The Role of Crested Wheatgrass in Reclamation of Drastically Disturbed Lands

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ABSTRACT: Rangelands of the western United States are subjected to a variety of drastic disturbances which necessitate reclamation for impact mitigation. Crested wheatgrass may play an important role in the revegetation phase of the reclamation process. Characteristics of the species governing its use in revegetation are discussed, and its past and present performance on drastically disturbed lands is reviewed. Conclusions and recommendations are drawn on the proper future role of crested wheatgrass in disturbed land reclamation.

INTRODUCTION

In response to expanding needs for energy, services, and essential raw materials, rangelands in the West are being devoted to an increasing variety of non-agricultural uses. Many involve drastic land disturbances which completely destroy existing ecosystems and land uses. Mining activity is perhaps the most recognized example of such drastic land disturbance, and certainly has produced major environmental impacts in many parts of the West. However, other types of disturbance such as oil and gas development; construction of pipelines, powerlines, highways, and railroads; and cropland reversion are numerous and in aggregate very important. If not reclaimed such disturbances will remove hundreds of thousands of acres of western rangelands from productive uses for indefinite periods of time.

The Significance and Nature of Reclamation

Reclamation comprises one obvious solution to the environmental trade-off dilemma of drastic land disturbances. As noted by the National Academy of Sciences (1981), the goal of reclamation is to insure that society does not lose the actual or potential land use opportunities available prior to disturbance. Reclamation has been recognized for some time as ethically, ecologically and agriculturally important (Box 1978); for many types of disturbance it is now legally mandated as well.

As reviewed by Box (1978), numerous concepts and definitions of reclamation exist. These range from complete restoration of prior conditions to rehabilitation on pre-designated criteria. For purposes of this paper, reclamation will be considered the process of returning a drastically disturbed site to conditions approximately equal to or greater than those prior to disturbance in terms of sustained support of functional physical processes, biological organisms and land uses. This definition is similar to that recently proposed by Narten et al. (1983).

Because reclamation essentially strives to re-establish entire, functional ecosystems on disturbed lands, the necessity of properly integrated, "entire-system" approaches has become widely recognized (Wali 1975). Reclamation thus becomes a complex endeavor with numerous facets, involving a multiplicity of scientific disciplines. Revegetation is one important aspect of the reclamation process, because its nature will obviously be a major determinant of the function and use of re-established ecosystems.

Revegetation Goals and Principles

In broad terms, revegetation objectives on disturbed rangelands usually call for establishment of permanent, self-sustaining vegetation to stabilize the soil and provide habitat and forage for livestock and wildlife (Narten et al. 1983). In a narrower sense, the specific nature of "successful" revegetation is controversial. Diverse, predominantly native vegetation on reclaimed lands is propounded by many (Blake 1981), and is the type of vegetation stressed in current reclamation regulations (Imes and Wali 1978). However, the feasibility or desirability of such objectives has frequently been challenged by those favoring a more flexible, utilitarian approach including the use of introduced species (Laycock 1980, Currie 1981, Hofmann et al. 1981).

Ries and DePuit (1984) felt the nature of successful revegetation largely depended upon

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proposed land uses, and its achievement rested on proper plant materials selection and revegetation methods. While great progress in revegetation methods has been made (Packer and Aldon 1978), selection of proper plant species often remains problematic or controversial.

DePuit (1982) proposed five criteria for selection of plant species in disturbed land reclamation:

1) adaptational and other autecological characteristics,
2) initial establishment characteristics,
3) synecological characteristics,
4) functional utility,
and 5) practical availability.

It was postulated that if a given species properly met these criteria, it should be acceptable for revegetation use, irrespective of its origin. Therefore, depending upon specific reclamation goals, environmental conditions and plant species characteristics, there should be a role for both native and introduced species in disturbed land reclamation (DePuit 1982, Thornburg and Fuchs 1978).

Objectives of Paper

Crested wheatgrass (i.e., the Agropyron cristatum, A. desertorum, A. sibericum complex) has been widely used in disturbed land revegetation in the Northern Great Plains, Rocky Mountain and Intermountain regions. For a number of reasons, this use has prompted more controversy than any other single species utilized in revegetation. This paper will analyze the characteristics of crested wheatgrass pertinent to species selection criteria, review the past and present use of the grass on disturbed lands, and then draw conclusions on the proper future utilization of this species in revegetation.

CRESTED WHEATGRASS FOR DISTURBED SITE REVEGETATION

Characteristics Pertinent to Revegation

Adaptational and autecological characteristics.--To be considered for revegetation use, a plant species must be adaptated to prevailing climatic, physiographic and edaphic conditions of the site. Such conditions are usually more severe (i.e., less conducive to plant growth) on disturbed than on non-disturbed sites. The autecological characteristics of the species also must be conducive to the desired functions and uses of the re-established ecosystem.

Crested wheatgrass is a perennial, cool-season bunchgrass first introduced into the United States in 1896 (Holechek 1981). Crested wheatgrass exhibits one of the widest adaptational amplitudes of any grass species (native or introduced) in the western United States (Rogler and Lorenz 1983). As summarized below much information is available on the specific adaptational nature of crested wheatgrass (Holechek 1981, Rogler and Lorenz 1983, Thornburg 1982, Wasser 1982, Keller 1979).

Climatically, crested wheatgrass is a cold-tolerant xerophyte best adapted to areas of 9 to 15 inches (23 to 38 cm) annual precipitation and cool to cold winters. These conditions typify a significant portion of the Northern Great Plains and Intermountain regions. Its drouth tolerance is very high, an important adaptational characteristic in light of the overriding importance of moisture availability as a limiting factor for western revegetation (May 1975).

Edaphically, crested wheatgrass can establish and persist on a wide variety of soils, but is best adapted to moderately deep, well-drained, loamy soils. While certainly responsive to increased fertility (DePuit and Coenenberg 1979), the species can establish on soils with relatively low inherent fertility (Holechek et al. 1982). Such tolerance of infertility is a physiological asset on drastically disturbed soils, which commonly are low in certain essential plant nutrients (Bauer et al. 1978). Soil salinity or sodicity are edaphic constraints to revegetation on many arid and semiarid disturbed lands (Sandoval and Gould 1978). Although not adapted to highly salty (especially sodic) soils, crested wheatgrass has often established well on moderately saline disturbed soils in the West (Holechek 1981).

In addition to its adaptational traits, crested wheatgrass possesses a number of other autecological characteristics pertinent to its role in revegetation. As reviewed by Rogler and Lorenz (1983), crested wheatgrass is a long-lived species under proper management, is capable of self-regeneration, is tolerant of fire (in the dormant stage), and has relatively few disease problems. These characteristics enhance the desirability of the species for disturbed land revegetation in terms of providing permanent, self-sustaining vegetation.

The relatively good forage production potential of crested wheatgrass is also an asset. It is a cool-season species exhibiting maximum growth and forage quality during the spring. This attribute carries a number of implications for the functional utility of crested wheatgrass on reclaimed lands.

Initial establishment characteristics.--In addition to adaptation when mature, rapid initial establishment is a requisite of plant species used in revegetation. As noted by DePuit (1982), mature plant adaptation and ease of initial establishment are not always positively correlated on disturbed lands. Weak or slow initial establishment may detrimentally affect revegetation through accelerated soil erosion or weed infestation. Poor initial establishment of a seeded species also may increase chances of its competitive inhibition or exclusion by more rapidly establishing species.

A great amount of accumulated information is available on the seed and seedling ecology and physiology of this species (Johnson this volume, Wasser 1982, Fulbright et al. 1982). Although exceptions have occurred, research and practice have demonstrated that crested wheatgrass is a rapidly establishing grass on sites where it is adapted within the Northern Great Plains and Intermountain regions (Plummer 1977, Hafenrichter et al. 1968, Thornburg 1982). Germinative capacity of seeds is typically high (Wasser 1982). Further, crested wheatgrass germinates and initiates active growth very early in the spring, contributing to relatively good seedling vigor.

Initial establishment of crested wheatgrass can usually be achieved using known and available cultivation, direct seeding and subsequent management practices (Keller 1979, Wasser 1982, Fulbright et al. 1982). Crested wheatgrass has often responded well to cultural practices applied to promote plant establishment on disturbed lands, most notably fertilization (DePuit and Coenenberg 1979).

Therefore, crested wheatgrass meets the initial establishment criterion for species selection quite well, adding to its credibility as a disturbed site revegetation species.

Synecological characteristics.--As noted previously, current regulations strongly emphasize species diversity in revegetation of many types of land disturbance, especially surface mining. Logical arguments have been propounded both for (Monsen 1975, Plummer 1977) and against (Laycock 1980, Currie 1981) this regulatory predisposition, with respect to feasibility, ecological desirability and utility. Despite the ongoing controversy, the fact remains that revegetation goals for many, if not most, disturbances involve re-establishment of mixtures of plants rather than single species. It is therefore important that species included in seeded mixtures be synecologically compatible. As noted by Power (1978), the area of interspecific competition and compatibility within mixed plant communities on disturbed lands is one of the least understood aspects of revegetation.

Crested wheatgrass is an exceptionally vigorous, competitive species on sites where it is adapted due to its specific physiology, phenology and morphology (Caldwell et al. 1981, Richards and Caldwell 1982, Harris 1977). Because of its competitive nature, crested wheatgrass coexists variably with other species in mixed stands. Persistent and useful mixtures of crested wheatgrass with certain shrubs, introduced legumes and grasses have sometimes been established on improved pastures, rangelands and disturbed lands (Dubbs 1975, Rumbaugh et al. 1982, DePuit and Coenenberg 1978). However such mixed communities are often floristically simple--particularly on disturbed lands (DePuit et al. 1978).

Considerable evidence exists of the synecological incompatibility of crested wheatgrass with many native grasses, forbs and shrubs whose presence in reclaimed plant communities is sometimes desirable. The competitive superiority of crested wheatgrass over many native grasses has been long recognized in rangeland seedings (Heinrichs and Bolten 1950). In a recent Wyoming study, Schuman et al. (1982) seeded crested wheatgrass with both single species and mixtures of native grasses. While crested wheatgrass comprised only 25% of the initial seed mix in all cases, after four years it comprised an average (across all treatments) of 85% of the ultimate stand. Similar results were reported from Montana mined land studies (DePuit et al. 1978, Sindelar 1978), in which crested wheatgrass and other seeded introduced species competitively excluded concurrently seeded native species. DePuit et al. (1980) concluded that it may be necessary to exclude crested wheatgrass and other exceptionally vigorous species from seed mixtures to enable establishment of diverse plant communities on Northern Great Plains mined lands.

These results on Northern Great Plains disturbed lands have major implications for use of crested wheatgrass relative to revegetation goals. If a relatively simple plant community dominated or co-dominated by crested wheatgrass is acceptale, seeding of the species may be justified. Conversely, if a more diverse community is required for land use or regulatory goals, inclusion of crested wheatgrass in seed mixtures may be inadvisable.

These general relationships for the Northern Great Plains region may require qualification for specific sites or for other regions. However, synecological incompatibility between crested wheatgrass and certain other species does exist, indicating that relationships between crested wheatgrass and other desired plant species must be considered in designing species mixtures.

Functional utility.--Selection of any plant species for disturbed land revegetation must be based in part upon its functional utility, in terms of both the processes associated with reclamation and the projected land use goals. Such functional utility depends upon many of the autecological and synecological characteristics already discussed.

In terms of reclamation processes, the rapid initial establishment, vigor and hardiness of crested wheatgrass provide considerable potential for the soil stabilization mandatory on drastically disturbed lands. However, because of its bunchgrass morphology, crested wheatgrass may not be as effective in longterm erosion control as certain rhizomatous species, and for this reason should often be seeded in conjunction with the latter for maximum site stabilization (Cook et al. 1970). The relatively high production potential of crested wheatgrass on adverse sites is also an asset in reclamation processes. Higher organic matter production will promote soil development and carbon/nutrient cycling (Schafer and Nielson 1978). However, if accelerated plant community development (i.e. succession) toward a "native" condition is desired, establishment of crested wheatgrass may be inappropriate due to its competitiveness and persistence.

The functional utility of crested wheatgrass on disturbed lands also depends upon its suitability for the type or types of land use goals established. For livestock land use, results of mined land grazing studies in Montana and North Dakota (Hofmann et al. 1981, DePuit and Coenenberg 1978, DePuit 1983) have indicated crested wheatgrass has high utility for early season grazing, in terms of forage quality and quantity, animal production and vegetation responses. These results conform to those of many rangeland studies. However, the forage value of crested wheatgrass during other seasons is often inferior to other species currently available for revegetation, both on mined lands (DePuit 1983) and elsewhere (White and Wight 1981, Rumbaugh et al. 1982). Therefore, the functional utility of crested wheatgrass for livestock grazing on disturbed lands is linked to its management:

1) as a component of complementary grazing systems involving other seasonal forages in other pastures (DePuit 1983, Currie 1981); or

2) as a part of mixed stands with other species of different seasonal forage values (Rumbaugh et al. 1982).

As previously discussed, the latter approach may not always be possible due to the synecological incompatibility of crested wheatgrass with certain other species. If neither of the above approaches prove possible or practical, species other than crested wheatgrass may be more appropriate for revegetation.

In addition to livestock, reclamation goals for many disturbed sites in the West include support of wildlife. Considerable controversy has surrounded the value of crested wheatgrass for wildlife on disturbed lands (Harju 1980). Crested wheatgrass, contrary to the impressions of many, does have specific value to some wildlife species at certain times of the year (Urness et al. 1983, Holechek 1975). However, these benefits can be outweighed by the negative effects of crested wheatgrass on vegetation diversity, which is recognized as a prerequisite for both diversified wildlife populations and adequate season-long support of many individual wildlife species. The detrimental effects of large-scale crested wheatgrass plantings on many wildlife species have been recognized (Value 1974).

Practical availability. In addition to acceptability in terms of autecological, synecological and utilitarian characteristics, any plant species used in disturbed land revegetation must have seeds or propagules available in sufficient quantities. Due to its ample seed production and ease of harvest and treatment (Hafenrichter et al. 1978), adequate commercial seed availability is usually not a problem with crested wheatgrass. Several species and species cultivars within the crested wheatgrass complex have been evaluated and released for use, such as Nordan, Fairway, Ruff, Parkway and Siberian. Each of these selections exhibit somewhat different autecological, synecological and utilitarian characteristics (Thornburg 1982, Wasser 1982).

Past Use and Performance on Disturbed Lands

Crested wheatgrass has been one of the most commonly used grass species for general range reseeding in the western United States (Holechek 1975). Because of its history of use on rangelands, crested wheatgrass early became a prime species in disturbed land revegetation efforts when reclamation of such lands became a major concern in the 1960's. The species found an early place in roadside revegetation and stabilization (Cook et al. 1970, Hodder 1970, Jensen and Sindelar 1979). Crested wheatgrass was also a common component of early seed mixtures for mined lands in North Dakota, Montana, Wyoming, Colorado and Utah. This use was generally vindicated by adequate initial establishment, site stabilization, vigor, productivity and persistance (Frischknecht and Fergusen 1979, Ries et al. 1978, DePuit et al. 1978, May et al. 1971, Sims and Redente 1974).

Although crested wheatgrass proved useful in revegetating disturbed lands in the region, certain problems were associated with its usage. The paramount problem involved the competitive aggressiveness of crested wheatgrass, which has often eliminated or reduced other concurrently seeded and desired species (Sindelar 1978, Ries et al. 1978). DePuit et al. (1978) also suggested that without proper management (i.e., grazing or maintenance of fertility), vigor of crested wheatgrass would decline over time on disurbed lands. In addition, the high responsiveness of crested wheatgrass to fertilization (DePuit and Coenenberg 1979, Redente et al. 1982) has sometimes created soil C:N imbalance problems (Schafer and Nielsen 1978, Sindelar 1978) and declines in vegetation diversity (DePuit and Coenenberg 1979, Doerr et al. 1983). Clearly, proper management of crested wheatgrass is as essential on disturbed lands as elsewhere, and such management on disturbed lands involves some rather unusual problems.

Grazing studies on reclaimed pastures containing crested wheatgrass have demonstrated the species to be either tolerant of or stimulated by livestock utilization if well-established (Hofmann et al. 1981, DePuit 1983). Animal performance during spring grazing periods was excellent. DePuit (1983) found that lower forage quality during summer and fall was associated with reduced animal gains relative to native rangeland pastures.

Present Use on Disturbed Lands

Because of its early successful establishment on disturbed lands in the West, crested wheatgrass was perhaps over-utilized -- that is, used in many situations where other plant species could have been established and were better suited to projected land uses. This "overuse" has led to a current public and regulatory reaction against crested wheatgrass in reclamation and a reduction in use. Another reason for reduced utilization of crested wheatgrass in reclamation arises from the development of other plant species with high revegetation potential, including many native species (Thornburg 1982). A third reason for reduced crested wheatgrass use involves a current prejudice against introduced species in general within environmentalist and regulatory sectors, which some observers feel to be highly unjustified (Laycock 1980, Currie 1981).

Consequently, and in contrast to earlier years, crested wheatgrass is presently being "under-used" in disturbed land revegetation. Nowhere is this more evident than in mined land reclamation. In response to regulatory mandates and other considerations, many mine companies in the region have completely eliminated crested wheatgrass from seed mixtures (e.g., Coenenberg 1982). In some cases, this elimination may be justified on ecological or utilitarian grounds. But in other cases it may be unfortunate, because crested wheatgrass, if properly utilized in appropriate situations, has a role to play in reclamation.

SUMMARY

The characteristics of crested wheatgrass pertinent to disturbed land revegetation are those relating to its adaptation and autecology, initial establishment, synecology, utility, and availability. Autecologically, the species has many desirable attributes, including wide climatic and edaphic adaptation, tolerance of poor quality soils, long life, capability for self-regeneration, vigor, good production potential and tolerance of grazing.

Due to certain of its seed and seedling characteristics, crested wheatgrass can be established readily on disturbed lands with conventional seeding methods, and is generally responsive to cultural practices applied to promote initial plant growth. The availability of crested wheatgrass seed is not a practical problem, and several species/species cultivars have been developed for use in specific situations. These attributes suggest that crested wheatgrass is an excellent species for revegetation.

The major limitations of crested wheatgrass for disturbed land revegetation derive from its synecological and utilitarian nature. Its vigor, hardiness, aggressiveness and persistence enable crested wheatgrass to inhibit certain other plant species whose presence may be desirable in mixed communities. There often appears to be an inverse relationship between crested wheatgrass dominance and plant community diversity, which limits its value where floristic diversity is an important reclamation goal.

In a utilitarian sense, crested wheatgrass has a number of attributes which are beneficial to the reclamation process itself, such as capability for rapid soil stabilization and increasing organic matter accumulation. However, its persistence and competitiveness may retard community succession toward a "native" condition, an obviously undesirable effect if such a progression is a goal. Optimal maintenance of crested wheatgrass on disturbed lands may be dependent upon somewhat more specialized or intensive management practices than those required for other species. The land-use capabilities of crested wheatgrass tend to be more specific than general. For instance, the phenology of crested wheatgrass makes it valuable for spring grazing. During other seasons, however, it may be inferior to other plant species currently available for revegetation.

Crested wheatgrass has been widely, perhaps over-widely, used in disturbed land revegetation programs. The species generally performed well in terms of initial establishment, productivity and persistence over a wide range of environmental conditions. Nonetheless, the use of crested wheatgrass on disturbed lands has recently been greatly curtailed. This is partly a result of a public and regulatory reaction to the earlier over-use of the species. In some cases, this reaction may be justified; in other cases, the reduced use of crested wheatgrass is neither objective nor logical.

CONCLUSIONS: THE PROPER FUTURE USE OF CRESTED WHEATGRASS ON DISTURBED LANDS

In the past, crested wheatgrass was perceived by many as a "panacea" species for range seeding and disturbed land revegetation over much of the West. Recent recognition of the fact that crested wheatgrass - like any species - has ecological and utilitarian limitations has negated this perception. Crested wheatgrass, as noted by Keller (1978), indeed does not have universal utility. Conversely, neither does the species have universal inutility. Any plant species with desirable characteristics may prove valuable in disturbed land revegetation if used properly (DePuit 1982, Currie 1981), and crested wheatgrass is certainly no exception. The proper role of crested wheatgrass on disturbed lands depends on an integration of environmental conditions and reclamation goals. This yields a number of general recommendations for use of crested wheatgrass in reclamation:

1) Extensive, monotypic seedings of crested wheatgrass on disturbed lands should be avoided, for both ecological and utilitarian reasons.

2) Crested wheatgrass use should be limited or eliminated on sites where relatively high floristic diversity or accelerated succession toward native conditions are reclamation goals. The research basis for this recommendation is strongest within the Northern Great Plains, but the principle may apply (with some modification) to the Intermountain region as well.

3) If its dominance is expected or desired, crested wheatgrass may be profitably used to support livestock in separate pastures managed in a complementary grazing system with pastures dominated by other species. The inter-pasture community (i.e., "habitat") diversity engendered by such management may also provide benefits to wildlife.

4) If non-complementary, season-long grazing is a land-use goal but high floristic diversity is not, crested wheatgrass may be used in relatively simple mixtures with other species that are synecologically compatible and which have differing phenologies or morphologies. A number of other species (grasses, legumes and shrubs) meet these criteria. Without such concurrently established species, optimum season-long forage benefits probably cannot be attained.

5) Crested wheatgrass may have particular value as a primary revegetation species in situations where its autecological attributes outweigh any synecological or utilitarian limitations. Examples of such situations include sites with edaphic or climatic conditions sufficiently adverse to preclude establishment of other species, and sites where the limitations of crested wheatgrass are not relevant to reclamation goals.

The above recommendations are generalizations, and specific exceptions may occur. They nonetheless outline broad considerations related to the appropriate use of crested wheatgrass in reclamation. The future use and evaluation of crested wheatgrass on disturbed lands should be based on its characteristics in relation to the criteria, principles and goals of reclamation, rather than on polarized positive or negative opinion. Only in this manner will the true value of this controversial species in disturbed land reclamation be recognized and achieved.

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