Development of wildlife habitat on mined lands
by Robert Steven Carlson

A paper submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Land Rehabilitation
Montana State University

Abstract:
The current rate of energy consumption in the U. S. has mandated increased development of the surface mineable coal reserves of the NGP. In addition to coal, however, the NGP supports a valuable wildlife resource which, historically, has not been considered in mined land reclamation programs. This has been due, in part, to 1) inaccurate assessments of the true "values" of wildlife; 2) inadequacies in conceptualizing what wildlife habitat is; 3) misconceptions in legally emphasized philosophies concerning wildlife and re-establishment of wildlife habitat; and 4) improper application of reclamation technologies.

If productive wildlife habitat is to be a realistic postmine land use objective, a holistic approach incorporating an understanding of the soil-vegetation-wildlife relationships must be implemented. Reclamation programs must be designed which emphasize topographic and soil diversity, correlated to appropriate revegetation schemes, to meet the species-specific habitat and forage requirements of targeted wildlife species. Then, the integrity of mined lands, with respect to support and perpetuation of viable wildlife populations, can be maintained.

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ABSTRACT

The current rate of energy consumption in the U. S. has mandated increased development of the surface mineable coal reserves of the NGP. In addition to coal, however, the NGP supports a valuable wildlife resource which, historically, has not been considered in mined land reclamation programs. This has been due, in part, to 1) inaccurate assessments of the true "values" of wildlife; 2) inadequacies in conceptualizing what wildlife habitat is; 3) misconceptions in legally emphasized philosophies concerning wildlife and re-establishment of wildlife habitat; and 4) improper application of reclamation technologies.

If productive wildlife habitat is to be a realistic postmine land use objective, a holistic approach incorporating an understanding of the soil-vegetation-wildlife relationships must be implemented. Reclamation programs must be designed which emphasize topographic and soil diversity, correlated to appropriate revegetation schemes, to meet the species-specific habitat and forage requirements of targeted wildlife species. Then, the integrity of mined lands, with respect to support and perpetuation of viable wildlife populations, can be maintained.

INTRODUCTION

Coal Resource Development and Wildlife

America's population and consequent energy consumption have grown significantly over the past decades. As a result, demands for new energy sources for the production of manufactured goods and services have also increased. The coal deposits of the Northern Great Plains (NGP) are considered an important asset in meeting these present and future energy needs.

Of the 160 billion tons of coal in the 63 county NGP area, 80.2 billion tons have been determined to be surface mineable with a potential on-site disturbance area of 1.04 million hectares (2.6 million acres) (NGP Resource Program 1975). Although this surface area represents less than three percent of the nearly 36.8 million hectare (92 million acre) NGP area, adverse impacts in certain areas, with respect to degradation of wildlife habitat and associated aquatic resources, are potentially significant (NGP Resource Program 1975).

The NGP supports a considerable wildlife resource. Viable populations of big game mammals such as pronghorn antelope, mule deer, and white-tailed deer inhabit the area. Upland game birds such as sharp-tailed grouse, sage grouse, Merriam's turkey, and ring-necked pheasant are also present. Migratory waterfowl use aquatic areas for nesting and brood rearing. Also, diverse populations of songbirds, fur bearing mammals, rodents, raptors, reptiles, amphibians, and fish are present. In addition, the NGP supports many

threatened and endangered species or animals of relatively unknown population status including the black-footed ferret, whooping crane, American peregrine falcon, northern swift fox, spotted bat, American osprey, northern prairie chicken, mountain plover, northern long-billed curlew, and western burrowing owl. Although this area may serve as only seasonal or temporary habitat for some of these species, its value for the retention and maintenance of viable populations for all these species is of utmost importance.

In 1977 the United States government passed the Federal Surface Mining Control and Reclamation Act. This act attempted to control the degradational effects of surface mining and suggested mitigating measures to rehabilitate mine disturbances. These measures included the return of mined sites to viable wildlife habitat. This legal "intent" of the law, however, becomes somewhat clouded within the context of the act because of misconceptions as to what wildlife habitat is. If wildlife habitat is to be seriously considered as a postmine land use objective, a more holistic understanding of what ecological components comprise habitat must be made.

Potential reclamation procedures and processes involved in the retention or enhancement of wildlife habitat on mined lands must be legally implemented and enforced. In addition, an assessment of the true "values" of wildlife, aside from game species, must be made. This assessment should be approached from the view point that wildlife

have values which are not necessarily directly related to economics. All wildlife possess inherent aesthetic values which relate to an animal's natural beauty expressed through physical form and life style. All wildlife also possess functional values. These values relate to an organism's role in food chains, energy dissipation within the ecosystem, and ways it directly or indirectly affects the functioning of that ecosystem.

This paper will attempt to define the components of wildlife habitat which should be considered when rehabilitating mined lands for wildlife use. Misconceptions between the intent of the Federal legislation and the means of achieving that intent (the extent of the legislation)will be discussed. Reclamation procedures and processes will be suggested which will maximize the value of mined lands as wildlife habitat.

Conceptual Definitions

Habitat

Habitat is a difficult term to define. Differences exist with respect to how it is humanly perceived and the specific criteria used to descibe it. Daubenmire (1968) defined habitat type as a specific kind of environment or living space which provides at least the minimal conditions for one organism or group of organisms to appear together. Odum (1959) stated that habitat is simply the place where a group of organisms appear together.

At this time, an important distinction between habitat and environment must be made. Environment is considered a fuctional entity that relates to a specific organism via its sensory capabilities and physiological and/or behavioral responses. Thus an area which represents habitat for numerous organisms is perceived differently by those organisms. This distinction accentuates the necessity of defining and considering habitat in terms of specific organism life requirements.

Habitat will be described in this paper as one or more properties of the organism in question such as the organism's morphological, physical, and behavioral requirements both in space and time. Habitats possess characteristics including landform, topography, climate, and vegetation. Habitats are also dynamic with respect to both organism use and successional change. When considering reclamation for habitat, per se, a holistic or systems approach incorporating all components of the system, both in sequence and location, must be understood and used.

Wildlife

Wildlife is defined within the context of this paper as the biotic animal component of an ecosystem. Wildlife includes mammals, birds, amphibians, reptiles, fish, crustaceans, insects, micoorganisms, etc. They all possess value, either economically, aesthetically, functionally, or any combination of these factors.

Regarding human perception of animal life, wildlife can be classified as being either "visible" or "nonvisible."

"Visible" wildlife are defined as organisms the general public recognizes and appreciates either through visual experiences or by knowledge gained through awareness and publicity. These species also characteristically possess high economic and aesthetic values in addition to functional values. Visible wildlife would include game animals, raptors, noticable animals such as beavers, selected songbirds such as robins and cardinals, trout, and earthworms. The size of this group is largely dependent on their visibility to the general public and the level of public interest concerning their existence.

"Nonvisible" wildlife are defined as organisms the general public sees but does not recognize. They are organisms people do not acknowledge because they seem to serve no obvious worthwhile function, eg. they are not hunted or actively pursued for aesthetic reasons. They also include animals which people attempt to eliminate because they are "infringing on people's rights." These species characteristically possess only functional values. Nonvisible wildlife would include small rodents, crows, coyotes, microorganisms, and most reptiles and amphibians.

Targeted species of reclamation programs are generally visible wildlife. Their return enhances the area economically, aesthetically,

and to some extent functionally. However, the existence of many visible wildlife species is highly dependent on the presence of nonvisible animals. For example, soil microorganisms influence the vegetation component of an area. Also, raptor use of an area is directly related to the presence of small mammals functioning as a food source. An assessment of the true value of all wildlife present in an area must be implemented so that the area's wildlife habitat potential may be realized. The functional value of all wildlife species and their requirements must be considered when reclaiming for wildlife habitat. Failure to consider the nonvisible component of wildlife can result in the inability to re-establish targeted visible wildlife species.

Wildlife Habitat

The concept of wildlife habitat will be described within the context of this paper as a complex of physical and structural features across an area. The relative juxtaposition of these habitats with respect to providing food, water, cover, and space for differing wildlife species determines their values. The wildlife environment can be species-specific in that a complex of components required by one species can be of marginal or no value in meeting the resource needs of a different species. On the other hand, an area used primarily by one species because of its value as a food source may be used concurrently as a cover source by a different species. Each

component of an area designated as wildlife habitat provides a function within the habitat complex.

Leopold (1933) stated that game (presence) is a phenomenom of edges, eg. where two or more physical and/or structural habitats come together. The increased use potential of these edges is due either to the desirability of simultaneous access to more than one environmental type, the greater richness of border vegetation, or both. Species of low mobility require more numerous edge effects within a smaller unit of area than do species of higher mobility.

The number of edge effects encountered across a land unit constitutes interspersion. The more edge effect present, the higher the degree of interspersion. Theoretically, the higher the degree of interspersion, the more habitat type diversity present within an area and thus the greater the potential productivity of that area as wildlife habitat.

Terrestrial wildlife habitat types are delineated by the vegetative life forms present. The degree of habitat type diversity expressed across an area is a direct function of the landforms present. Differences in topographic position, aspect, and soil composition, coupled with climatic factors, determine the potential variability of habitat types that can be expressed across the landscape. The wildlife present, therefore, represent an integrated

product of the net array of both the biotic and abiotic factors present in an ecosystem.

When reclaiming for wildlife habitat, differences in the postmine physiography and soil composition will determine the degree of habitat type diversity that can ultimately be expressed. Overburden and topsoil handling to promote a soil mosaic across the site will increase the potential for re-establishment of variable habitat types. A working knowledge of what habitat type complex is most desired by the targeted wildlife species will enhance the value of that reclaimed site as potential wildlife habitat.

INTENT VERSUS EXTENT OF FEDERAL LEGISLATION CONCERNING RECLAMATION FOR WILDLIFE HABITAT

Introduction

This section is a critique of selected portions of the 1977 Federal Surface Mining Control and Reclamation Act (PL 95-87). This legislation was enacted to minimize the adverse effects of surface mining on the environment and society. Basic reclamation procedures and philosophies to facilitate this end are suggested in this law. The terms intent and extent suggest a dichotomy between legislative goals and the real effects of implementation of reclamation laws. "Intent" refers to the inherent goals of reclamation as stated in this legislation with respect to retention of, and enhancement of wildlife

habitat on surface mined lands. "Extent" of legislation refers to the procedural recommendations and their limiting effect upon the ability of the coal extraction industry to fulfill the desired goals of reclamation. As a result, legal descriptions of desired postmining ecological conditions are codified, but the implementation of appropriate practices which would accomplish these goals is not realistically considered or allowed.

The law does not allow adequate flexibility in its regulations to fulfill the intended purpose of reclamation for wildlife habitat. This is partially due to legally stated wildlife habitat concepts which do not fully explain or emphasize the complexities and interactions involved in such a postmine land use. With this in mind, the following questions arise:

1) If reclamation proceeds according to legal guidelines, to what extent will the postmine ecosystem fulfill the desired intent with respect to reclamation for wildlife habitat;

2) What are some misconceptions which exist in the legal guidelines with respect to wildlife and wildlife habitat on mined lands?

To address these questions, relevant information from the above-mentioned Federal legislation pertaining to reclamation for terrestrial and aquatic wildlife habitat on mined lands will be cited. A discussion evaluating areas of this legislation where misconceptions

and shortcomings exist will be emphasized. Suggestions remedying this situation will be set forth.

Terrestrial Wildlife Habitat

Legal guidelines in the Federal Register (USDI 1977) state that, "where wildlife habitat is to be included in the postmining land use, the permittee shall consult appropriate State and Federal wildlife and land management agencies and shall select those (plant) species that will fulfill the needs of wildlife including food, water, cover, and space. Plant groupings and water resources shall be spaced and distributed to fulfill the requirements of wildlife. Further, fish and wildlife habitat, water, and vegetation of significant value and the habitats of threatened or endangered species shall and will be protected."

These statements indicate a basic understanding by regulatory personnel that terrestrial wildlife have definable life and habitat requirements and that the distribution of these resources is important. These resource requirements, however, cannot be thought of as separate entities but must be conceptualized as a coordinated and functioning complex of terrestrial units. Thoughtful apportionment of these units must be considered to maximize the potential productivity of the reclaimed area as well as the defined land unit as a whole.

Regulations require surface mine operators to protect or restore productive wildlife habitats upon which continued wildlife species

survival is dependent (USDI 1979). Protection of areas designated as critical use areas is extremely important. However, habitat humanistically designated as minimal use areas must be considered in the overall needs of the species. Consideration of the total habitat and spatial characteristics of components of that habitat must be emphasized.

The law states that the best technology currently available (BTCA) must be applied to minimize disturbances and the adverse impacts on fish and wildlife resources and related environmental values, and these resources are to be enhanced where practicable (Public Law 95-87 1977). The assumption must be made that the BTCA is economically feasible and not legally restricted. A difference in currently applied technology and the "best technology currently available" in the field of reclamation may exist.

Reclamation for wildlife habitat involves considerations for the return of soil, vegetation, and topographic components of an ecosystem. Legislation addresses these components individually. This approach is one of the main shortcomings of the legislation. Integration of these components is more suitable when attempting to convey an understanding to mining companies of what wildlife habitat is.

Regulations address vegetation by stating that revegetation, based on site-specific species selection, should encourage the rapid

proliferation of vegetative cover and promote recovery to productivity levels compatible with approved land use, in this case, wildlife habitat (USDI 1977). Use of plant species of high wildlife nutritional value and potentially high ground cover in the seed mix will tend to enhance the use of areas, particularly by game species (USDI 1979). The Federal Register (USDI 1977) further states that vegetative cover should be capable of stabilizing the soil surface. Seeded vegetation should also be of the same seasonal variety native to the area. Vegetation will be considered of the same seasonal variety when it consists of a mixture of species of the same or superior utility for wildlife use when compared with the utility of naturally occurring vegetation during each season of the year.

The preceeding statements indicate a regulatory understanding of the importance of revegetating potential wildlife habitat with plant species which will fulfill wildlife food and cover requirements. Revegetation to control erosion and promote species similar in seasonal utility to premine vegetation is an acceptable requirement provided site characteristics can support this vegetation, but differential plant growth medium characteristics and depths resulting in gradations of habitat types down a slope may need to be considered.

The Final Environmental Statement (USDI 1979) states that vegetation establishment is largely dependent upon substrata and soil moisture conditions. Reclamation regulations require proper topsoil

handling and replacement to promote revegetation of wildlife habitat on mined lands. "Intent" as stated here cannot be realized unless soil diversity expressed through topographic variety is implemented. To this end, legislation introduced the concept of approximate original contour (AOC) (Public Law 95-87 1977, USDI 1977). This concept states, "The reclaimed area... closely resembles the general surface configuration of the land prior to mining and blends into and compliments the drainage pattern of the surrounding terrain with all highwalls and spoil piles eliminated..."

A major misconception exists in the legal philosophy that a complex of habitat types may be achieved by implementing the concepts of legally emphasized seeding mixtures and AOC. The vegetation expressed on a site is a reflection of the soil's chemical, physical, structural, and positional characteristics. The site's level of productivity is a direct result of soil nutrient availability and soil water holding capacity. Establishment of habitat type diversity across regraded, gently rolling topography cannot be achieved simply by planting a diverse seed mixture on a relatively homogeneous soil. Diverse habitat types may be established initially but the ultimate, self-perpetuating vegetative composition will be an expression of the inherent physical and chemical characteristics of the replaced soil medium. Vegetative composition will change in response to inter- and intra-specific plant species competition in accordance with changing

soil characteristics to ecologically express these inherent characteristics. An understanding that diversity of returned soil and geologic materials, correlated to topographic position and aspect, to promote diversity of vegetative habitat types across an area is of utmost importance when considering wildlife habitat as a postmine land use goal.

The Final Environmental Statement (USDI 1979) stated that adverse impacts of the regulations would result from several requirements that may cause more loss of wildlife habitat than mining. These would include storage of segregated soil which requires disturbance of land for storage piles, and design criteria for diversions, impoundments, sedimentation ponds, and roads. Broad and long-lasting impacts on wildlife, however, are caused by habitat impairment (USDI 1979). The life requirements of many animal species do not permit them to adjust to changes created by land disturbances. These changes impair the habitat component called living space. It thus becomes extremely important for mining companies to determine species-specific responses to alterations in living space. This will result in a more accurate assessment of actual impact levels on mined land wildlife species.

The regulations state that unavoidable impacts of mining on wildlife may be lessened through the requirements of a wildlife protection plan (USDI 1979). The wildlife protection plan includes a statement of how the mining plan will minimize disturbances and

adverse impacts on fish and wildlife and related environmental values during surface coal mining and reclamation operations, and how enhancement of these resources will be achieved where practicable. The protection plan should cover the mine plan area and portions of adjacent areas as determined by the regulatory authority. Also, a statement explaining how the applicant will utilize impact control measures, management techniques, and monitoring methods to protect or enhance the following, if they are to be affected by the proposed activities:

1) Threatened or endangered species of plants or animals listed by the Secretary (Interior) under the Endangered Species Act of 1973 and their critical habitats;

2) Species such as eagles, migratory birds or other animals protected by State and Federal law, and their habitats, or other species identified through the consultation process; or

3) Habitats of unusually high value for fish and wildlife such as wetlands, riparian areas, cliffs supporting raptors, areas offering special shelter or protection, reproduction and nursery areas, and wintering areas (USDI 1979).

The wildlife protection plan is a needed and beneficial aspect of the legal regulations. A thorough assessment of the potential impacts on wildlife habitat and populations of a mined area and the knowledge

of their extent is of utmost importance when adequately determining and implementing mitigation schemes.

Aquatic Habitat

Legal guidelines state that the regulatory program provide for the restoration, protection, enhancement, and maintenance of aquatic life in waters that may be affected by coal mining (USDI 1979). The regulations also provide for the utilization of the BTCA for minimizing adverse impacts on aquatic resources and related environmental values, where possible, as well as the enhancement of the resources where practicable (USDI 1979). These regulatory statements imply that aquatic resources have value and that protective measures will be implemented to retain their integrity.

With respect to permanent impoundments, the law states that they may be retained for beneficial purposes such as stock ponds, irrigation, fire protection, recreation, or water supply. The requirement to achieve AOC does not prohibit construction of small depressions if they are approved to minimize erosion, conserve soil moisture, or promote vegetation (Public Law 95-87 1977). Permanent impoundments may be retained provided all highwalls are eliminated by grading to appropriate contour and provisions for postmining land use and protection of hydrological balance are met (Public Law 95-87 1977). The beneficial purposes stated relate to human economic needs which do not include the value standing water provides for wildlife

use or the resultant increased habitat diversity. Watershed capabilities related to AOC landscape design must also be considered for impoundment size and permanency.

Regulations recognize that impoundments will eliminate habitat for certain wildlife species, however, they will create new habitat for other wildlife species (USDA 1979). This statement relates primarily to spatial considerations. The inherent value impoundments add to the overall habitat complex far exceeds the spatial habitat lost. This consideration should be emphasized in the regulations.

With respect to streams, requirements in the regulations encourage the restoration of both diverted intermittent and perennial streams, and require that diverted streams contain alternating patterns of riffles, pools, and drops rather than a uniform depth which causes changes in stream bed characteristics, water temperature, as well as dissolved gasses important to aquatic life (USDI 1979).

Alternating patterns of riffle, pool, and drop sequences in restored streams are legally emphasized. A misconception exists, however, as to the extent to which such a goal may be ultimately realized. Alternating patterns are a result of diversity in stream channel characteristics. If this stream condition is the desired land use goal, diversity in materials used in stream bed and channel reconstruction must be selectively handled and appropriately returned

so alternating patterns result. In-channel structures and bank vegetation also need to be considered and implemented to achieve this goal.

Riparian habitats associated with water resources are of unusually high value to wildlife, especially in semiarid parts of the west (USDI 1979). These habitats have a relatively diverse vegetational structure which in turn generally support more diverse and productive wildlife populations than do adjacent areas. The regulations address riparian habitat by requiring a buffer zone of 100 feet between surface mining activities and perennial streams or streams with a micro-invertebrate biological community. Protection of such buffer zones assures continuing riparian vegetation and riparian habitat of value to most wildlife species (Public Law 95-87 1977, USDI 1979). Vegetation associated with aquatic resources must be maintained. The value riparian community types afford the entire habitat complex of a mined site must be legally emphasized.

The Federal Register (USDI 1977) states that stream diversions and construction of temporary impoundments to comply with regulations protecting water quality and quantity will have temporary adverse effects. These would include loss of riparian habitats, problems in maintenance of stream inflows, sedimentation, and toxic elements. Regulations addressing these problems are stated in the Final Environmental Statement (USDI 1979). However, reclamation procedures

which must be implemented to mitigate these conditions are not adequately emphasized.

Summation

The intent of legislation as stated and procedurally implemented could have beneficial results in the re-establishment of terrestrial and aquatic wildlife habitat on mined lands. Misconceptions exist as to the extent to which such intents may be realistically fulfilled. Procedural recommendations, specifically in the area of AOC and the return of a homogeneous topsoil-rooting medium or stream bed medium, will not fulfill the goals of habitat type diversity in terrestrial or aquatic ecosystems. A better understanding of the relationships involved in the wildlife habitat complex would facilitate its return. Considerations for the diversity of habitat types across an area must be made to ensure viable living space for wildlife. An understanding of the importance water resources possess in enhancing the overall habitat complex and how these resources affect wildlife distribution and use of an area must be realized. A coordinated effort involving an understanding of what wildlife is, what interactions are involved which determine use potential of a site, and what procedural rehabilitation methods will adequately fulfill its re-establishment needs to be implemented. An approach synthesizing these aspects into a workable scheme will greatly enhance efforts to reclaim mined areas for wildlife habitat.

DEVELOPMENT OF WILDLIFE HABITAT ON MINED LANDS

Soil-Vegetation-Wildlife Relationships

Wildlife species present in an area are a function of habitat types. These, in turn, are a function of plant species life form and composition. An understanding of why and where different vegetative life forms exist is of utmost importance when attempting to reclaim mined lands for wildlife use. The inter-relationships of soil, vegetation, and wildlife (Fig. 1) must be evaluated to successfully rehabilitate viable habitat complexes. Furthermore, these inter-relationships must be emphasized to enhance the value of areas as wildlife habitat.

Soils are very important in wildlife habitat development. A determination of the potential visible plant components of habitat and the resultant level of value to wildlife may be realized through proper segregation and application of soil and overburden. An awareness and consideration of the values that landscape structural features, such as rock outcrops and depressions, possess in enhancing diversity within these habitats must also be evaluated.

Soils of an area directly influence the potential vegetative composition that will dominate a site (Fig. 1a). Soil is a plant growth medium possessing inherent chemical, physical, and structural properties. These properties, in turn, influence the ability of the soil to support vegetation. The plant species composition of an area

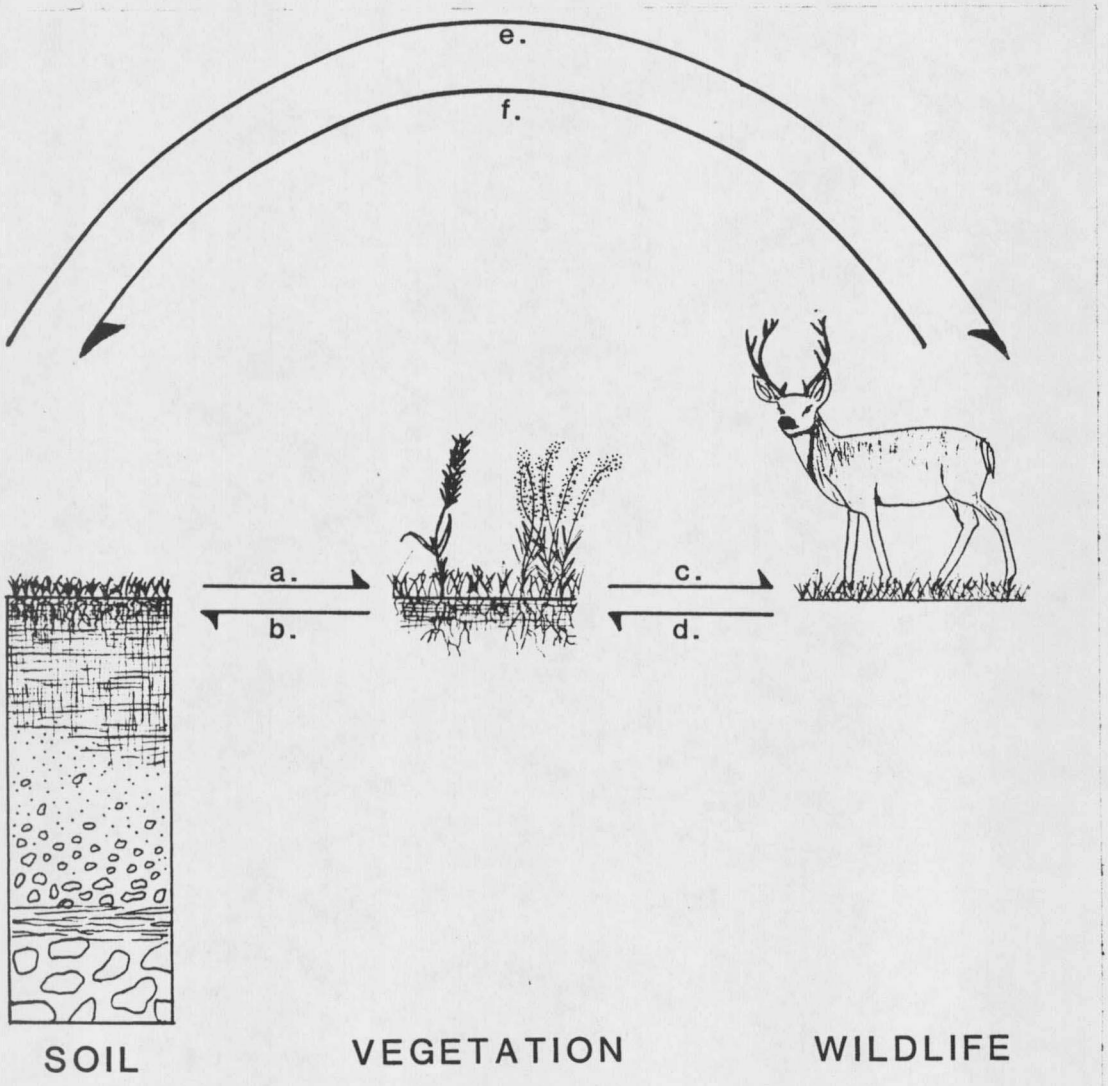

Figure 1. SOIL - VEGETATION - WILDLIFE RELATIONSHIPS

is, therefore, at least partially determined by the soils present.

The vegetation of an area has a reciprocal effect on the soils (Fig. 1b). Vegetation can, through root action, facilitate decomposition of rock or parent material, increase infiltration, and decrease compaction of minesoils. Exudates from plant roots can alter soil pH. Vegetation can hold and protect soil so it is minimally affected by the erosive forces of wind and water. Also, decomposition of plant residues affects the soil chemically and physically with respect to electrical conductivity, cation exchange capacity, organic matter content, texture, structure, water holding capacity, and color.

Vegetation composition and spatial distribution affects the potential wildlife use afforded that area (Fig. 1c). Habitat types provide specific kinds of environments or living spaces for different wildlife species. The proximity of these habitats to one another results in edge effects. Their distribution across a landscape is measured by an index of interspersion. The result is an area possessing varying degrees of value as habitat for different wildlife species.

Wildlife present in an area can actively affect the vegetative composition of that area (Fig. 1d). Wildlife utilize certain plants and plant parts for varying reasons. Seasonal changes in use also occur. These uses result in differential impacts on the vegetation

community. For example, if an animal eats the apical meristems of a plant, this will retard vertical growth and lead to more horizontal spread of the plant. This may alter animal species use of the plant. In addition, preferential browsing may cause a change in the competitive ability of the plant which could lead to a change in the vegetative composition of the area. Simultaneously, grazing or browsing of some plant species increases tiller growth compared to ungrazed or unbrowsed plants. Another example would be girdling of trees by wildlife. This results in a change from a live, healthy tree to a snag altering the use potential afforded wildlife by that tree.

The nature of the soils of an area affect the wildlife use of that area (Fig. 1e). Crawford (1950) stated, "As soil goes, so goes wildlife," and, "Wildlife is a crop of the land." By studying animal productivity related to soil fertility, Crawford found that a positive correlation existed between soil fertility and wildlife productivity, density, and condition. This type of information indicates that the soil quality of an area can affect the wildlife quality of that area.

Wildlife activities can affect soils in various ways (Fig. 1f). Microbial wildlife affect soils chemically and physically and are essential for mineral cycling. Defecation, hoof action, and trampling affect soil physically and structurally. Burrowing wildlife species affect soil structure and can lead to the formation of krotovinas.

Through this complex of interactions, structural and functional changes in each aspect of the ecosystem occur. Understanding and evaluating each aspect with respect to its present condition and its direction of successional change is very important. From this, an accurate assessment of the present and future values an area has as wildlife habitat can be determined.

Reclaimed Habitat Complex-Misconception

A misconception exists as to the level at which realistic success has been achieved pertaining to the re-establishment of productive wildlife habitat complexes on mined lands. Wildlife use of reclaimed "habitat complexes" has been observed. Wildlife use, however, may not necessarily be a result of the habitat complexes reclaimed for, per se, but a result of the successional processes inherent on any disturbed site. The reclaimed habitat complex is, in many instances, a temporary situation. Its value as a long-term residence capable of perpetuating diverse wildlife populations is limited.

Mined areas possess revegetated sites from different periods of applied reclamation technology. Differing topographic requirements, seed mixtures, planting schemes, soil amendments, etc. have subsequently led to a variety of vegetative expressions. A complex of different vegetative habitats has resulted across some mined areas. The expressed diversity together with edge phenomenom and interspersion, have greatly increased the value of these reclaimed

complexes as wildlife habitat. However, edaphic considerations emphasizing those environmental factors which will contribute to the retention of this complex have not been historically emphasized.

As successional sequences continue, invasion of different species or expansion of planted species either of which are more adapted to the inherent site characteristics will occur. These species may change the vegetative composition of the site. Regardless of the initial manipulative revegetation methods used, sites with similar edaphic characteristics will reflect similar habitat types. The initial area diversity which resulted in a complex of habitat types across the area will be minimized. Diversity of wildlife use and value of the area as wildlife habitat will concomitantly decrease.

Topography: Approximate Original Contour-Discussion

Terrestrial Habitat

The legal concept of approximate original contour, aptly coined AOC, is beneficial. Contour diversity is needed for the full expression of habitat type diversity on mined lands. Varying habitats are essential and ultimately dictate wildlife diversity and utilization potential of an area. Within the context of reclamation philosophies, there is legal encouragement for the return of the gross topographic appearance of an area. Variation in revegetation efforts as expressed by individual seed mixtures promote species establishment and perpetuation relative to their topographic position. It was

anticipated that this would ultimately lead, through diversity of re-established vegetation types, to diversity in wildlife species use of the area. Within the AOC concept, desired re-establishment of habitat type diversity, as stated, may not be a realistic occurrence.

The premine topographic contour of a landscape was present, due, in part, to the varying physical and structural characteristics of the geologic materials present. Areas with differential resistence to weathering processes had resulted in a variety of potential plant growth media. These media ultimately dictated the habitat complex to be expressed. For example, knolls or areas of elevated topography were present due to a surface or capping strata material which was more resistent to erosive processes than the materials around it. The habitat diversity thus expressed was a function of resistent surface strata characteristics and varying topsoil depths as a result of differential erosion and deposition processes. The presence of strata outcrops and exposure also influenced the expressed habitat diversity (Fig. 2a).

Within the context of AOC ideology, a virtually homogeneous, with respect to texture, and uniform, with respect to depth, "soil" material is contoured to a predetermined shape. The potential habitat diversity expressed on and around that returned knoll is a function of topsoil characteristics and probably exposure (Fig. 2b).

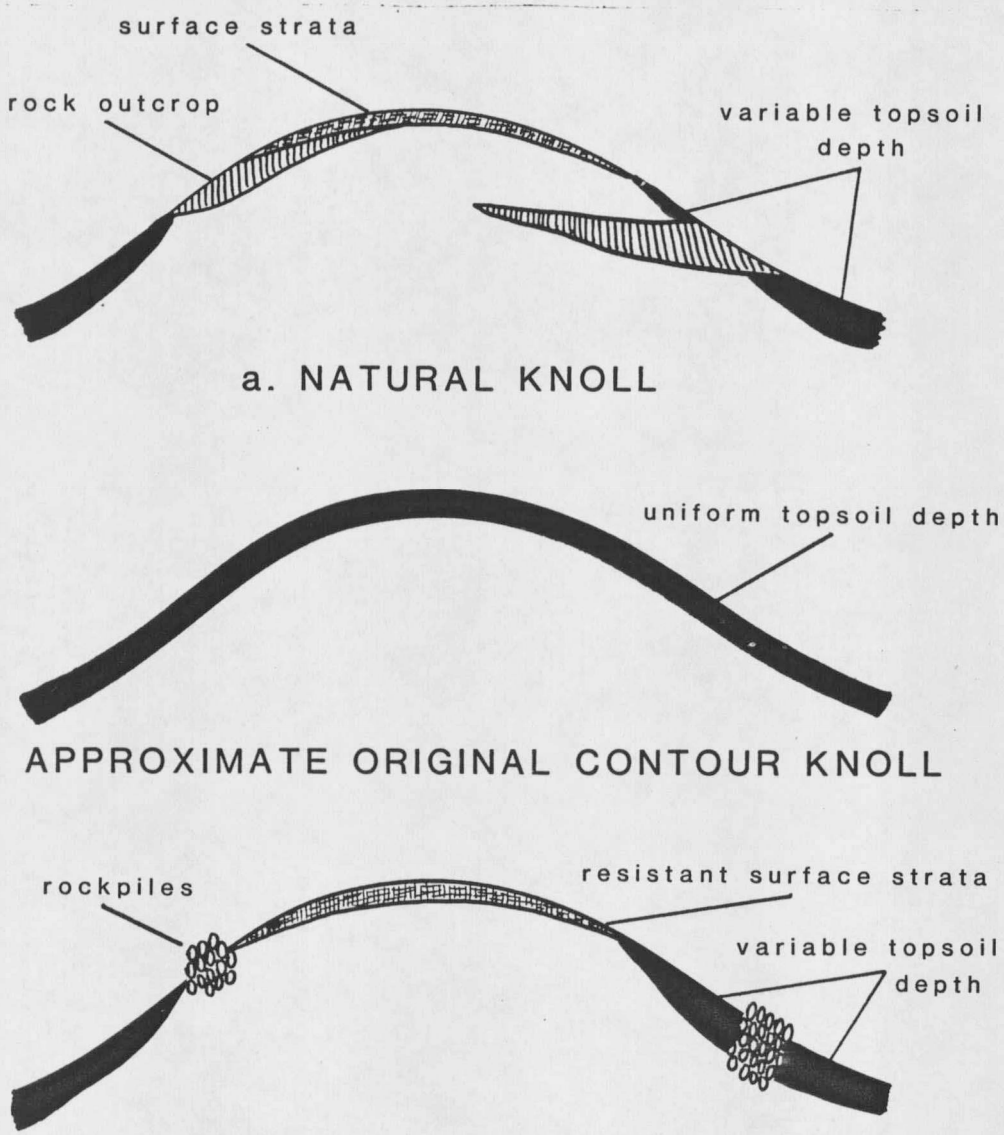

Figure 2. APPROXIMATE ORIGINAL CONTOUR - DISCUSSION

A proposed alternative involving intensified soil and overburden selective handling procedures within the context of the AOC concept would be to diversify the geologic constituents of the returned knoll area. Reapplication of coarse textured materials to the top of the knoll, variability in topsoiling depths down the slope, and placement of rock piles at varying levels down the slope are possible considerations. Habitat diversity on and around that returned knoll could then be a function of the resistent capping material, variable topsoil depths, rock piles simulating strata outcropping, and exposure (Fig. 2c). In addition, soil handling to promote woody plant species in draws will greatly increase habitat diversity. Also, selective placement of materials for alluvial valley floor (AVF) re-establishment is important. Utilization of such procedures is needed to return some semblance of plant growth medium diversity to a reclaimed site. In this way, habitat type diversity can be a realistic postmine goal.

Aquatic Stream Habitat

The concepts of increased selective handling of geologic materials to promote diversity of habitats can be applied to stream reclamation. A reclaimed stream channel designed with homogeneous materials will result in uniformity of flow resistence. Regardless of the returned channel configuration, a relatively straight, uniform channel will ultimately result. Diversity in flow and potentials for

aquatic habitat will be minimized. Stream meandering and pool, riffle, eddie, and drop sequences develop in response to grade, in-stream structures, and channel bank characteristics which subject the water flow to varying levels of contact and resistence. Use of in-stream and channel bank structures such as rocks, trees, established vegetation, or artificial structures (riprap) will promote diversity in flow rates. Stream bed materials are transported and deposited within a channel commensurate with varying flow rates. Productivity of streams is directly related to diversity in flow rates and types and distributions of stream bed materials. Reclamation procedures which emphasize flow rate diversity while simultaneously promoting the development of productive stream bed habitat must be considered. The resultant diversity in flow rate, water depth, etc. increases the aquatic habitat potentials of that reclaimed stream.

Species-specific Habitat Requirements

Mined lands provide valuable potential habitat situations for seasonal and permanent wildlife. However, habitat and forage requirements differ among wildlife species. When reclaiming mined lands to encourage use by specific (targeted) species, knowledge of their habitat and forage preferences is vital. The following is a review of literature relating specific wildlife species to their seasonal preferences for topography, food, cover, and water. Considerations for the seasonal habitat and forage preferences of

targeted wildlife will be beneficial in the design of rehabilitation programs for these species. Such information is a valuable aid when attempting to reclaim mined lands for wildlife habitat.

Seasonal differences exist within animal taxa with respect to preferred foods, optimal cover situations, and the need for water. Variations in diet are related to seasonal availability, succulence of food materials, and age status of individual animals. Cover selection is related to functional cover differences which occur throughout a season (i.e. brood, loafing, nesting, roosting, fawning, winter cover, etc.). Water use is based on availability and form (i.e.open water, succulence, dew, etc.). The amount of water needed by a species at any one time is related to the physiological state of the animal. These differences will be elaborated upon so that seasonal, species-specific management recommendations can be made.

Species-specific habitat and food preferences will be stated for many geographic areas. Some are not specifically referenced. Mining companies must perform adequate and thorough premine vegetation inventories to determine the plant characteristics of the mine site. Then, appropriate reclamation procedures, emphasizing geographically and climatically selected plant species, may be applicable.

Within the context of this paper, colloquial names for animals and plants will be used. Common names with their appropriate scientific name are listed in Appendix A.

Pronghorn Antelope

Pronghorn antelope habitat is characterized by open prairies and sagebrush plains (Sundstrom et al. 1973). Habitat types include big sagebrush/grassland, grassland, and cropland (Bayless 1969, Cole and Wilkins 1958). Big sagebrush is the major controlling factor in habitat selection and use. A gently rolling topography with stands of taller browse and intermediate sized shrubs has been suggested for optimal pronghorn use (Hinkle et al. 1981). Dispersed water developments lead to better distribution of use across an area (Bayless 1969, Hinkle et al. 1981).

Habitat preferences are to some extent seasonal for this species. Sagebrush/grassland is the heaviest utilized habitat type in winter. Major plant species in this vegetative type include big sagebrush, fringed sagewort, and Sandberg bluegrass. The sagebrush/greasewood type is also important. Grassland and sagebrush/grassland are the most commonly used vegetative types during spring. Sagebrush/grassland, grassland, and croplands containing alfalfa are important habitat types during summer. Sagebrush/grassland and deciduous shrub/grassland are frequented during fall (Bayless 1969, Beale 1970, USDI 1978).

Succulence and availability are the major attributes determining seasonal forage preferences (Beale 1970). Winter diets consist primarily of shrubs and evergreens. Juniper and big sagebrush are

important species during this time. Forbs, including fringed sagewort, constitue part of the winter diet. New growth of grass, browse, and forbs are important spring foods. Sandberg bluegrass, thickspike wheatgrass, saltbush, rabbitbrush, fringed sagewort, pricklypear cactus, and Russian thistle are some species of use and reveal the variable diet of pronghorn during this season. Summer diet is predominantly forbs including fringed sagewort, alfalfa, dandelion, and yellow sweetclover (Beale 1970, Schwartz and Nagy 1976, Cole 1956, USDI 1978, Hinkle et al. 1981). Browse species such as snowberry and rabbitbrush may also be important. Browse and forbs constitute the bulk of the fall diet. Big sagebrush, western snowberry, snakeweed, and alfalfa are most important during this period (Cole 1956). Grass may be utilized during periods of late fall green-up (Bayless 1969).

Mule Deer

Ideal mule deer habitat is characterized as containing 50 percent brushland, 25 percent woodland, and 25 percent nonforested land (Hinkle et al. 1981). A midsuccessional vegetation matrix having high species diversity or those which provide small openings with nearby escape cover of brush, woodland, or forest taller than 2 meters (6 feet) has been suggested by the Fish and Wildlife Service (USDI 1978). Where vegetation does not provide sufficient cover, landforms providing topographic cover may replace it (Kerr 1979).

Mule deer migrate seasonally in response to the topographic

protection available at different elevations and the persistence of snow pack (Gurell and Papez 1963, USDI 1978). Mule deer show preference for winter ranges dominated by browse species. Winter range habitat types include pinyon/juniper, sagebrush/grassland, sagebrush/bitterbrush, ponderosa pine, lodgepole pine, and Douglas fir (Nellis 1969, Constan 1972, USDI 1978). Summer range habitat types include conifer/aspen, spruce/fir, pine/Douglas fir, sagebrush/grassland, ponderosa pine, haymeadows, juniper/pinyon, and grasslands (Constan 1972, Kerr 1979). All seasonal vegetation (forage and cover) types, as well as water, must fall into the 0.8 to 4.0 kilometer (0.5 to 2.5 mile) home range of mule deer. Frequency of watering is affected by such factors as weather and succulence of vegetation (Hanson and McCulloch 1955, Kerr 1979).

Forage preference of mule deer is related to seasonal availability and palatability of species within habitat types. Winter diets on the NGP consist primarily of the browse species big sagebrush, antelope bitterbrush, mahogany, serviceberry, rubber rabbitbrush, and currant (Nellis 1969). Conifers such as ponderosa pine, Douglas fir,and juniper are also used. Forbs and grasses are used, their amount being dependent on availability and succulence. Penstemon, fringed sagewort, lupine, western wheatgrass, and Idaho fescue are considered relatively important (Nellis 1969, Constan 1972). Spring diets consist primarily of forb, browse, and grass

species. buttercup, balsamroot, fringed sagewort, yellow sweetclover, and dandelion receive heavy use. Browse species include big sagebrush, chokecherry, mock orange, mahogany, antelope bitterbrush, rubber rabbitbrush, and serviceberry (Nellis 1969, Constan 1972). Grass use, during spring green-up, includes western wheatgrass, Idaho fescue, and sedges (Constan 1972, Hinkle et al. 1981). Forbs constitute the bulk of the summer diet, but browse is utilized to some extent. Grass use typically decreases during the summer, the extent being a function of succulence. Haycrops such as alfalfa are also used (Lovaas 1958, Nellis 1969, Constan 1972). Browse use increases during the fall but forbs may be utilized to some extent. Grass use may occur during the fall green-up period (Nellis 1969, Lovaas 1958).

White-tailed Deer

White-tailed deer habitat is characteristically a complex of ponderosa pine, interspersed with bunchgrass parks, dryland and riparian shrubs and conifers, and dense stands of aspen, associated with agricultural lands (Martinka 1968). Woody cover is paramount in white-tailed deer habitat. Habitats providing dense cover in close proximity to foraging areas such as breaks or bottoms are preferred wintering areas. Cottonwood/greasewood and cottonwood/weed habitat types are considered important. A multiple habitat complex including trees, shrubs, meadow, and weed types is preferred during summer. Daily access to water within the 2.6 square kilometer (1 square mile) home range is needed (Sparrowe 1970, Allen 1968, USDI 1978). Natural

sodium licks, typically located in bottomland soils, are heavily used in April and May (Weeks and Kirkpatrick 1976).

White-tailed deer select food for their palatability, succulence, availability and nutrition. Seasonal preferences for particular species occur (Allen 1968, Weeks and Kirkpatrick 1976, Martinka 1968, USDI 1981). Woody deciduous plants receive year-round use. Winter diets consist primarily of browse. Western snowberry, cottonwood, willow, sagebrush, Douglas fir, ponderosa pine, skunkbush sumac, red-osierdogwood, juniper, white cedar, poplar, and serviceberry are important species. Forbs such as honeysuckle, plantain, greenbriar, summer cypress, sunflower, goat's beard, and soapweed receive some use. In spring, forb and grass use increases but browse is still important. Grass species used, associated with spring green-up, include wheatgrasses. Forbs such as goat's beard are preferred spring foods with browse species such as poplar and juniper also being used. Fungi may be utilized for their high sodium content (Weeks and Kirkpatrick 1976). Summer diets consist almost exclusively of browse, forbs, and woody vine foliage. Species of use would include western snowberry, cottonwood, red-osierdogwood, alfalfa, Russian knapweed, and summer cypress (Allen 1968, Martinka 1968, Weeks and Kirkpatrick 1976). Fall diets consist of browse; forb and grass use is dependent on moisture conditions. Barberry, chokecherry, poplar, arbor vitae,

cottonwood, willow, and western snowberry are some important species (Martinka 1968, Allen 1968, USDI 1978, 1981). Agricultural crops also receive use (McKean 1954).

Sage Grouse

The single most important component of sage grouse habitat is big sagebrush (Colenso et al. 1980, Klebenow 1969, Wallestad 1975a and b). Sagelands, grasslands, shrublands, and creek and river bottoms are use areas depending on season, availability, and abundance of sagebrush and forbs. Winter habitat is characterized as heavy sagebrush and sheltered lowlands with big sagebrush being the most important shrub. Big sagebrush/grassland benches with greater than 15 percent cover and averaging 37 centimeters (15 inches) in height are preferred spring habitat for nesting and brood rearing (Klebenow 1969, Wallestad 1974, Wallestad 1971, Colenso et al. 1980). Habitats containing scattered and open areas (10 to 14 percent cover) are preferred in early summer. A shift from open areas to mesic bottomlands with greasewood/alfalfa and greasewood/grassland habitat types in close proximity to sagebrush occurs during midsummer. A shift to sagebrush with broods congregating around open water occurs during late summer. Fall habitat is sagebrush/grassland (Wallestad 1971, USDI 1978).

Big sagebrush is the most important food item consumed year-round. However, seasonal diet shifts do occur and are related to availability and succulence of forbs and grouse age (Klebenow 1969,

Wallestad 1975a and b). Winter diets consist exclusively of big sagebrush while this species and forbs are eaten by adults in spring and summer. Forb use includes fringed sagewort, prickly lettuce, dandelion, goat's beard, curlycup gumweed, clover, and alfalfa. Adult diets in late summer include some animal matter. Grasshoppers, ants, and beetles comprise 100 percent of the juvenile diet during their first week (Wallestad 1975a and b). From weeks one through 11, juveniles eat milky forbs (flowers and buds) and insects. After three months of age, juveniles eat sagebrush. Fall diets for all sage grouse shift back to big sagebrush with forbs and grains from agricultural crops utilized depending on availability (Wallestad 1975a and b).

Sharp-tailed Grouse

Sharp-tailed grouse habitat is characterized by rolling mixed grass prairie and grainfields broken occasionally by brushy draws (Hillman and Jackson 1973, Trippensee 1948). Shrub/grassland habitat types including skunkbush/grassland and silver sagebrush/grassland in association with ponderosa pine/grassland, poplars, birches, and open water provide optimum year-round living conditions. Of prime importance is the spatial relationship of each habitat component to each other and to the center of the sharptails' "community activity center" or courtship ground (Hillman and Jackson 1973). Winter habitat is associated with areas containing high densities of shrubs

and woody cover in draws. These include grassland/agricultural fields, big sagebrush/grassland, silver sagebrush/grassland, and creek bottom/coulee bottom habitat types. Trees, providing dense cover, bordering grainfields and meadows are also important. Uplands with breaks containing silver sagebrush/grassland, grassland, and skunkbush/grassland are preferred spring and summer habitat types. Knolls, ridges, or rises with sparse vegetation, used as courtship areas, in close association with luxuriant grassland ridges and knolls (vegetation at least 30 centimeters (12 inches) in height), used as nesting sites, are important spring habitat components (Hillman and Jackson 1973). Forbs such as dandelion, fringed sagewort, cudweed sagewort, curlycup gumweed, and sunflower are an important vegetational component providing nest shelter, shade, and escape cover for broods. Edges near thickets are also used (Trippensee 1948). In fall, skunkbush/grassland and grassland in close proximity to ponderosa pine/grassland are used extensively.

Food preferences for sharp-tailed grouse vary seasonally largely due to availability. Browse comprises the bulk of the year-long diet. Winter diets consist primarily of buds, berries, and seeds from hawthorn, Russian olive, skunkbush sumac, silver buffaloberry, western snowberry, rose, serviceberry, willow, chokecherry, and ponderosa pine. Agricultural grains such as wheat, corn, alfalfa, and sunflower are also used. Spring and summer diets still contain some browse with

forbs and grasses increasing in importance. Sandberg bluegrass, buttercup, and dandelion are important forage species during this time. Insects such as grasshoppers and caterpillars are important late summer and fall foods. In addition to insects, fall diets consist of forbs and browse. Seeds, buds, and berries from rose, buckwheat, clover, yellow sweetclover, weeds, skunkbush sumac, chokecherry, and ponderosa pine are important. Agricultural grains may also be utilized.

Ring-necked Pheasant

Ring-necked pheasant habitat is synonymous with farmland (MacMullen 1961). Seasonal feeding and cover areas in close proximity to one another provide optimal habitat situations (Lyon 1959, Weigand and Janson 1976). Habitat preferences change seasonally to some extent in response to the needs for wintering, nesting, and roosting areas (Olsen 1977).

Dense cover in shelterbelts, bottomlands, marshes, willow thickets, meadows, ditches, and fencerows provides preferred winter habitat (Baskett 1947, Gates and Hale 1974, Yaeger et al. 1951). Spring nesting habitat is closely associated with undisturbed residual cover of grasses, forbs, or stubble and the proximity of this nesting cover to winter cover is important. Alfalfa, reed canarygrass, hayfields, small grainfields, and weeds of greater than 15 centimeters (6 inches) in height are preferred nesting habitat (Kuch 1970, Baskett

1947, MacMullen 1961, Olsen 1977). Areas blending herbaceous meadows and marsh, brush, tree clumps, and food patches are preferred crowing areas. Spring and summer roosting cover in small grain stubble fields, marshy vegetation, grassy swales, weeds, ditchbanks, and trees are important. Broods prefer hay meadows, clover, grainfields, and sagebrush as summer habitat. Accessibility of adults to dusting areas may also be important. Fall roosting cover includes lowlands, wetlands, stubble fields, trees, brushy woodlots, and fencerows (Gates and Hale 1974, Olsen 1977). Pheasants also need year-round loafing cover when predators are present. Woody vegetation with an overhead canopy is preferred (Robertson 1958). Water from dew, succulent fruits, open water, green vegetation, and insects are very important. Calcium directly influences pheasant distributions and is an important soil constituent for laying females and for growth of young pheasants (Harper and Labinsky 1964, Olsen 1977). Grit, necessary for digestion, is an important source of calcium (Olsen 1977, Korschgen 1964).

Ring-necked pheasant diets consist primarily of annual seeds of which cultivated crops, waste grain, and associated weeds are important (Hiatt 1946, Weigand and Janson 1976, Olsen 1977, Korschgen 1964). Diets change seasonally in response to availability and age class of bird. Winter diets consist of wild fruits and seeds from corn, soybeans, dayflower, bur-cucmber, and buckwheat. Spring

juvenile diets consist of insects and weed seed. Spring adult diets consist of cereal grains, corn, wheat, barley, oats, dayflower, smartweed, dandelion, and some insects. Adult females prefer green forage such as leaves from alfalfa, prickly lettuce, and yellow sweetclover during the laying season (Hiatt 1946, Weigand and Janson 1976). Corn, foxtail, wheat, rice, millet, and wild cherry are preferred summer foods for all pheasant age classes. Insects such as grasshoppers and cutworms are also used. Fall diets consist of agricultural seeds, insects, ragweed, foxtail, and sunflower.

Merriam's Turkey

Merriam's turkey is strongly associated with ponderosa pine and cottonwood habitats in close proximity to natural clearings or open ridges providing a food source and roosting cover (USDI 1978, Hoffman 1968). A preference has been shown for easterly exposures, and tall, mature, open-branched trees with no branches near the ground (Boeker and Scott 1969). Pine-oak-grassland vegetative associations and pinyon/juniper, mountain/shrub, ponderosa pine, and spruce/fir habitat types comprise optimal habitat (Hoffman 1968). Habitat type use varies seasonally to some extent with tall, mature ponderosa pine, Douglas fir, white fir, and cottonwood habitats being preferred winter roosting and feeding habitats (Nish 1973). Ponderosa pine/scrub oak type and ash/boxelder and hawthorn/plum communities in lower drainages may also be used (Jonas 1966, Nish 1973). Use of grassland habitats

increases in spring, summer and fall provided they are in close proximity to tree and shrub escape cover and roosting sites. Preferred tree and shrub habitats include the ponderosa pine/scrub oak belt and higher into the Douglas fir, aspen, and lodgepole pine belts (Hoffman 1962). Grasslands are used for feeding and as escape cover for young poults (Jonas 1966, Burget 1957). Turkeys require daily access to drinking water which is situated within 0.8 to 1.6 kilometers (0.5 to 1.0 mile) of roost sites (Boeker and Scott 1969, Nish 1973). Roost sites, with tall, mature ponderosa pine being the preferred species, must involve a complex of several trees to receive maximum use.

Seasonal food preferences vary, mainly due to availability. Ponderosa pine seeds, acorns, and persistent fruits of hawthorn, western snowberry, wild rose, juniper, and cactus are staple fall and winter foods (MacDonald and Jantzen 1967, Hoffman 1962, Nish 1973). Spring and summer foods include ragweed, sunflower, dandelion, smartweed, sedges, rushes, and several species of fescue in addition to seeds, acorns, and fruits. Insects are important summer foods. In addition, agricultural crops such as wheat, corn, barley, and oats may be taken when they become available.

Hungarian Partridge

Hungarian partridge persist primarily in ring-necked pheasant and sharp-tailed grouse habitats with optimal habitat being a by-product of agricultural practices (Trippensee 1948, Weigand 1980). A complex

of interspersed cultivated crops, weed, grassland, and brush vegetation types provide optimum year-round habitat. Agricultural fields in close association with woody cover are used extensively during winter. Hayfields, grainfields, dead grass, grassy swales, roadsides, fencerows, and ditchbanks containing residual vegetation are important in providing spring nesting sites as well as year-round cover.

Hungarian partridge diets vary depending on age of bird. Juveniles less than one month old feed exclusively on insects such as grasshoppers and ants. Agricultural waste grains such as corn, barley, wheat, and oats comprise year-round adult diets. Weed seeds from ragweed, alfalfa, dandelion, knotweed, foxtail, and lamb's quarter are also important. Leaves of alfalfa, dandelion, and bluegrass as well as insects are utilized to some extent from late spring through fall (Trippensee 1948, Weigand 1980).

Waterfowl

Surface feeding or puddle ducks include mallard, pintail, gadwall, blue-winged teal, American wigeon, and wood duck. They live primarily in association with shallow waters, creeks, ponds, and marshes (Peterson 1961). Some nest in open areas far from water others in grass, residual vegetation, uplands, and in cavities of trees depending on the species (Bellrose 1976). Preferred foods include seeds, leaves, stems, and roots of aquatic and agricultural

plants and small aquatic animals and insects (Bellrose 1976, USDI 1981).

Diving ducks include canvas back, lesser scaup, redhead, and ring-necked duck. They are commonly found on deep lakes and rivers and breed in marshes (Peterson 1961). They nest in shallow ponds, upland grass, and emergent vegetation over or close to water (Bellrose 1976). Preferred foods include animal life, and seeds, stems, leaves, and roots of aquatic plants (Peterson 1961, USDI 1981).

Other Wildlife Species

Raptors, including osprey, hawks, kites, buzzards, eagles, and falcons, occupy a wide range of habitat types ranging from desert shrub to pine/fir. Home ranges fluctuate seasonally in response to the availability of nest sites, and to the number of feeding places or hunting perches used and the distance between them. Nesting sites include cliffs (peregrines), isolated trees or snags, groves of trees (goshawk), patches of forest or ground cover, reed beds (marsh harriers), and old buildings (falcons) thus showing the interspecific variation in nest site selection which occurs (McGahen 1968, Newton 1979). Seasonal food preferences depend mainly on the activities of prey species - migrations, hibernations, and breeding - and differ according to the animals involved (Newton 1979). In general, common foods include fish (osprey, bald eagle), birds (goshawk, common kestrel, peregrine, Cooper's hawk), small mammals (red-tailed hawk,

red-shouldered hawk, bald eagle), and insects (kestrels) (Dunstan 1975, Mollhagen et al. 1972, Newton 1979).

Non-game avian habitat must provide food, nest sites, song posts, and shelter within species-specific territories (USDI 1978). It has been found by MacArthur and MacArthur (1961) that foliage height density (FHD) is strongly correlated with bird species diversity. This indicates that revegetation efforts which provide a wide diversity of habitat types will support a diversity of bird species. General food items would include insects, seeds, fruits, vegetative plant parts, earthworms, and carrion (USDI 1978). Water may be an extremely important component of avian habitat; its species-specific needs are dependent on succulence of food items taken.

Small mammals, including field mice, voles, and shrews, occupy a variety of habitats ranging from dryland, shortgrass prairie to mixed grass prairie to mixed shrub/grassland types. Most small mammals are opportunistic feeders with insects, seeds from grass, forbs, and shrubs, and leafy material comprising the bulk of their diets. Preferred plant species would include buffalo-grass, blue grama, western wheatgrass, Indian ricegrass, needle-and-thread grass, dandelion, Russian thistle, penstemon, lupine, buckwheat, alfalfa, pricklypear cactus, scarlet globemallow, sagebrush, saltbush, and shadscale (USDI 1978).

Lagomorphs, such as cottontail rabbit, occupy a variety of

habitats from desert/shrub to shrub/grassland, to grassland types (USDI 1978). Pastureland, cropland, and woodland or combinations of these interspersed with brushy areas provide preferred habitat situations. Escape cover of dense vegetation, accumulations of brush, openings and crevices in rocks is important. Diets consist mainly of green, succulent forbs and grass. Shrubs and trees are utilized when succulent plants are unavailable (USDI 1981).

SUMMARY OF WILDLIFE HABITAT RECLAMATION

This section contains suggestions pertaining to mined land reclamation for various wildlife species in the NGP. In most cases, these suggestions are very specific. It becomes the responsibility of the reclamation manager to determine which suggestions are applicable to his unique mine site so that habitat situations can be emphasized to maximize the site-specific habitat potential of the mine area in question. Considerations for what habitat types would be most productive in terms of wildlife use of the reclaimed area as well as the surrounding area must be implemented. Then, appropriate reclamation procedures throughout all phases of the mining and reclamation operation can be used to maximize the potential success of reclamation of habitat for the targeted species.

When reclaiming a mine site as pronghorn antelope habitat, considerations for season of use are important in determining which

habitat types should be emphasized. As a generalization, a gently rolling topography vegetated with big sagebrush/grassland would be most desirable. Plantings, located where appropriate site conditions exist, including big sagebrush, black sagebrush, rabbitbrush, greasewood, fringed sagewort, alfalfa, Sandberg bluegrass, bluebunch wheatgrass, western wheatgrass, and Indian ricegrass would be desirable in meeting both food and cover requirements. South facing, windswept slopes are beneficial as loafing areas during periods of deep snow. A complex of watering areas would aid in distributing pronghorns across the entire mined area thus allowing for better utilization of the whole range.

Mule deer use a variety of vegetation types including hardwoods, conifers, and shrubs, in addition to herbaceous species. Adequate interspersion of appropriate food, cover, and water resources within the seasonal home range is important. Considerations for season(s) of use will aid in the determination of specific planting schemes. Plantings including aspen, conifers, mahogany, bitterbrush, sagebrush, rabbitbrush, serviceberry, currant, fringed sagewort, and sedges would provide food and cover for mule deer. Rim rocks, rockpiles, and dense stands of natural vegetation should be retained where possible to enhance the area for mule deer. Following mining, ridges, draws, rockpiles, and dense stands of vegetation should be established as seasonal cover and fawning areas, rather than leaving a level

landscape. Development of secure travel lanes between use areas is an important consideration. A well interspersed habitat complex containing 60 percent forage area and 40 percent cover area is appropriate to maximize use of an area by mule deer.

When reclaiming mined lands for white-tailed deer habitat, a revegetation plan which eventually provides a distribution of cropland, tall weeds, grassland, and young woodland including hardwoods, conifers, shrubs, and woody thickets must be developed. Considerations for providing woody cover such as trees or brush on slopes and along ridges is very important. Areas of rough topography in open areas are also used for cover. A well interspersed pattern of vegetation types, water within one mile, and salt blocks will increase utilization of the area. Food needs can be met by including fruit-producing species, grasses, forbs, mast, and browse species in plantings. Brushy cover should be maintained along all water courses as escape and winter cover, and travel lanes.

For sage grouse habitat big sagebrush is the most important plant species. Considerations for controlling factors such as quality and quantity of nesting, brood rearing, and wintering habitat are important (Tate 1979). An interspersed complex of dense sagebrush for cover and feeding in close proximity to forb/bunchgrass and streamside communities will meet these requirements. A density of 2,000 sagebrush plants per hectare (800 per acre) will provide optimum

requirements for sage grouse food and cover (Phillips 1972). Sagebrush stands between 5 and 15 percent canopy cover will afford the best conditions for growth of understory grass and forbs. A gently rolling topography vegetated with diverse densities of sagebrush in close proximity to open water would optimize the use potential of an area as sage grouse habitat.

A gently rolling topography of ridges and swales vegetated with a habitat complex including grassland and cropland interspersed with shrub/grassland, early forest growth, shrubby thickets, and sagebrush constitutes desirable sharp-tailed grouse habitat. Water developments located at least 0.8 kilometers (0.5 miles) from coulees with good deciduous shrub cover or other high grouse use areas would be beneficial. Development of winter browse plants such as Russian olive, cottonwood, willow, poplar, western snowberry, serviceberry, and skunkbush sumac would be suggested. Planted food and cover patches should be between 0.4 and 4.0 hectares (1 to 10 acres) with numerous small patches being preferred. Considerations for desired season(s) of use are important so that appropriate cover, feeding, and/or nesting sites may be coordinated.

Ring-necked pheasant habitat includes areas of cultivated grain highly interspersed with fencerows, shelterbelts, ditchbanks, and hedgerows. Since pheasant habitat is a direct by-product of farm management, a checker board of dense cover areas in close proximity to

cultivated areas are prime pheasant habitat situations. Agricultural grains (oats, wheat, barley), alfalfa, and grass species such as crested wheatgrass, intermediate wheatgrass, and tall wheatgrass are good pheasant plantings. Retainment of residual stubble and adequate waste grain for winter and spring use is very important. Two to four hectares (5.0 to 10.0 acres) of food plantings for every 40 hectares (100.0 acres) of woody or marsh habitat would be an appropriate ratio for maximum pheasant use.

Reclaiming mined lands for Merriam's turkey habitat is very difficult due to the age characteristics of trees used as roosting sites. If suitable roosting sites border the reclaimed area, however, reclamation efforts emphasizing foraging habitat will be beneficial. Plantings of preferred grass and forb species intermixed with fruit producing shrubs and trees is suggested. Dispersed watering sites in close proximity to this complex are a very important consideration. Protection of feeding areas from grazing has been suggested as the most beneficial management practice (MacDonald and Jantzen 1967).

Hungarian partridge habitat includes cultivated fields in close association with densely vegetated fencerows, ditchbanks, and no till weed and grass fields. Watering areas should also be available.

Water impoundments on mined lands may be used for seasonal or permanent waterfowl habitat depending on species distribution. Suitability of strip mine ponds as waterfowl habitat varies with

bottom material, quality and quantity of water available, and depth and topography of basin. Large ponds, 0.4 to 4.0 hectares (1.0 to 10.0 acres) with lush shorelines of emergent vegetation are preferred. Standing water, regardless of size or depth, however, may be used during migration periods. Shallow depths of 0.6 to 1.0 meters (2.0 to 3.0 feet) over a portion of the pond are essential for emergent and submerged vegetation establishment; specific plant species are a function of quality of bottom material and water depth. Irregular shorelines and numerous low islands provide areas for nesting cover and protection from predators and environmental factors. If livestock grazing occurs around the impoundment, residual vegetation of greater than 15.0 centimeters (6.0 inches) should be left as spring nesting, loafing, and brood escape cover. Artificial nesting structures should also be considered to increase potential waterfowl use.

Plant species listed in Table 1. have been suggested as important food and cover species for waterfowl. Associated upland plantings of agricultural crops are also important.

When reclaiming mined lands for raptor habitat, Newton (1979) suggested that considerations for nesting sites and feeding areas are of utmost importance. Development of artificial nest sites such as nest boxes (kestrels), ledges and nest holes in cliffs (falcons), nest platforms (osprey and bald eagle), and artificial tree nests (peregrines) may be important in increasing raptor densities on mined

Table 1. Plant species important for waterfowl food and cover.

Genus and species	Common name
Brasenia spp.+	Water shield
Ceratophyllum spp.+	Coontail
Echinochloa spp.#	Millet
Eleocharis spp.+	Spike sedge
Leersia oryzoides	Cutgrass
Lemna spp.+	Duckweed
Myriophyllum spp.	Watermilfoil
Najas spp.	Naiad
Nuphar spp.+	Water lily
Oryza spp.	Rice
Phalaris arundinacea	Reed canarygrass
Polygonum spp.#+	Smartweed
Polygonum polymorphum	Fleeceflower
Potamogeton spp.#+	Pondweed
Ranunculus spp.	Buttercup
Rorippa spp.	Watercress
Scirpus spp.+	Bulrush
Typha spp.	Cattail
Vallisneria spp.	Wild celery
Zostera spp.	Eel grass

From Evans and Kerbs 1967, USDI 1981
most important
+ preferred by diving ducks

lands. Selecting postmine land uses which promote high prey populations such as shrublands and dense grasslands devoid of heavy grazing by livestock and no till agricultural practices will be beneficial in attracting raptors to an area. It should be noted that specific raptor species cannot be managed without some knowledge of their habitat needs and potential limiting factors.

Reclamation for non-game bird habitat is enhanced by greater

plant species diversity. Both horizontal and vertical diversity contribute to a greater number of potential avian niches. If specific non-game birds are targeted, knowledge of their seasonal habitat and food preferences must be known. Food and cover plantings can then emphasize desired bird species.

Small mammals are a very important "non-visible" wildlife component of an ecosystem. Their presence on reclaimed lands is essential for the re-establishment of some "visible" wildlife species such as raptors and mammalian carnivores. Reclamation efforts emphasizing the re-establishment of small mammal habitat is, thus, very important. Reclamation practices such as initial development of heavy cover with annual grasses and forbs and plantings of cover crops are beneficial in establishing viable small mammal populations immediately following mining. Postmine management practices such as no till agriculture, leaving residual stubble following haying, and minimal grazing by livestock will aid in retaining and enhancing mined areas as long-term small mammal habitat.

A complex providing brushy and rocky areas as cover in close proximity to grass and forb feeding areas is appropriate for lagomorph habitat. Development of rock and brush piles would provide needed cover areas for lagomorphs as well as enhance the overall diversity of a mined site.

CONCLUSIONS

The concepts and suggestions stated in this paper have resulted from two years of intensive investigation concerning the establishment of viable wildlife habitats on mined lands. Readers must be mindful that, although species were treated as separate entites in this paper, they should not be interpreted as interacting only among themselves on mined land. The recommendations for specific habitat and forage requirements for unique species cannot be interpreted as being mutually exclusive. The reclamation coordinator must use the recommendations in this report as guidelines for creating desired habitat associations. An integration of two or more species-specific requirements, utilizing both the available on-site and off-site resources, to develop a complex of habitat use areas should be implemented. In this way, a habitat complex supporting a diversity of wildlife species can be achieved. In addition, the reclamation manager must realize that habitat for targeted species will incur use by non-targeted organisms. It is very important that reclamation scientists be aware that multiple use of habitats will occur and habitat enhancement decisions can encourage this type of use.

APPENDIX

APPENDIX A

PLANT AND ANIMAL SPECIES LIST

Plant Species List

Genus and Species	Common Name
Abies concolor	White fir
Acer negundo	Box elder
Agropyron spp.	Wheatgrass
A. cristatum	Crested wheatgrass
A. dasystachyum	Thickspike wheatgrass
A. elongatum	Tall wheatgrass
A. intermedium	Intermediate wheatgrass
A. smithii	Western wheatgrass
A. spicatum	Bluebunch wheatgrass
Ambrosia spp.	Ragweed
Amelanchia alnifolia	Serviceberry
Artemisia frigida	Fringed sagewort
Artemisia ludivaceana	Cudweed sagewort
Artemisia spp.	Sagebrush
A. cana	Silver sagebrush
A. nova	Black sagebrush
A. tridentata	Big sagebrush
Atriplex spp.	Saltbush
A. canescens	Shadscale
Avena spp.	Oats
Balsamorhiza spp.	Balsamroot
Berberis spp.	Barberry
Betula spp.	Birch
Bouteloua gracilis	Blue grama
Buchloe dactyloides	Buffalo-grass
Carex spp.	Sedge
Centaurea spp.	Russian knapweed
Chamaecyparis thyoides	White cedar
Chenopodium spp.	Lamb's quarter
Chrysothalmnus nauseousus	Rubber rabbitbrush
Commelina communis	Dayflower
Cornus stolonifera	Red-osierdogwood
Crataegus spp.	Hawthorn
Echinochloa spp.	Millet
Elaegnus angustifolia	Russian olive
Eriogonum spp.	Buckwheat
Festuca idahoensis	Idaho fescue
Fraxinus spp.	Ash
Glycine spp.	Soybean
Grindelia squarrosa	Curleycup gumweed
Helianthus spp.	Sunflower
Hordeum spp.	Barley
Juniperus spp.	Juniper

Plant Species List (cont.)

Genus and Species	Common Name
Kochia scoparia	Summer cypress
Lactuca serriola	Prickly lettuce
Lonicera spp.	Honeysuckle
Lupinus spp.	Lupine
Medicago spp.	Alfalfa
Melia spp.	Mahogany
Melilotus officinalis	Yellow sweetclover
Opuntia spp.	Pricklypear cactus
Oryza spp.	Rice
Oryzopsis hymenoides	Indian ricegrass
Penstemon spp.	Penstemon
Phalaris arundinacea	Reed canarygrass
Philadelphus lewisii	Mock orange
Picea spp.	Spruce
Pinus spp.	Pine
P. contorta	Lodgepole pine
P. ponderosa	Ponderosa pine
Plantago spp.	Plantain
Poa sandbergii	Sandberg bluegrass
Polygonum spp.	Knotweed, smartweed
Populus spp.	Poplar
P. deltoides	Cottonwood
P. tremuloides	Aspen
Prunus spp.	Plum
P. serotina	Wild cherry
P. virginiana	Chokecherry
Pseudotsuga menziesii	Douglas fir
Purshia tridentata	Antelope bitterbrush
Quercus spp.	Oak
Q. ilicifolia	Scrub oak
Ranunculus spp.	Buttercup
Rhus trilobata	Skunkbush sumac
Ribes spp.	Currant
Rosa spp.	Rose
Salix spp.	Willow
Salsola kali	Russian thistle
Sarcobatus vermiculatus	Greasewood
Setaria spp.	Foxtail
Shepherdia argentea	Silver buffaloberry
Sicyos angulatus	Bur-cucumber
Smilax spp.	Greenbriar
Spaeralcea coccinea	Scarlet globemallow
Stipa comata	Needle-and-thread

Plant Species List (cont.)

Genus and Species	Common Name
Symphiocarpus spp.	Snowberry
S. occidentalis	Western snowberry
Taraxacum officinale	Dandelion
Thuja spp.	Arbor vitae
Tragopogon dubius	Goat's beard
Trifolium spp.	Clover
Triticum aestivum	Wheat
Xanthocephalum spp.	Snakeweed
Yucca glauca	Soapweed
Zea mays	Corn

(Genus and species, and common names from Fernald 1970).

Animal Species List

Mammals

Genus and Species	Common Name
Antilocapra americana	Pronghorn antelope
Canis latrans	Coyote
Castor canadensis	Beaver
Euderm maculatum	Spotted bat
Microtus	Vole
Mustela nigripes	Black-footed ferret
Odocoileus hemionus	Mule deer
Odocoileus virginianus	White-tailed deer
Peromyscus spp.	Field mice
Sylvilagus spp.	Cottontail rabbit
Sorex spp.	Shrew
Vulpes velox	Northern swift fox

Birds

Genus and Species	Common Name
Accipiter cooperii	Cooper's hawk
Accipiter gentilis	Goshawk
F. Anatidae	Dabbling ducks
Aix sponsa	Wood duck
Anas acuta	Pintail
Anas discors	Blue-winged teal
Anas platyrhynchus	Mallard
Anas strepera	Gadwall
Mareca americana	American wigeon
F. Aythyinae	Diving ducks
Aythya affinis	Lesser scaup
Aythya americana	Redhead
Aythya collaris	Ring-necked
Aythya valisineria	Canvas back

Animal Species List (cont.)

Birds

Genus and Species	Common Name
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shouldered hawk
Centrocercus urophasianus	Sage grouse
Corvus branchyrhynchus	Crow
Eupoda montana	Mountain plover
Falco peregrinus	Peregrine falcon
Falco sparverius	Common kestrel
Haliaeetus leucocephalus	Bald eagle
Meleagris gallopavo	Merriam's turkey
Numenius americana	Long-billed curlew
Pandion haliaetus	American osprey
Pedioecetes phasianellus	Sharp-tailed grouse
Perdix perdix	Hungarian partridge
Phasianus colchicus	Ring-necked pheasant
Richmondena cardinalis	Cardinal
Speotyto cunicularia	Western burrowing owl
Turdus migratorius	Robin
Tympanuchus cupido	No. prairie chicken

Insects

Phylum Arthropoda	Insects
O. Coleoptera	Beetles
O. Hymenoptera	Ants
O. Lepidoptera	Caterpillars, cutworms
O. Orthoptera	Grasshoppers

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