NATIONAL COAL UTILIZATION
ASSESSMENT

**Big Game Resource in the
Powder River Basin Region,
Montana - Wyoming**

July 1977

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June 1977

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SUMMARY

The big game resource in the Powder River Basin Area of Wyoming and Montana is an integral part of the environment. Historically, big game animals have fared badly as man-induced regional landscape changes have favored domestic livestock and cultivated crops. The last stronghold of big game animals is in the sparsely populated Western states. Large populations of pronghorned antelope, mule deer and white-tailed deer reside in the Powder River Basin Area. The two major constraints that keep the present big game populations in concert with the available range are severe winter weather and regulated hunter harvests. The annual hunter harvest of animals averages about 23,000 antelope and 60,000 deer.

Coal extraction will displace big game animals from parts of their range overlying surface minable coal seams. Conventional land rehabilitation practices will probably restore the mined lands to a condition acceptable to big game but the time span is in terms of decades.

Coal combustion and its associated airborne releases, especially in terms of long-term, low level releases is too poorly known to assess its impact on the big game resource at this time.

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HISTORICAL BACKGROUND

Accelerating demands on land use and outdoor recreation challenge the future of wildlife in the western United States, the last remaining stronghold of big game in the contiguous United States. Wise land use depends upon the knowledge, attitudes, and needs of all land owners, Federal, state, and private. Thus, wildlife is an important aspect of the Powder River Basin in southeastern Montana and northeastern Wyoming. Hunting and spectator enjoyment of wildlife is an integral part of the environment.

The advent of livestock grazing to the Powder River Basin, about 1860, signaled the beginning of the end for the very large native herbivores, bison and elk, and their large predators, wolf and grizzly bear (Mussehl et al., 1971). Regional populations of deer and antelope were at all time lows in the 1920's. To the wildlife, the drought years of the 1930's imposed severe stresses but also had some benefits by relieving agricultural and livestock uses of marginally productive land. When rainfall again became more plentiful in the late 1930's, antelope and deer populations benefited as forage quality increased and by the mid-1940's populations were building up.

The severe drought conditions were, in part, responsible for withdrawal of low productivity lands from intensive livestock and crop use in the early 1930's. However, increased productivity of agricultural lands in the mid-western states through improved crop plant genetics, low-cost chemical nitrogen fertilizers, and improved soil tillage and plant harvesting machinery made agricultural use of the less productive land economically unprofitable in comparison with more fertile acreages in the plains states to the east.

Along with an increased effort in crop research an awareness also was developed to manage semiarid lands that are characteristically too dry, stony, or steep to plow for crops, to produce meat without irreparably destroying the sparse cover of nutritious, native grasses. This created a new field of study now known as Range Science. Range Science research centers on establishment of optimum livestock stocking levels; seasons of

grazing use; eradication of unpalatable, nonforage plants (shrubs and trees) through applications of chemical herbicides or fire or the mechanical ripping or uprooting woody plants by bulldozing; introduction of alien grasses; fencing to provide rotational grazing patterns; development of watering sites; disease prevention and the selective control of large predators (e.g. coyote) and small but sometimes abundant herbivores, lagomorphs, rodents and insects.

At the turn of the century, however, modern game management practices designed to preserve remnant wildlife populations as natural resources were initiated. Game management is much like range management except that there is much less physical control of individual animals. Game research centers on maintaining wildlife populations in concert with the ability of the range to provide suitable forage during the most stressful seasons of the year. In the Powder River Basin, this is usually winter for deer and antelope populations. In the absence of large mammalian predators, the population constraint is either hunter harvests or severe winter weather coupled with a shortage of nutritious forage plants.

Superimposed upon the traditional land uses of crop production, range and game management is an expanding new land use related to energy development. This new land use involves surface mining of coal seams, coal combustion, coal gasification and transportation of electricity, coal, or coal gas from the Powder River Basin to the more densely populated parts of the United States.

COAL DEPOSITS

The Powder River Basin area is characterized by many acres underlain by surface mineable coal. Montana lists approximately 1.4 million acres and Wyoming 0.4 million acres (Figures 1 and 2) (Packer, 1974). The total acreage amounts to about 1.8 million acres in the general area designated as the Powder River Basin (NGPRP 1975). This region contains nearly 240 billion tons of sub-bituminous coal. Clearly, there is potential for displacement and possible local extirpation of native mule deer, white-tailed deer and antelope populations during coal extraction and during the time required to restore vegetative cover to the rehabilitated pits.

According to Packer (1974) surface-mined acreages in southeastern Montana and Wyoming have the potential for successful revegetation as judged from a review of existing knowledge and demonstration practices.

FIGURE 1. Surface Mineable Coal Deposits in Southeastern Montana Showing Locations of Active Surface Mines (after NGPRP 1975)

FIGURE 2. Surface Minable Coal Deposits in Northeastern Wyoming Showing Locations of Operating and Proposed Surface Mines (after NGPRP 1975)

NATIVE VEGETATION

The native vegetation of the Powder River Basin is mostly grassland characterized by perennial wheatgrasses, needlegrasses, gramma grass, blue-stems, and fescues. Overgrazing by buffalo, and later by livestock, has resulted in a general increase in sagebrush and rabbitbrush, especially in the shortgrass prairies (Packer, 1974). The cold-desert vegetation type, dominated by sagebrush, and the montane-coniferous forest vegetation type, dominated by ponderosa pine, also occur in the Powder River Basin. Cottonwood, willow, and ash trees of the deciduous forest vegetation type dominate the gully bottoms along streams and rivers. Fourwing saltbush, and saltgrass usually indicate the presence of alkaline or saline soils. Frequently, sand sage and prairie sandreed occupy the most sandy areas. Nine broad vegetation types occur on surface mineable seams. A brief description of these vegetation types in respect to their suitability and availability for rehabilitation is briefly discussed in the following paragraphs.

1. Floodplain. This vegetation type occurs on the bottomlands and banks of major rivers and on the broad floodplain terraces that have alluvial soils. It occupies sites, some highly saline, that have high water tables. The floodplain type is characterized predominately by hardwood trees and shrub species that are poorly suitable and not readily available for rehabilitation purposes.
2. Badlands. This vegetation type occupies steep broken lands along rivers and streams and the steep south slopes of exposed shales, sandstones, and clays. Dominant plant species are arid land shrubs and grasses associated locally with poor growth ponderosa pine forests. The species that characterize this type are poorly suitable and not readily available for rehabilitation purposes.
3. Short-Grass Prairie. This vegetation type occupies shallow soils. Dominant species are blue grama grass, western wheatgrass, and various

needlegrasses. The species that characterize this type have moderately poor suitability and fair availability for rehabilitation.

4. Mid-Short Grass Prairie. This type occupies rolling prairies on loam to clay loam soils in eastern Montana. It is characterized by western wheatgrass, needle-and-thread grass and blue grama grass. These species have moderately poor suitability and only fair availability for rehabilitation.
5. Mid-Grass Prairie. This type, which occurs on loamy soils in extreme eastern Montana, southwestern North Dakota, and northwestern South Dakota, contains no dominant short grass species. Principal species are needlegrasses, wheatgrasses, and blue stem grasses. Most species that comprise this type are fairly suitable and have good availability for rehabilitation.
6. Grassland-Sagebrush. This vegetation type occurs with scattered sagebrush, and occurs on silty clay loam soils in southeastern Montana and northeastern Wyoming. Most of the species that comprise this type have good suitability and moderately good availability for rehabilitation.
7. Sagebrush-Steppe. This type is dominated by sagebrush in open grassland stands containing wheatgrasses and needle-and-thread on silt to silty clay loam soils. It occurs chiefly in northeastern Wyoming and most of the major species have moderately good suitability, but are presently unavailable for rehabilitation.
8. Mid-Tall Grass Prairie. This vegetation type occurs on gently rolling prairies northeast of the Missouri River in North Dakota, and is characterized by wheatgrass, big and little bluestem grass, and needle grass on loam soils of glacial till origin. Nearly all species in this type have good suitability and availability for rehabilitation.
9. Ponderosa Pine Forest. This vegetation type occurs mainly on uplands, ridges, and north slopes that have shallow loam soils. Prominent

species are ponderosa pine, snowberry, blue grass, fescue, and June grass. These species are only fairly suitable, but have good availability for rehabilitation.

EXISTING VEGETATION MOSAIC

The existing vegetation mosaic (pattern) in the Powder River Basin consists of a matrix of native plant communities intermixed with cultivated fields. The most intensively used lands are the valley bottoms and the dryland wheat fields. The native plant communities are grazed by sheep and cattle. Logging is practiced in the forested areas. Satellite imagery "Landsat" is an accurate and relatively inexpensive way that has been employed in documenting the distribution of vegetational patterns in the Powder River Basin area. Its main value is its ability to repeatedly record changes in vegetational patterns at various time periods ranging from weeks to years.

REHABILITATION POTENTIAL

The native vegetation types and their species represent the endogenous potential for reestablishment of native plant cover on surface-mined areas after surface soil has been replaced. In places where higher precipitation and more fertile soils occur, surface-mined lands may be restored to agricultural uses rather than to native cover types. In some instances, surface-mined lands may lend themselves to other uses such as development of parks, lakes, marshes, or forests. Except for rehabilitating agricultural lands and for occasional specialized reclamation opportunities, the greatest potential for rehabilitating surface-mined lands lies in using native plant species that characterize each area (Packer, 1974).

Most plant ecologists believe that in the long-term, i.e. a century or more, native plants are the most suitable for rehabilitation purposes. That is, these kinds of plants have evolved over long periods of time in concert with gradually shifting climatic regimes and a developing soil profile. They are, therefore, the logical choices for rehabilitation trials. However, range managers concerned with livestock production often opt to plant exotic grasses as monocultures to produce more meat per acre. On the other hand, wildlife managers often opt for mixed species plantings that can produce both food and shelter for several selected wildlife species.

Almost all researchers and land users agree that the productivity of a particular site is determined by the microclimate, the quality and quantity of soil as a plant rooting medium, and the inherent genetic constitution of the plant species grown on the site.

Most researchers also agree that plant communities are subjected to two kinds of environmental stresses: 1) abiotic stresses that are characterized by temperature extremes, drought, wind, fire, soil quality etc., and 2) biotic stresses such as grazing, intra and inter-species competition, diseases, phytotoxins, etc.

As a general rule environmental stresses are relatively well understood for crop plants but little is known about stresses in rangeland plant communities. One of the reasons for this is that most crop plants are annuals while rangeland plants are perennials. Experimental protocols are easier to perform with annual species because of the shorter time in completing life cycles.

REHABILITATION PROCEDURES AND COSTS

For the most part, the aim of revegetation is to provide a self-sustaining vegetative cover that can provide for long-term sustainment of wildlife and/or livestock at a level equal to or better than that before the advent of surface mining.

At the time of this writing, estimates of direct onsite rehabilitation costs range from approximately \$700 to \$1,800 per acre, depending upon the location and the special problems encountered. Rehabilitation costs include land shaping, seedbed preparation, seeding, fertilizing, soil amendments, water control on slopes, mulching, sediment control in retention basins, shrub or tree planting, and soil surfacing. Sites having the poorest potentials for rehabilitation are located in northeastern Wyoming where the sites are characterized by unproductive soils, native species that grow slowly and are difficult to obtain for rehabilitation purposes, and low annual precipitation. Surface mineable sites that have intermediate rehabilitation potentials are predominant in southeastern Montana.

BIG GAME RESOURCE

Three big game species provide almost all of the harvestable big game animals in the Powder River Basin. These are the pronghorn antelope, mule deer and white-tailed deer (Mussehl, 1971). As a general rule, the preferred habitats of big game animals are those places most isolated from direct human contact. As a general rule, mule deer prefer the roughest topography with scattered stands of ponderosa pine; the white-tailed deer prefer the brushy draws and heavily forested slopes. Antelope prefer the open grassy plains.

BIG GAME TOLERANCE TO PEOPLE

A brief summary of critical environments and general tolerance to people is shown below:

<u>Big Game Species</u>	<u>Critical Environment</u>	<u>Tolerance of People</u>
Mule Deer	Winter forage--rough topography	Moderate
White-tailed Deer	Winter forage--dense brush	High
Pronghorn Antelope	Winter forage--open grassy plains	Low

White-tailed deer often are quite tolerant of people, relying on dense plant cover for protective shelter. Antelope are very wary of the presence of people. Mule deer are intermediate in tolerance to people, relying mostly upon rough topography as protective escape shelter. In winter, tolerance to people increases as food becomes scarce, especially during periods of deep snow cover. A limited amount of suitable winter range is often the critical factor in maintaining big game populations. Because winter range is usually restricted to the lowest elevations and valley bottoms, the interface between big game animals and agriculture is most evident in the cultivated river valleys.

Although big game animals eat a wide variety of plants and plant parts, there are clear preferences for certain plant species. These preferences

change with the season of the year and the changing availability and quality of forage. Some of the more important big game forage plants are listed in Table 1.

LAND USES THAT AFFECT BIG GAME POPULATIONS

Some of the land uses that either have affected or have the potential to affect big game populations are summarized below.

Man-induced Landscape Changes

- Farming is the most widespread land use that directly impacts game animals. Cultivation is harmful to those animals that depend largely upon native plants for food and/or shelter, e.g., antelope. Crop raising pre-emptes the best soils and the crops are designed to be of maximum benefit to man either as direct food for man or indirectly as forage for livestock. However, some of this production can be used by wildlife in the period between planting and harvest and sometimes crop residues (unharvested) also provide big game forage.
- Livestock Grazing. Grazing is practiced on soils generally too shallow or the topography too steep to plow. Spring, summer, and fall grazing can affect the amount of winter forage left for big game animals. Lack of winter forage causes big game encroachment on cultivated crops.

On these less productive acres, big game animals often compete for forage with domestic sheep and cattle. This association can be harmful to big game if summer and autumn grazing by livestock depletes the supply of critical winter forages.

Livestock growers generally attempt to manage rangeland pastures for maximal production of livestock forages and try to control plants that are not palatable to livestock. However, sometimes these nonpalatable plants are the critical wildlife forages.

TABLE 1. Forage Plants in the Powder River Basin Area

<u>Forage Class</u>	<u>Species Use</u>
<u>Grasses</u>	
Bluebunch wheatgrass	Cattle
Needle-and-thread grass	Cattle
Crested wheatgrass ^(a)	Cattle
Western wheatgrass	Cattle
Blue grama grass	Cattle
Brome grasses ^(b)	Cattle
<u>Small-leaved Short Shrubs</u>	
Bitterbrush	Mule Deer
Big sagebrush	Mule Deer, Antelope
Fringed sagebrush	Mule Deer, Antelope
Silver sagebrush	Mule Deer, Antelope
Rabbitbrush	Mule Deer
Mountain mahogany	Mule Deer
<u>Broad-leaved Medium-tall Shrubs</u>	
Chokecherry	Mule Deer, White-tailed Deer
Service berry	Mule Deer, White-tailed Deer
Mountain maple	Mule Deer, white-tailed Deer
Dogwood	Mule Deer, White-tailed Deer
Evergreen ceanothus	Mule Deer, White-tailed Deer
Red-stemmed ceanothus	Mule Deer, White-tailed Deer
Skunk Bush	Mule Deer, White-tailed Deer
Snowberry	White-tailed Deer
<u>Herbaceous Broad-leaved Plants</u>	
Many species, particularly	All classes of wildlife
Compositae, Leguminosae, and	
Cruciferae (annual weeds)	
<u>Crops</u>	
Wheat (Dryland)	Cattle
Alfalfa (Irrigated)	Cattle, White-tailed Deer, Mule Deer

(a) Introduced from Eurasia and widely used in rangeland revegetation, not a self-sustaining species.

(b) Introduced (inadvertently) from Eurasia regarded as a rangeland pest, self-sustaining on abused native habitats.

- Shrub Eradication. Shrub eradication is commonly practiced by livestock raisers to eliminate plants that are not used much by sheep and cattle. However, shrubs, e.g., sagebrush, are critical winter forage for both sagegrouse and antelope. Chemical herbicides (2,4-D) have been applied by aircraft to kill sagebrush over very large acreages. Fire can also be effective in eradication of sagebrush. The theory behind shrub eradication is that grass growth can be improved by removing shrub competition for scarce soil mineral nutrients and soil water.
- Revegetation. Severely depleted range lands can result from years of excessive livestock grazing use. These lands can again become productive by seeding with crested wheatgrass or other forage grasses. However, maintenance of forage yields will probably require repeated seedings and prudent stocking rates.
- Logging. Cutting of mature stands of ponderosa pine is profitable for lumber. Pine stands provide important shelter for mule deer. Clear cutting could jeopardize local populations. Pine recovery is in terms of decades. Forests are managed to yield wood or wood products sometimes with little thought of forage production for wildlife or livestock use.
- Surface Mining. Surface mining is destructive of vegetative cover and, for a time, the mined land is removed from biological productivity. Mine operators are required by law to return surface mined lands to approximate original land forms, provide topsoil cover, and plant a self-sustaining vegetative cover. The acceptability of rehabilitated lands by wildlife is unknown. Restoration of herbaceous cover is probably in terms of about 1 decade, shrubs 1-2 decades and trees 3-4 decades.
- Air Pollution. The airborne release of combustion products has the potential for long-term effects of SO_2 on plant growth, trace metal buildup in soils with potential for selective uptake by plant species, and transfer to diets of deer, antelope, and domestic livestock. These effects are mostly unknown.

- Recreation. Hunting has a direct impact on big game populations. Hunting is a useful way to keep populations within the limits of the range to provide water, shelter and forage. All terrain vehicle use can be deleterious to big game if their populations are harassed in winter when the population is under physiological stress or during the critical first few days of the fawning season.

BIG GAME BEHAVIOR

Big game populations are seldom restricted to small acreages. One notable exception is the white-tailed deer. An individual deer may spend its entire life within the boundaries of a few hundred acres. Mule deer and antelope are wanderers; sometimes herds may move tens of miles between summer and winter ranges. These kinds of movements are sometimes advantageous to nomadic herds because it provides a way to conserve forage by utilizing different parts of the range at different seasons of the year, i.e., summer range is used when plants are green and growing. In summer, plants on winter ranges are growing without grazing or browsing stress. When animals return to winter ranges, they consume the dried and cured plant parts produced during the previous summer. If winter ranges are used for summer livestock foraging, there may be little food left for game animals. There is often competition between game animals and livestock on Federal and private lands. Federal lands are sometimes leased to livestock raisers for summer grazing and private lands may be invaded by herds of big game animals during winter.

The barbed wire fence is an effective, long lasting, and relatively inexpensive way to confine livestock to specific pastures so that forage use can be most effectively used during the proper season. Ordinary range pasture fences are no real obstacle to mule deer, which are good jumpers, or white-tailed deer, which can jump and crawl. However, antelope seldom jump and rely on crawling beneath fences to move from one place to another. However, fences that are tight enough to confine domestic sheep are often impassable to antelope. Such fences can seriously impede the normal movements of antelope unless provisions are made to permit antelope passage by providing special openings.

BIG GAME HARVEST DATA

In the virtual absence of other large mammalian predators, hunting is a practical and useful way to keep healthy populations of deer and antelope at levels synchronous with the range's ability to provide nutritious foods, water and shelter. If populations are in equilibrium with the land, any loss of acreage or use of land that is not compatible with the physiological or social requirements of deer and antelope is deleterious to the overall regional population.

One of the aims of big game management is to regulate the annual hunting harvest to keep the herds in check but not to overharvest the animals so that the potential for reproduction is impeded, i.e., harvest exceeds births. To regulate the harvest, hunting seasons (days) are set, game management districts (geographic areas) are designated and licensed hunters are polled by mail to obtain an estimate of the number of deer and antelope killed each year. The following data are taken from game department records from Montana and Wyoming.

ANTELOPE HARVESTS

The estimated hunter kill of antelope in southeastern Montana averaged nearly 7000 animals in the 1973 and 1974 hunting seasons. All antelope management districts (Figure 3) in southeastern Montana produced some animals but some districts were much more productive than others (Table 2). For example district number 720 produced only 6 animals in 1973 and 4 in 1974. At the same time district number 730 produced an estimated 1142 animals in 1973 and 990 in 1974.

Game management districts include the operating mines at Colstrip and Decker (districts 722 and 740). These districts produced 3.1% of the harvested antelope in 1973 and 2.5% of the harvest in 1974.

The estimated hunter harvests of antelope in northeastern Wyoming averaged about 16,000 animals each year over a 3-year period, 1972-1974 (Table 3). Harvest ranged between 205 in game district 21 to 1832 in district 26.

FIGURE 3. Antelope Management Districts in Southeastern Montana

Two game districts in the heart of the surface mineable coal area, (districts 17 and 23) produced 11% of the antelope harvest (Figure 4).

MULE DEER HARVEST

The estimated hunter harvests of mule deer in southeastern Montana game management districts is shown in Table 4. The total harvest varied from year to year; 23,102 (1972), 21,754 (1973) and 15,559 (1974). Three game management districts in the Colstrip and Decker mining areas (722, 740, 742) produced 12% of the mule deer harvest (Figure 5). The same general decline in harvest experienced in southeastern Montana was also reflected in the presently active mining districts.

TABLE 2. Hunter Harvests (Estimates) of Antelope from Game Management Districts in Southeastern Montana 1973 and 1974

District No.	1973				1974			
	M	Fe	Fa	Total	M	Fe	Fa	Total
710	278	139	17	434	332	96	24	452
711	340	160	0	500	275	122	10	407
712	369	246	25	640	241	127	25	393
713	62	21	5	88	70	24	3	97
714	--	--	--	--	76	36	16	128
720	6	0	0	6	3	1	0	4
721	142	50	0	192	112	24	18	154
722	67	28	0	95	83	28	3	114
730	904	238	0	1142	699	252	39	990
731	247	268	19	534	270	160	11	441
733	--	--	--	--	363	116	29	508
740	76	38	0	114	43	21	0	64
741	162	57	19	238	174	67	0	241
742	111	44	0	155	123	65	12	200
743	165	82	9	256	224	109	0	333
750	46	11	0	57	44	11	0	55
760	86	57	0	143	111	33	7	151
761	551	147	37	735	443	207	15	665
770	195	43	0	238	200	61	24	285
771	269	23	12	304	182	97	0	279
772	73	13	0	86	117	28	3	148
773	--	--	--	--	--	--	--	--
780	195	171	0	366	210	102	29	341
781	296	99	37	432	210	87	15	312
782	36	3	0	39	26	7	0	33
	4676	1938	180	6794	4631	1881	283	6795

M = Male, F = Female, Fa = Fawn

TABLE 3. Hunter Harvests (Estimates) of Antelope from Game Management Districts in Northeastern Wyoming 1972, 1973 and 1974

<u>District</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>$\bar{X}$</u>
1	--	437	604	347
2	499	273	499	424
3	--	--	--	--
4	272	355	328	318
5	--	294	565	286
6/7	1177	1424	1634	1412
8	1315	1316	1245	1292
15	170	207	268	215
16	218	386	349	318
17	943	1414	1984	1447
18	345	400	472	406
19	759	914	1004	893
20	652	876	1076	868
21	138	219	257	205
22	420	869	980	756
23	1160	1747	2156	1688
24	661	880	1866	1136
25	383	525	563	490
26	1735	1861	1900	1832
27	<u>1632</u>	<u>1627</u>	<u>1765</u>	<u>1675</u>
Total	12,479	16,024	19,515	16,008

The estimated hunter harvest of mule deer for northeastern Wyoming is shown in Table 5. The harvests were 15,444 (1972), 25,893 (1973) and 23,270 (1974). The two game management districts in the area where coal can be stripped (districts 18 and 21) produced 19% of the mule deer harvest in northeastern Wyoming (Figure 6).

FIGURE 4. Antelope Management District in North-eastern Wyoming

WHITE-TAILED DEER HARVESTS

The estimated hunter harvest for white-tailed deer in southeastern Montana is shown in Table 4. The harvest of white-tailed deer was 5,742 (1972), 5,584 (1973) and 1,460 (1974). About 5% of the harvest was from the Colstrip and Decker mining areas (districts 722, 740, 742).

The estimated hunter harvest for white-tailed deer in northeastern Wyoming is shown in Table 5. More white-tailed deer were killed in Wyoming than in Montana largely because of the very favorable white-tailed deer habitat found in the Black Hills area of extreme northeastern Wyoming. The harvest was 4,306 (1972), 9,174 (1973) and 12,328 (1974). Only a few white-tailed deer were killed in districts 18 and 21.

TABLE 4. Hunter Harvests for Deer (Estimates) from Game Management Districts in Southeastern Montana

Dist. No.	1973				1974				1975			
	M	W	U	Total	M	W	U	Total	M	W	U	Total
510	124	4	8	136	279	13	30	322	72	0	4	76
512	119	9	9	137	--	--	--	--	43	23	3	69
592	--	--	--	--	--	--	--	--	152	18	0	170
710	2369	487	129	2985	1257	597	140	1995	--	--	--	--
720	266	99	17	382	264	113	23	400	391	156	16	563
721	555	85	42	682	328	131	35	494	460	142	36	638
722(a)	657	16	20	693	503	107	25	635	490	51	34	575
730	1742	406	49	2197	1564	603	91	2258	828	814	43	1685
731	522	718	38	1278	311	730	55	1096	18	370	14	402
740(a)	964	34	39	1037	835	106	65	1006	737	137	43	917
741	2223	215	40	2478	1762	232	55	2049	594	255	29	878
742(a)	1980	89	54	2123	693	70	57	820	367	46	66	479
743	2005	141	78	2224	1858	151	78	2087	327	90	20	437
744	0	892	26	918	--	--	--	--	1344	144	53	1541
760	1089	221	34	1344	885	256	63	1204	416	237	18	671
761	1869	571	116	2556	1559	618	107	2284	916	1061	84	2061
770	1235	249	33	1517	1417	184	72	1673	1150	358	63	1571
771	1919	430	69	2418	2668	652	105	3425	2399	1043	138	3580
781	197	389	0	586	600	262	28	890	1430	1417	141	2988
782	206	327	16	549	552	177	38	767	323	357	59	739
790	1255	229	23	1507	1742	345	47	2134	1556	474	101	2131
791	1294	31	57	1432	1684	121	67	1872	1129	111	40	1280
792	512	50	24	586	993	116	39	1148	417	156	25	598
	23,102	5,742	921	29,765	21,754	5,584	1,220	28,558	15,559	7,460	1,030	24,049

M = Mule deer; W = White-tailed deer; U = unknown

Estimates by hunter questionnaires includes resident and nonresident hunters.

(a) Colstrip and Decker mining area

FIGURE 5. Deer Management Districts in Southeastern Montana

FIGURE 6. Deer Management Districts in Northeastern Wyoming

TABLE 5. Hunter Harvests of Deer (Estimates) from Game Management Districts in Northeastern Wyoming 1972, 1973 and 1974

Dist.	1972			1973			1974			$\bar{X}$
	M	W	Total	M	W	Total	M	W	Total	Total
1	253	231	484	889	947	1836	998	1317	2315	1545
2	263	1855	2118	728	4006	4734	711	6166	6877	4576
3	166	261	427	492	1110	1602	453	906	1359	1129
4	75	706	781	171	1208	1379	186	1320	1506	1222
5	144	34	178	346	380	726	597	609	1206	402
6	68	45	113	395	141	536	631	241	872	507
7	116	7	123	214	0	214	183	0	183	173
8	309	26	335	475	0	475	619	36	655	488
9	196	14	210	238	0	238	211	0	211	219
10	155	0	155	309	0	309	296	20	316	260
11	154	7	161	495	0	495	364	10	374	343
12	228	10	238	502	0	502	441	0	441	393
13	431	17	448	1090	0	1090	963	54	1017	851
14	228	0	288	1070	0	1070	890	9	899	752
15	--	--	--	--	--	--	--	--	--	--
17	580	10	590	1529	0	1529	1375	80	1455	1191
18	1016	62	1078	3042	0	3042	2528	186	2714	2278
19	263	0	263	485	0	485	266	0	266	271
20	149	0	149	313	0	313	246	0	246	236
21	397	0	397	817	0	817	753	0	753	655
22	427	0	427	1590	0	1590	851	15	866	961
23	2645	143	2788	2768	237	3005	2322	235	2557	2783
24	622	281	903	384	455	839	670	402	1072	938
25	566	61	627	490	0	490	378	0	378	498
26	1309	74	1383	1290	173	1463	1062	155	1217	1354
27	672	354	1026	688	241	929	714	205	919	958
28	581	32	613	313	29	342	210	22	232	395
29	215	16	231	145	0	145	153	36	189	188
30	1085	54	1139	1063	104	1167	1100	140	1240	1182
31	464	6	470	831	0	831	734	38	772	691
32	527	0	527	585	0	585	404	8	412	508
33	722	0	722	1222	143	1365	1345	111	1456	1181
34	358	0	358	924	0	924	616	7	623	635
	15,444	4,306	19,750	25,893	9,174	35,067	23,270	12,328	35,598	29,783

M = Mule Deer; W = White-tailed Deer

AIRBORNE CONTAMINATION AND BIG GAME

Ambient air quality standards have been established under the Clean Air Act Amendments of 1970 for the major, but not all, pollutants generated by fossil fuels. National Ambient Air Quality Standards (NAAQS) have been established for sulfur oxides (SO_x), particulates, carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons, and oxidants. These standards were based upon the best information available at the time of their promulgation. New source performance standards (NSPS) have been established for several industries, including electric utilities. These new standards restrict the emissions of SO_x , NO_x , particulates, and other pollutants and apply to the operation of fossil fueled generating stations constructed or modified after August 1971 (United States Environmental Protection Agency, 1976).

The Clean Air Act states that "...air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutants in the ambient air, in varying quantities" [Section 108(a)]. The Act further states that national primary ambient air quality standards are regulations which "...in the judgment of the administrator, based on such criteria, and allowing for an adequate margin of safety, are requisite to protect the public health" [Section 109(b)]. Air quality criteria, then reflect scientific knowledge, while primary air quality standards involve a judgment as to how this knowledge must be used in a regulatory action to protect public health. The secondary air quality standards determine the level of air quality required to protect the public welfare. Public welfare as defined in the Clean Air Act "...includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate..." [Section 302(h)].

The major categories of air pollutants emanating from fossil fuel energy stations are sulfur oxides, nitrogen oxides and particulate matter. These stations also contribute, to a lesser degree, to carbon monoxide and oxidant

burdens. Primary ambient air standards, based on health effects, have been established for these pollutants. Secondary standards have been established for sulfur dioxide, particulates, carbon monoxide, oxidants, hydrocarbons, and nitrogen dioxide. These standards are based on the best scientific information available at the time of their establishment. However, when they were established, significant knowledge gaps existed; even now major gaps in knowledge still exist for each pollutant. Therefore, under the Clean Air Act, EPA is required to continually examine and update the criteria for these standards. In addition to the above pollutants, numerous trace metals (such as copper, cadmium, zinc, lead, arsenic, mercury, and others), are emitted from coal-fueled power generating stations. In general, trace metals are emitted as particles adsorbed to fly ash and/or other particulate matter coming from the stack.

The following text represents a general overview of the EPA's Corvallis Ecological Research Laboratory's (CERL) coal-fired power station project in southeastern Montana (United States Environmental Protection Agency, 1976). The broad objective of the CERL program is to develop a set of guidelines to predict the impact of operational power stations on a grassland ecosystem. The study is concerned not only with the stability of ecosystem organization in relation to ambient conditions, but also with the predictability and reproducibility of the kinds of changes that do occur. It is the first attempt to develop methods that can predict bioenvironmental effects of air pollution before any damage is sustained. Historically, most terrestrial air pollution field research has dealt almost exclusively with direct, usually acute, effects on vegetation. However, this investigation intends to observe changes in ecosystem dynamics as a function of long-term, low level, chronic pollution challenges.

Even in a comprehensive investigation, extensive studies of a large array of species or processes is not possible. Considerable research is required to identify the specific parameters that will give an adequate, sensitive measure of air pollution to a grassland ecosystem and/or its

components. Probably the best documented account of airborne contamination in an ecological system that sustains a sizeable big game animal population is the study conducted by the U.S. AEC on the Alaskan Arctic caribou herd (Hansen and Palmer, 1965). The contamination was airborne radioactivity derived from the testing of nuclear weapons. Caribou obtained the world's highest body burdens of radiocesium by selectively foraging upon species of lichens during the winter months. The radiocesium in flesh of caribou was subsequently transferred to Alaskan people that depended upon caribou meat as a dietary staple. The impact of the increased body burdens on the caribou herd has not been fully investigated but accurate records have been kept of the changing body burdens of ^{137}Cs in the native population at Anaktuvuk Pass (Hedlund, 1975). Broad categories of important functions under investigation include; 1) productivity or biomass of ecosystem compartments, 2) life-cycle and population dynamic functions of "key" taxa, 3) community structure or diversity, 4) nutrient cycling, 5) sublethal biochemical or physiological changes in individuals or compartments, 6) behavior of mobile organisms, and 7) reproductive patterns and breeding success of terrestrial vertebrates.

Although CERL's ecosystem approach as implemented in southeastern Montana is commendable, the experimental design does not at this time include cattle or big game animals. Therefore it is necessary to rely upon the sparse available information concerning visible SO_2 damage (effects) on those plants that can serve as food or shelter for big game animals (Hill et al., 1974).

Research on the environmental impacts and monitoring of trace metals and SO_2 and other gaseous effluents is in the incipient stages of development. Some preliminary data on the concentrations of SO_2 required to observe damage in wild plants is shown in Table 6. These data indicate that the broad-leaved, deciduous plants are usually more sensitive than others.

Information concerning the potential impact of future releases of SO_2 upon crop plants is presented by Sauer (1976).

TABLE 6. Percent of the Total Leaf Area Injured by Different Concentrations of SO₂ in Fumigation Studies of Important Wildlife Forage and Shelter Species in the Western United States

	ppm						
	0.5	1	2	4	6	10	
<u>Broad-leaved Deciduous Trees and Shrubs</u>							Most Sensitive
Mountain Maple	-	0	-	10	60	-	↓
Serviceberry	0	0.2	3	22	33	80	
Snowberry	-	0.3	6	18	32	-	
Narrowleaf Cottonwood	0	0	2	11	20	-	
<u>Forbs</u>							
Goatsbeard	-	-	0	4	8	-	
Yarrow	-	0	0	0	10	30	
<u>Small-Leaved Short Shrubs</u>							
Mountain Mahogany	-	-	-	5	-	-	
Big sagebrush	-	-	0	4	9	-	
Rabbitbrush	0	0	0	0	1	-	
Rocky Mountain Juniper	-	0	-	0	0	25	
Skunkbush	-	-	-	-	0.3	0	
<u>Grasses</u>							↓
Crested Wheatgrass	-	-	-	-	20	-	
Blue Gramma	-	-	-	-	0	-	
Cheatgrass	-	-	0	0	0	10	
<u>Conifers</u>							
Ponderosa Pine ^(a)	-	-	-	0	0	1	
							Insensitive

(a) Shelter species

CONCLUSIONS

The mule deer is the most abundant big game animal in the Power River Basin of southeastern Montana and northeastern Wyoming and the white-tailed deer is probably the least abundant as indicated by hunter harvest. Because of the dense brushy habitats preferred by white-tailed deer, hunter harvests may not accurately reflect the size of the population. That is hunters may take fewer animals because animals are more difficult to locate. Strip mining will have relatively little direct impact on Wyoming white-tailed deer because the center of the white-tailed deer population is not in the coal seam area. Strip mining will probably have a more direct impact on white-tailed deer populations in Montana where potential coal-stripped acreages are more extensive and the deer population is apparently more evenly dispersed. Strip mining will have a deleterious impact on mule deer populations in Montana and Wyoming primarily because mule deer are less tolerant of man's activities than white-tailed deer and because mule deer are also well dispersed throughout the areas where coal can be stripped.

A substantial part of the antelope population in the United States is centered on and around the surface minable deposits in northeastern Wyoming. Antelope are probably the least tolerant of the three big game species to human intervention and will therefore likely be most affected by strip mining.

Disturbances to big game animals resulting from mining can be categorized as loss of vegetation (food and cover), changes in drinking water availability, changes in water quality, noise, increased contacts with people, and barriers to animal migration or grazing patterns and illegal hunting (poaching).

The loss of vegetative cover is clearly the most obvious and immediate impact of mining. Loss of shelter and forage is expected. On the other hand, the lush vegetation sometimes reestablished on irrigated and fertilized restored pits may supply above-average quantity and quality forage at least temporarily. The overall consequences of more verdant restoration, particularly if over a large area, may be significant to big game populations and create conflicts between cattle and big game use for use of the reclaimed land.

Strip mining totally obliterates natural drainage channels available to wildlife as watering areas. As the overburden is moved about, new drainage network and ponds are created. The water quality of the new ponds and streams, altered by leaching over and through mineral laden spoil materials may be unsuitable for wildlife use. In some cases, it is possible that water quality may be enhanced by constructing streamways and new impoundments making drinking water more available.

The noise and human activity around individual mine sites and their associated support facilities (such as roads and towns) may well be unacceptable to the human-intolerant species (antelope and mule deer).

The physical presence of the mining operation and support facilities can be expected to change migration patterns and grazing movements through changes in quantity and quality of forage and water as well as physically restricting movements by erecting impassable barriers; tall fences, deep ditches, heavily trafficked roadways etc.

It is still too early to tell if airborne emissions from coal combustion stations will have impacts on the well-being of big game animals living in the deposition impact zones.

REFERENCES

- Mussehl, T. W. and F. W. Howell. 1971. Game Management in Montana. Mont. Fish and Game Dept. Game Mgmt. Div. Helena, Montana.
- Packer, P. E. 1974. Rehabilitation Potentials and Limitations of Surface-Mined Lands in the Northern Great Plains. USDA Forest Serv., Gen. Tech. Rept. Int-14.
- NGPRP. 1975. Effects of Coal Development in the Northern Great Plains, Denver, Colo: Northern Great Plains Resources Program.
- United States Environmental Protection Agency, 1976. The Bioenvironmental Impact of a Coal-fired Power Plant. Second Interim Report, Colstrip, Montana, June 1975. U.S. EPA Office of Research and Development, Corvallis Environmental Research Laboratory, Corvallis, Oregon 97330.
- Hanson, W. L. and H. E. Palmer. 1965. Seasonal cycle of ^{137}Cs in some Alaskan natives and animals. Health Physics 11:1401-1406.
- Hedlund, J. D. 1975. Radiocesium in native residents of Anaktuvuk Pass, Alaska. Health Physics 30:345-347.
- Hill, A. C., S. Hill, C. Lamb and T. W. Barrett. 1974. Sensitivity of native desert vegetation to SO_2 and SO_2 and NO_2 combined. J. Air Poll. Cont. Assoc. 24:153-157.
- Sauer, R. H. 1976. Estimating Agricultural Production and its Response to SO_2 in the Pacific Northwest. BNWL-2084 RAP 10. Battelle Pacific Northwest Laboratories, Richland, Washington. 11 pp.

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