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LONG TERM VEGETATION DEVELOPMENT ON RECLAIMED SITES

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ABSTRACT

Successional change that leads to the development of stable long lived ecosystems on reclaimed lands is encouraged through the process of successional reclamation. Recognition of reclamation as a long term process on drastically disturbed sites can assist in defining reclamation goals and objectives that can be reasonably achieved in human time frames. The development of vegetation covers that assist in amelioration of adverse site conditions and that encourage natural successional processes can provide a first step in the reclamation process. Pioneering vegetation can improve soil organic matter content, nutrient levels, moisture holding capacity and soil structure. Key elements for successful development of pioneering vegetation include stabilization of unstable sites, control of erosion and an open cover into which native species can invade.

This paper explores the steps that can be used to assist natural successional processes in the development of successionally appropriate vegetation on disturbed sites and the development of that vegetation over the long term. Inferences about the future direction of vegetation development are proposed. Examples, including sites where soil bioengineering has been used as a first step in the revegetation process, are drawn from the author's experience.

INTRODUCTION

Reclamation legislation for mines in British Columbia dictates that the land be revegetated to a self-sustaining state using appropriate plant species (Sect. 10.6.6, Ministry of Employment and Investment, 1997). Productivity must be equal to or better than that which existed prior to mining. Restoration requirements for developments other than mines are not as well defined, although it is generally accepted that restoration should lead to stable productive ecosystems. Successional reclamation (Polster, 1989) seeks to restore the natural successional processes on the disturbed sites. Natural successional processes provide a model that can be followed during the reclamation of a site. Ultimately, these natural processes will lead to establishment of the most naturally productive ecosystems. These ecosystems will be self-sustaining or will lead to further successional development. Vegetation can be used as an indicator of the various ecosystem processes that are developing on a site.

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Successional reclamation has been used as a model for the treatment of a number of sites throughout British Columbia, Although the early results of these reclamation programmes are promising, little attention has been directed at the long term development of vegetation on sites where successional reclamation has been used. Initially, successional reclamation seeks to establish an erosion controlling cover of successionally appropriate vegetation on the disturbed sites. Typically agronomic grasses and legumes are used. This plant cover is supplemented with the establishment of pioneering woody vegetation, either directly through planting or by allowing native pioneering species to establish naturally. This vegetation cover provides conditions that assist in the establishment and growth of later successional species until eventually a cover of climax species is established on the disturbed site. The time required for this process to unfold on reclaimed sites dictates that the successional processes themselves be used as a surrogate for these later successional stages. Successional processes, primarily species replacement, provide an excellent tool for evaluating the potential long term development of vegetation on disturbed sites.

This paper provides a review of those features of a successional reclamation programme that encourage the further vegetation to development on a site. Key features of the early reclamation work can have a profound influence on subsequent plant establishment and in turn on the establishment of later successional species. Successional stagnation (Kimmins, 1987) can develop on sites where inappropriate seed mixes have been used to establish the initial cover on a site. This can make it very difficult to establish later successional species and may prevent the establishment of woody species entirely. Keystone species (Mills et al, 1993) can play a critical role in the establishment of later successional species. The role of these important species and the methods that can be used to ensure their establishment are presented. Results of assessments of sites where successional reclamation has been used are presented to collaborate the general theories of successional reclamation. Conclusions regarding the development of effective reclamation programmes are presented.

SUCCESSIONAL RECLAMATION

Successional reclamation is the term applied to a reclamation model that seeks to enhance natural successional processes for the rehabilitation of drastically disturbed sites. The major aim of successional reclamation programmes is the re-integration of the disturbed sites with the natural successional processes that operate in the local area to revegetate natural disturbances. The study of natural successional process on natural disturbances (Straker, 1996) can provide clues of the factors that can assist in the establishment of natural successional processes on sites disturbed by human activities. Polster (1991) lists five factors that limit natural vegetation growth on drastically disturbed sites. These are: steep slopes; adverse texture; poor nutrient status; adverse chemical properties; and soil temperature extremes. Amelioration of these adverse conditions is the first prerequisite in the development of a successional reclamation programme.

Steep slopes prevent vegetation establishment by having a continually moving surface. Soil bioengineering (Schiechtl, 1980) can be used to provide initial stability to slopes where the surface movement is preventing natural plant growth. The use of soil bioengineering for treatment of steep slopes in British Columbia is becoming common (Polster, 1997 & 1999). By providing the initial stability, soil bioengineering allows other plants to establish and eventually provide the stability needed to maintain vegetation on the site. Soil bioengineering uses pioneering plants that quickly give way to later successional species. Once the later successional species are well established they can take over the support of the slope through buttressing as well as the root network that is formed (Gray and Leiser, 1982). The initial stability provided by the soil bioengineering thus solves the problem of steep slopes and initiates the successional processes that lead to stable ecosystems.

Adverse soil textures can prevent vegetation growth. The coarse rock that accumulates at the toe of free dumped waste rock dumps is very difficult to revegetate. Resloping waste rock dumps to cover this coarse material with fine textured materials that accumulate near the top of the dump slope is the major means of addressing this problem (Popowich, J. 1978). Natural talus slopes provide a similar condition and allow the study of natural means of overcoming the problems associated with coarse textured materials (Polster and Bell, 1980). Natural accumulations of organic matter in the crevices between the boulders at the base of talus slopes provide a substrate in which vegetation can become established. Pocket planting, where soil is placed in the interstitial spaces between the rocks mimics this natural process and can be used to establish pioneering vegetation in coarse rock areas. Fine textured soils can also be problematic for plant establishment, although generally fine textured soil problems are associated with the stability of the soil. Soil bioengineering techniques can be used to treat fine textured soils.

Poor nutrient status can limit natural vegetation establishment on drastically disturbed sites. Typically drastically disturbed sites have very limited nutrient levels (SEAM, 1979). Fertilizer can be used to overcome this problem initial, however, in the long term, nutrients must be supplied by local nutrient cycling and the fixation of atmospheric nitrogen by legumes and other nitrogen fixing species. Use of a balanced seed mix that contains 30 to 40 percent legumes will assist in establishment of vegetation on low nutrient sites.

Adverse chemical properties such as acid rock drainage (ARD) or sodic spoils can present significant challenges for the establishment of vegetation (Morin and Hutt, 1997). Although there are some plants that can grow under extremes of pH, metals and other adverse chemical components, most plants are stressed under these conditions (Farmer, et al. 1976). Treatment of these conditions is often very difficult and specific methods of treatment are used for specific sites.

Soil temperature extremes, either hot or cold, can slow or even prevent natural vegetation establishment and growth. Dark coloured substrates on south facing (northern hemisphere) slopes can become very hot under the summer sun. These hot temperatures can kill young plants by denaturing the proteins that make up the various constituents of the plants. Similarly, cold temperature such as occurs in arctic regions can severely limit or even preclude vegetation growth (Bliss and Wein, 1972). Modifications to the surface of the soil can be used to ameliorate adverse temperature conditions. Disking in an east-west direction will create small soil windrows with northern and southern exposures. With dark substrates that are prone to being too warm vegetation can be established on the northern exposures while in cold climates the southern exposures will provide slightly warmer micro-sites that will allow vegetation to establish. Dark substrates can be treated with heavy mulch applications that reduce the albedo of the surface and thus prevent overheating.

Other site features such as exposure to various environmental influences such as prevailing winds, sunlight, salt spray and ice scouring can influence the patterns of vegetation establishment. Successional change in these communities may be primarily influenced by the site factors and therefore difficult to manage from a restoration perspective.

Once the vegetation limiting features of the site are addressed, pioneering vegetation can be established. The pioneering vegetation must provide a stable environment, space for invading native species and enhancement of the site relative to the species that will follow. One of the primary aims of the initial vegetation cover is to protect the site from excessive erosion. Invading vegetation can not become established on an actively eroding site. A cover of seeded grasses and legumes is typically used to control erosion, however, too dense a cover of seeded species will prevent invasion of later successional species by closing the space needed by the invading plants. Therefore an open cover of seeded species is needed.

This cover should include a good balance of grasses and legumes to provide site improvements that enhance the ability of later successional species to establish and grow.

Establishment of the pioneering cover leads the way towards establishment of later successional species. Whereas the pioneering vegetation is typically herbaceous in nature, in most parts of British Columbia, woody species dominate the next phase of vegetation that establishes. The various alder species that occur in British Columbia act as pioneering woody species in many ecosystems. Other deciduous species such as cottonwood and aspen may act in this capacity in some ecosystems. These plants play a pivotal role as a bridge between the short-lived herbaceous cover and the longer lived conifers that dominate most forest ecosystems in the province. It is into this pioneering woody species cover that later successional conifers can establish. The role of these serai species is essential to the long term health of forest ecosystems.

Replicating the essential features of natural successional patterns on drastically disturbed sites provides productive ecosystems. Each stage in the process is important, from the initial erosion controlling cover of grasses and legumes through the later successional woody species. Successional reclamation duplicates the vegetation patterns found in natural successional sequences.

MEASURES OF SUCCESS

The success of a successional reclamation programme can be measured by looking at the invasion of the reclaimed site by native species. Site manipulations that encourage establishment and growth of native species contribute to the long term success of the reclamation efforts. The following case studies present examples of where the theories of successional reclamation have been tested.

BP Exploration Canada Ltd. investigated the potential! for mining of a property known as the Sukunka property in the late 1970's and early 1980's. This property is located in the Northeast Coal Block near Chetwynd, B.C. Part of this programme consisted of establishing reclamation strategies that would be effective for the area. One idea that was tested was the use of artificial fertilizer applications to encourage native species establishment and growth. A series of trials was established on the Sukunka property in 1979 (Polster and Redgate, 1982). These consisted of applications of varying amounts of fertilizer to a variety of sites. The study concluded that fertilizer applications resulted in the subalpine areas resulted in an increase in cover of both native and agronomic species. In the alpine, fertilizer applications stimulated agronomic species growth but not native species establishment and growth. This effect was felt during the first year of growth but the heavy thatch that developed slowed growth during the second year. The conclusions about the impact of fertilizer applications on native species growth were that fertilizer did not improved conditions for native species in the alpine and the heavy thatch that developed following application of fertilizer to agronomic species slowed native species establishment and growth.

Reclamation of forest landslides is undertaken to reduce erosion and lessen the impacts of the landslides on aquatic habitats. Reclamation treatments on two adjacent watersheds were carried out in the mid 1990's. In one watershed, a successional approach was taken and a balanced seed mix was used resulting in the establishment of an open stand of vegetation. In the other watershed, the seed mix was not balanced and resulted in the establishment of a dense stand of seeded species. Assessments conducted in 1999 (Warttig and Wise, 1999) found that there were four times as many native pioneering species (alder) in the watershed where successional reclamation was used.

The CP Rail Roger's Pass Project was the first use of successional reclamation for a major project. Reclamation work on this project was conducted from 1983 to 1989. The reclamation work conduced on this project was the subject of an intensive study that culminated in the production of a thesis in 1998 (Lamb, 1998). Conclusions from this study indicated that the agronomic species were persistent and native invasion was most rapid along the edges of the disturbed areas. Native species invasion on the reclaimed sites may be limited due to the planting of native pioneers on most sites.

Reclamation of the sand cliffs surrounding the University of British Columbia was undertaken from 1988 to 1990. Soil bioengineering and successional reclamation were used. This reclamation work resulted in the establishment and dominance of willow and agronomic grasses and legumes on the slopes during the early 1990's. Rapid invasion of the site by red alder lead to a dominance by alder by the late 1990's. In addition, Douglas fir, sword fern and salmonberry were found on the slopes in 1999. Further evaluations of this site are planned.

CONCLUSIONS

The use of successional reclamation methods in the establishment of vegetation on disturbed sites can enhance the speed at which natural processes and native species establish on a site. Providing space for invasion by natives is essential. Space is provided by avoiding the use of a dense sod forming seed mix for the initial cover. In addition, fertilizer should be applied carefully to avoid the establishment of a dense thatch that will restrict native species invasion and growth. Stability of the site is essential for the establishment of native species. Soil bioengineering can be an effective means of providing site stability. Additional study of the long term development of vegetation on reclaimed sites is warranted. However, initial evaluations of the progress of reclamation on a variety of disturbed sites indicates that the objectives of reclamation will be met.

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