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

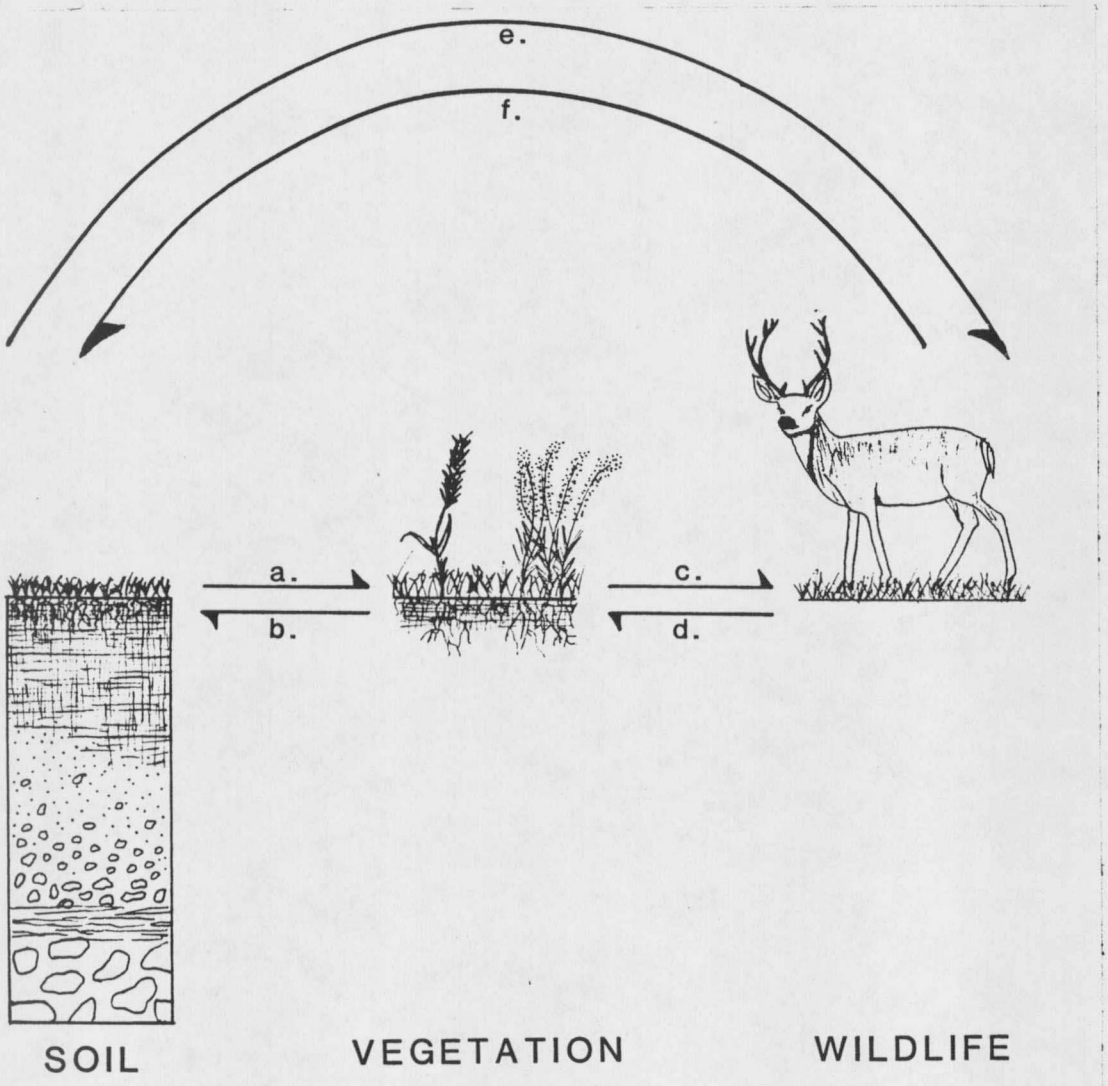

Figure 1. SOIL - VEGETATION - WILDLIFE RELATIONSHIPS

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).