography and constitutes a graphic example of how topographic heterogeneity can have profound effects on the pattern and outcome of disturbance (Pickett and White 1985, Urban et al. 1987). Another variable that determined the extent of damage was distance from the point source (stacks). The upper slopes of hills were most affected. Over time, the loss of vegetation on the upper slopes resulted in erosion of the topsoil and loss of the seedbank, thereby impeding regeneration and reestablishment of vegetation (Haywood 1907, Keammerer 1995).

Much of the area in the vicinity of Anaconda, Butte, and the upper Clark Fork River valley is included

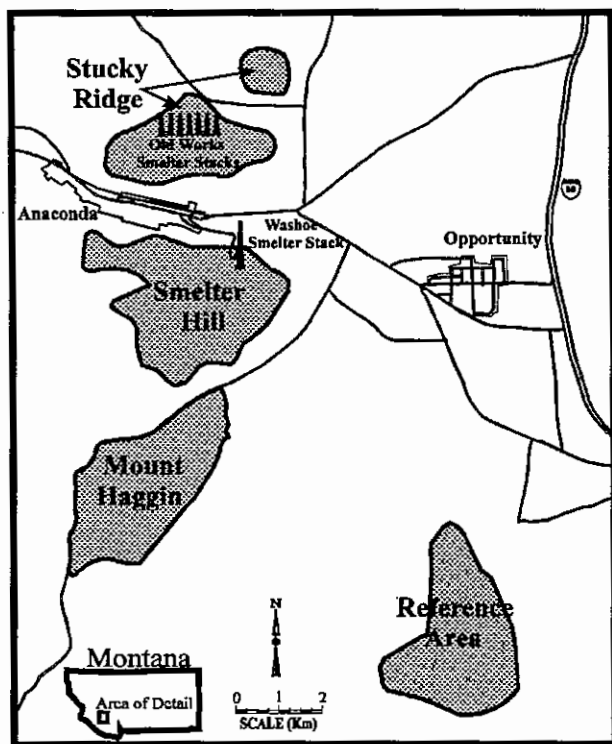


Figure 1. Smelter-affected upland study sites and reference area in relation to paved roads, smelter locations, and the towns of Anaconda and Opportunity, Montana.

within three contiguous Superfund sites which appear on the United States Priorities List (Clark Fork Superfund Sites Master Plan, 1996 Update, U.S. Environmental Protection Agency, August 1966). In 1983 the State of Montana filed a law suit seeking natural resource damage claims under the Federal Superfund Program. The State's claims encompass three discontinuous upland areas near old smelter sites in Anaconda. These three areas, known as Mount Haggin, Smelter Hill, and Stucky Ridge, range in size from 10.1 km<sup>2</sup> to 15.7 km<sup>2</sup> and collectively cover 40.8 km<sup>2</sup> (Figure 1).

### Study Area

Physiographically, the affected sites occur in foothills and mountains, varying in elevation from 1,615 to 2,296 meters, and are bisected with small valleys and headwater streams of the upper Clark Fork River. Vegetation consists primarily of habitat types belonging to the Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*) and, to a lesser extent, the limber pine (*Pinus flexilis*) series described by Pfister et al. (1977) for southwestern and south central Montana. Species composition within these types varies according to elevation, aspect, and history of past disturbance by fire, logging, grazing, and smelter emissions. Various grassland and shrub habitat types (Mueggler and Stewart 1980) occur on the lower elevation slopes while riparian shrubs occupy drainage bottoms. All sites on the study area are within defined hunt districts of the Montana Department of Fish, Wildlife, and Parks, and the hunting of mule deer (*Odocoileus hemionus hemionus*), Rocky Mountain elk (*Cervus elaphus nelsoni*), and Shiras moose (*Alces alces shiras*), which use these sites, is common. Because of the small size of the individual study sites and their proximity to human activities, the hunting of wild ungulates on these sites may influence the distribution of the more sensitive species (elk) within them (Morgantini and Hudson 1979).

Natural recovery of vegetation and wildlife habitats since closure of the smelter in 1980 is evident and much of the impacted area is now covered with colonizing patches of seral vegetation comprised of grasses, forbs, shrubs, and young trees. These patches of early seral vegetation include pockets of pole size to mature trees in areas apparently less affected by smelter emissions. Some of the ridge-top areas, where the topsoil has been eroded away and subsoil or bare rock prevails, remain devoid of vegetation and are intermixed with seral vegetation of varying ages and stages in an overall mosaic of heterogeneous habitat types.

## Study Sites

Most of the area within Smelter Hill and Stucky Ridge is located within 4 km of historical smelting operations and habitats on these sites sustained the most exposure to emissions (Figure 1). Mount Haggin is located between 3.5 and 11.3 km from the closest stack (Washoe Smelter stack) and, of the three affected sites, sustained the least exposure to emissions. The reference area is located between 10.1 and 15.6 km from the closest smelter stack and was selected because it: (1) has no visible or documented evidence of smelter damage, (2) is relatively close to the affected sites, and (3) is similar to the affected sites in regards to physiographic features (elevations, slopes, aspects) and vegetative series.

Smelter Hill and Mount Haggin historically supported a mixture of grass/shrubland, aspen/willow, and mixed-ages of coniferous forests. This is still true today, but the proportions of each type have likely changed and successional stages are younger. Today, much of the historic conifer forest is gone due to a combination of logging, fire, mining, and emissions (Haywood 1907), and these areas are dominated by vegetative mosaics comprised of seral grasses, forbs, shrubs, aspen, and young conifer (Table 1). Colonizing upland seral vegetation constitutes most of the ground coverage on both Smelter Hill (79.8 percent) and Mount Haggin (66.3 percent) (Table 1). Stucky Ridge is, and probably always has been vegetated with predominately grass/shrubland (70.3 percent) (Table 1), small patches of aspen/willow (1.6/3.2 percent), and scattered limber pine (1.6 percent) along drainages (Kearmerer 1995). The reference area is dominated by older stands of mixed-age lodgepole pine and Douglas fir (63.8 percent) (Table 1) interspersed with smaller areas of grassland (28.6 percent) and isolated small pockets of aspen (7.3 percent). Since the cessation of smelting operations in 1980, natural recovery on small portions of Smelter Hill and Stucky Ridge has been aided through reclamation efforts.

The road density and degree of exposure to human disturbance varies greatly among the study sites and reference area and is likely to have an influence on the amount of time elk spend there (Hayden-Wing 1979, Morgantini and Hudson 1979, Ward 1976). Both Smelter Hill and Stucky Ridge are bordered by the Town of Anaconda, roads, and railroads and are easily accessed via numerous internal roads and tracks. Mount Haggin is farther removed from Anaconda with less exposure to roads. It is bordered on the west by a paved road and has a maintained dirt and gravel road through the middle of its northern half. The reference area is the farthest

Table 1. Percent cover of major surface land cover types on the study sites.

Vegetation Type	Stucky Ridge	Smelter Hill	Mount Haggin	Reference Area
Aspen	1.6	8.1	15.8	7.3
Conifer	1.6	—	3.4	63.8
Barren	23.3	11.1	13.4	0.3
Grassland	—	—	—	28.6
Willow/Shrub	3.2	1.0	1.0	—
Colonizing <sup>1</sup>	70.3	79.8	66.3	—

<sup>1</sup> Upland mixture of seral grasses, forbs, shrubs, and young conifers.

removed from Anaconda and is not proximal to paved roads. However, one gravel road extends through this area from north to south and several shorter internal tracks exist.

The lawsuit filed by the State presented the need and opportunity to quantify and compare big game use of habitats on affected areas exposed to 96 years of smelter emissions with a more distant reference area that had sustained no visible or documented deleterious effects from smelter emissions. Therefore, in 1994, fourteen years after the closure of the last smelter, fecal pellet group surveys were conducted on the three affected areas and reference area in order to: (1) quantify relative levels of use by wild ungulates, and (2) compare levels of use between affected sites and the reference area.

## Methods

To obtain indices of seasonal use, belt transects were surveyed for mule deer, elk, and moose fecal pellet groups during May and June, 1994 for winter droppings, and again during August and September, 1994 for summer droppings. The proportion of each affected site and reference area sampled was very similar and averaged 0.254 and 0.259 percent, respectively. The inventory of wild ungulate droppings, for the purpose of obtaining seasonal use indices, is a common and effectively used practice (Neff 1968) that has been applied to most species of wild ungulates, including elk (Skovlin 1982), mule deer (Neff 1968, Rogers et al. 1958, and Smith et al, 1969), and moose (Franzmann and Schwartz 1982).

Because of the diversity of habitats, slopes, elevations, aspects, and the large size of the sites to be surveyed, sampling and analytical procedures were selected that would facilitate a large representative sample of the pellet group populations of all three species

over each of the study sites. Each study site was stratified into blocks one mile in width and locations for two belt transects were randomly selected within each stratum (Neff 1968). Sample strata and transect axes were oriented to intersect the primary sources of habitat variation (slope, elevation, and aspect) at right angles (Robinette et al. 1958, Wallmo 1964). In order to represent variation within each stratum, each transect extended from border to border, across the study site (Neff 1968). To maximize survey efforts and reduce between-transect variance, sampling along each transect was continuous with transects constituting single plots 1.83 m (6 ft.) wide and as long as the width of the study site (McConnell and Smith 1970, Neff 1960, 1968, Robinette et al. 1958, Smith 1964). An exception to this procedure had to be made in order to adequately sample the important riparian habitats. Because of the limited aerial extent and narrow configuration of these habitats, a single transect was placed along the long axis of the largest riparian zone within each study site (Bull and Skovlin 1982, Emmerich and Vohs 1982, Meents et al. 1981, Mills et al. 1991, Stauffer and Best 1980). Riparian transects followed the course of the drainage bottom in which they occurred and extended for about 1-1.5 km. The length of each transect was searched and numbers of ungulate pellet groups found within the 1.83 m transect width were recorded by species, location, and habitat type.

Only fresh droppings deposited during the previous season (winter or summer) were tallied. Fresh droppings were distinguished from those one year or more in age by coloration, degree of deterioration, and the extent to which they were overlain by litter. The determinations of species and season of deposition were based on a combination of pellet size, shape, coloration, and size of internal particals. A pellet group was considered to be a single evacuation and was determined by the general size, shape, and coloration of individual pellets (Smith 1964). Pellet groups which were strewn-out or scattered were tallied only when half or more of the pellets were within the transect width (Neff 1962). In order to minimize observer biases (Neff 1968) and maintain consistency and accuracy, specific sampling procedures were standardized and strictly adhered to, and only experienced biologists who had been thoroughly familiarized with procedures were used in collecting field data. In addition, the large sample size (0.25% of each study site and reference area) helped to: (1) compensate for and minimize observer errors, (2) insure adequate representation of each habitat type, and (3) provide good estimates of variance for the dropping populations (McConnell and Smith 1970, Neff 1960, 1968, Robinette et al. 1958, Smith 1964).

The data for wild ungulates were converted into densities or pellet groups-per-hectare for each transect and habitat type on each study site. Densities were then weighted by transect length and transformed using a standard square root procedure. Two-way Analyses of Variance (GLM for weighted data, MINITAB Ver. 10.2) were performed on the transformed density data comparing each study site to the reference for both site and habitat differences for both the winter and summer data sets. Due to the current and historical lack of conifers on Stucky Ridge, only the non-conifer habitats on the reference area were used in the Stucky Ridge/reference area comparison and analysis.

Surface cover type maps were prepared for each of the affected sites and the reference area by combining an interpretation of aerial photography with early vegetation maps prepared by Keammerer (1995). The maps produced through these efforts were then refined according to ground truthing performed during the surveys of big game pellet groups. The area of each of the major cover types was determined by digital computer analysis.

Indices of horizontal diversity, which Patton (1992) defines as landscape heterogeneity or the arrangement of plant life-forms in different successional stages along a horizontal plane, were calculated for each study site and the reference area. Vegetation maps were overlaid with a grid of evenly-spaced lines perpendicular to the long axis of the area boundary. The number of habitat changes on each grid line was tallied and weighted by line length. A Mann-Whitney test (MINITAB Ver. 10.2) was used to test for a difference in the median horizontal diversity index between each affected area and the reference area.

## Results

Four species of wild ungulate droppings were found during upland pellet group surveys. Elk, mule deer, and moose pellet groups were common to abundant on all four upland study sites, while bighorn sheep (*Ovis canadensis canadensis*) were uncommon on Mount Haggin and Stucky Ridge and were not found on Smelter Hill or the reference area. Droppings data for bighorn sheep were not used in statistical analyses because of the low frequency of occurrence.

Analysis of Variance results show that for mule deer: (1) there is no significant difference in densities of winter droppings between any of the affected areas and the reference area, and (2) all three affected areas have significantly higher summer dropping densities than the

reference area (Mount Haggin  $p=0.010$ , Smelter Hill  $p=0.000$ , and Stucky Ridge  $p=0.000$ ) (Table 2). Elk use: (1) on Mount Haggin is significantly higher ( $p=0.013$ ) than the reference area during the summer and does not differ significantly from the reference area during the winter ( $p=0.059$ ), (2) on Smelter Hill is significantly lower than the reference area during both summer ( $p=0.030$ ) and winter ( $p=0.000$ ), and (3) on Stucky Ridge does not differ significantly from the reference area during the summer ( $p=0.401$ ), but is significantly lower during the winter ( $p=0.000$ ). The densities of winter and summer moose droppings on Smelter Hill and Stucky Ridge did not differ significantly from those on the reference area. Mount Haggin, however, had significantly more moose droppings than did the reference area for both the winter ( $p=0.001$ ) and summer ( $p=0.006$ ) periods. These moose results are corroborated by the frequency of moose sightings documented during the field surveys and the frequently observed evidence of heavy browsing of willow and regenerative aspen by moose throughout Mount Haggin. Dropping densities of moose on Smelter Hill and Stucky Ridge did not differ

significantly from those on the reference area during either the winter or summer periods (Table 2).

Horizontal diversity indices (HDI) were greater on each of the affected areas than on the reference area (Table 3). The HDI for Mount Haggin was significantly greater than for the reference area, with about 3 times the number of habitat changes ( $p=0.0007$ ) for a given linear distance. Smelter Hill also had a significantly greater diversity index than the reference area with about twice the number of habitat changes ( $p=0.0422$ ). The diversity index for Stucky Ridge was also greater than for the reference area, but was not statistically significant.

### Discussion

Nearly a century of exposure to smelter emissions and other anthropogenic perturbations in areas proximal to the Anaconda smelters adversely impacted the vegetation, particularly mature forest, and reversed portions of some areas to a barren or primary successional stage. The decades of perturbations and

Table 2. Analysis of variance for site comparisons of pellet-group-density adjusted for habitat using weighted observations and square-root transformed data.

Season	Species	Area comparison	P-value
Winter 1993-1994	Deer	Mount Haggin - Reference Area	0.825
		Smelter Hill - Reference Area	0.738
		Stucky Ridge - Reference Area	0.646
	Elk	Mount Haggin - Reference Area	0.059
		Smelter Hill - Reference Area	0.000 <sup>A</sup>
		Stucky Ridge - Reference Area	0.000 <sup>A</sup>
	Moose	Mount Haggin - Reference Area	0.001 <sup>B</sup>
		Smelter Hill - Reference Area	0.761
		Stucky Ridge - Reference Area	0.176
Summer 1994	Deer	Mount Haggin - Reference Area	0.010 <sup>B</sup>
		Smelter Hill - Reference Area	0.000 <sup>B</sup>
		Stucky Ridge - Reference Area	0.000 <sup>B</sup>
	Elk	Mount Haggin - Reference Area	0.013 <sup>B</sup>
		Smelter Hill - Reference Area	0.030 <sup>A</sup>
		Stucky Ridge - Reference Area	0.401
	Moose	Mount Haggin - Reference Area	0.006 <sup>B</sup>
		Smelter Hill - Reference Area	0.588
		Stucky Ridge - Reference Area	0.129

<sup>A</sup> Significantly greater on the reference area at  $\alpha = 0.05$ .

<sup>B</sup> Significantly greater on affected area at  $\alpha = 0.05$ .

Table 3. Mann-Whitney test of the median horizontal diversity index (frequency of habitat changes per 240 meters) on upland areas for a 95% confidence test of reference area less than affected area.

Area comparison	n		Median diversity index		P-value
	Reference	Affected area	Reference	Affected area	
Reference Area - Mount Haggin	10	12	0.55	1.51	0.0007 <sup>A</sup>
Reference Area - Smelter Hill	10	11	0.55	0.97	0.0422 <sup>A</sup>
Reference Area - Stucky Ridge	10	10	0.55	0.81	0.1207

<sup>A</sup> Significantly greater on the affected area at alpha=0.05.

subsequent natural recovery have resulted in early successional grass/shrub, aspen, and young conifer now occupying much of the affected areas. These processes of natural recovery have created a complexity of habitats that exhibit greater levels of horizontal diversity than are currently found in similar unaffected areas.

The creation of these disturbed areas has apparently introduced habitat elements which are beneficial to wild ungulate populations. This study showed that ungulate use on the affected areas is comparable to or higher than on the reference area, except for three comparisons. All three of the instances of lower use involved elk and are probably influenced substantially or confounded by the tendency of hunted elk populations to avoid human activities and roads (Hayden-Wing 1979, Morgantini and Hudson 1979, Ward 1976). Many researchers have reported that early successional habitats favor wild ungulate populations as much or more than the more mature forest types (Bagilen and Biggens 1976, Bartos and Mueggler 1979, Carlson et al. 1993, Degraaf et al. 1992, Forman 1995, Leege 1968, 1975, Leege and Hickey 1971, Ricklefs 1973, Skovlin 1982).

Mosaics of early seral stages are valuable to ungulates because of the production of forage and browse that is within reach of feeding animals (Gashwiler 1970, Irwin and Peek 1983). In addition, the larger scale landscape or region-wide vegetative mosaic, created by the interspersion of affected areas with less affected or unaffected areas, produces a level of heterogeneity that offers wild ungulate species more options and habitat values than the more uniform or monotypic habitats that would prevail in the absence of disturbances (Cowan et al. 1950, Leopold 1950, Martinka 1974). For example, Knowlton (1960) found that moose in the Gravelly Mountains of southwestern Montana moved out of feeding sites in willow bottom lands into adjacent coniferous timber during winter storms. Merrill et al. (1987) have described how elk best meet their foraging requirements in the early stages of forest succession, while their cover needs are best met in more mature

forest habitats. The interspersion of these two basic habitats is valuable in that it allows elk to meet all of their requirements within a relatively small total area. The comparability of big game use levels between such dissimilar sites as the affected and reference areas appears to be an expression of big game benefiting from the increase in habitat options produced by the close proximity of these sites and the opportunity to use different areas and habitat types for different purposes at different times of the year (Pearson et al. 1995).

Mule deer and moose appear to have benefitted from vegetative recovery on the upland study areas. Use of the affected areas is greater than or equivalent to use of the reference area (Table 2). This observation parallels the response of deer (Behrend and Patric 1969, Patton and McGinnes 1964, Pengelly 1963, Wallmo et al. 1972) and moose (Cowan et al. 1950, Crawford et al. 1994, Houston 1968) to areas disturbed by clear cutting and fire. The increase in early successional shrubs and herbage, including willow and aspen, on the affected areas has likely been beneficial to these species (Knowlton 1960, Stevens 1970). Of particular significance is the fact that such modified, early successional habitats favor deer populations (Crawford et al. 1994, Patton 1976, Regelin and Wallmo 1978, Regelin et al. 1974, Thill et al. 1983) which provide more recreation hunting days than any other species of big game in Montana (Bell 1996).

Because both mule deer (Reed 1981) and moose (Peterson 1955) are very tolerant of, and can become habituated to ongoing nearby human activities, measurements of their habitat utilization levels are relatively unaffected by these activities. Hunted populations of elk, however, require security cover and are known to avoid areas of human activity (Skovlin 1982). Measurements of area use patterns by elk are likely to be confounded by this behavioral conditioning.

There is good evidence that elk have also benefitted from vegetative changes on the affected upland

areas. Elk use on these areas, in three of the six tests, was either not significantly different or was significantly greater than use on the reference area (Table 2). The importance and suitability of early successional forest habitats to elk is well documented (Irwin and Peek 1983, Leege 1969, Moen 1973). Skovlin (1982) reports that elk prefer areas which have undergone habitat perturbations because such areas provide more edges or ecotones, greater habitat diversity, and a greater variety of forage plants used by elk than do adjacent undisturbed communities. Merrill et al. (1987) found that elk obtained a higher year-round energy intake from early successional forest habitats than from more mature habitats. The three comparisons in which elk use on the affected areas was significantly lower than on the reference area (Smelter Hill and Stucky Ridge) may represent the influence of high human activity. In these areas utilization patterns were influenced or modified by the behavioral characteristics of this species which cause it to avoid areas proximal to human activities. For example, elk use of areas within 0.4-2.9 kilometers of roads is less than on areas further removed (Burbridge and Neff 1976, Hayden-Wing 1979, Hershey and Leege, 1976, Lyon 1979, Marcum 1976, Morgantini and Hudson 1979, Pedersen 1979, Perry and Overly 1976, Rost and Bailey 1979, Ward 1976).

#### Mount Haggin

Deer, moose, and elk utilization levels on Mount Haggin are comparable to or significantly greater than those on the reference area (Table 2). Use levels which are significantly greater on Mount Haggin include: elk summer use, moose winter and summer use, and deer summer use. Mount Haggin is farther removed from Anaconda, provides more security cover than Smelter Hill and Stucky Ridge, and is not heavily roaded. Consistent with these characteristics, winter elk use of Mount Haggin is not significantly different than the reference area. The significantly higher summer elk use of Mount Haggin and the observation of 69 cows and calves there indicate that this site may be an elk calving and nursery area.

#### Smelter Hill and Stucky Ridge

Summer deer use on Smelter Hill and Stucky Ridge is significantly higher than on the reference area. The use of Smelter Hill and Stucky Ridge by deer during the winter and by moose during the winter and summer does not differ significantly from use levels on the reference area. However, elk use is significantly lower on both of these sites during both summer and winter (Table 2). Winter elk use on these areas is probably

influenced by their proximity to the Town of Anaconda, extensive road systems, and easy access to hunters and other recreationists. Winter elk use on Stucky Ridge has probably never been as great as on the reference area because it has historically been unforested and never provided security cover for elk in adequate amounts. Other human activities that have contributed to elk avoidance of the Smelter Hill area include construction and traffic disturbances along the north slope during removal of the smelter-related structures and support facilities. Other human activities that contribute to the continuing disturbances on Stucky Ridge include ongoing remediation activities.

#### Horizontal Diversity

The increases in early successional vegetation and wildlife habitats on the affected areas have resulted in an increase in the horizontal structural diversity of vegetation that is greater than that found on the reference area (Table 3). Edible grasses, forbs, shrubs, and trees increased in parts of the affected areas, as mature monotypic stands of pine and Douglas fir, which are of low food value to many wildlife species, decreased. Apparently this increase in horizontal diversity has largely compensated for, and in some cases surpassed, the effects of a concomitant reduction of forested areas and vertical diversity. In spite of reduced vertical diversity on the affected areas, wild ungulate populations are widely distributed and levels of big game use are generally equivalent to or higher than those on the reference area. These changes in vegetation have modified structural diversity, but apparently not simplified or reduced it.

The higher levels of horizontal diversity found on the affected areas probably explain why these sites support levels of deer, elk, and moose utilization that are, in most cases, comparable to or in excess of those found on the reference area. Because ungulate species obtain their forage near to or on the ground, a variety of habitat types along a horizontal plane is more important to them than a vertical variation in vegetative structure. Any vertical variation in vegetative structure that is out of reach is of no forage value to ungulates.

#### Regional Ecological Diversity

Local perturbations of mature forest habitat contribute to ecological diversity at the landscape or regional level by generating a variety in habitat structure and plant species composition over horizontal area or space. Areas of modified habitat produce a corresponding variety or diversity of wildlife species and,

as Lidicker (1995) has observed: "---they (landscapes) are characterized by a suite of new emergent properties that are not features of the community-types of which they are composed." This heterogeneity is an important component in the landscape that significantly contributes to species diversity and richness (Coleman et al. 1982, Patton 1992, Siderits and Radtke 1977, Thomas et al. 1979, Wiens 1976). The process of tree removal and regeneration is a natural one and has been going on for thousands of years primarily through forest fires, outbreaks of foliage-consuming insects, windthrow, and flooding. Over time a large range of plant and animal species have adapted to each of the many forest regeneration stages or seres. Mature forest is but one of these stages and supports its own unique compliment of wildlife species, as do each of the other stages. Therefore, in order to maximize species diversity, a region must contain a mixture or proportion of all of the many age phases in the forest regeneration series (Urban et al. 1987). Although the consideration of the spacial distribution of habitats at the landscape or regional level is important and desirable in land management (Urban et al. 1987), it is difficult to accomplish and is seldom achieved (Hansen et al. 1992).

Structured field studies, along with extensive opportunistic sightings and field observations, indicate that fourteen years after the closure of the last remaining smelter (Washoe Smelter) wild ungulate habitats on the affected areas have undergone substantial natural recovery and sustain levels of mule deer, moose, and elk use that are comparable to unaffected upland habitats typical of this area of Montana. Although rates vary considerably, other researchers have reported relatively rapid recovery rates for vegetation on certain areas severely impacted by anthropomorphic and natural events (Franklin et al. 1988, Kauffman et al. 1995, Winterhalder 1995b).

This study supports the contention of Kauffman et al. (1995) that it is important to understand the extent to which "ecological processes facilitate recovery." This study also reinforces the need for: (1) the management of wild ungulate habitats at the landscape or regional level, and (2) biologists working together with restoration ecologists in the formulation and execution of restoration goals.

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