"Fertilization Can Reduce the Amount of Seed Needed to Revegetate Degraded Soils"

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Abstract

Fertilization is not usually recommended use in the ecological restoration of plant communities, because exotic and weedy species typically respond to nutrient addition more than longer-lived and slower-growing native plants. Yet native plant materials are often expensive and difficult to obtain, thereby providing an incentive to optimize their survival and growth on restoration sites. We have spent several years collecting, propagating and field-testing species of *Achillea*, *Carex*, *Elymus*, *Festuca*, *Geum* and *Lupinus* indigenous to the northern interior of British Columbia, Canada. These species have been sown in field trials at densities ranging from 375 to 6000 pure live seeds per m^2, with and without 18-18-18 fertilizer, on sites degraded by road construction and logging activities. Preliminary results suggest that fertilization can increase the cover produced by a given density of seed by two to five times. These findings may permit the substitution of inexpensive fertilizer for some expensive native plant seed, but only on sites relatively free of weeds.

Introduction

Re-introducing native grasses and forbs to degraded land is an integral consideration in ecosystem restoration. Large areas of land in British Columbia need to be revegetated due to extensive logging, mining, road construction and other industrial activities. Plants are needed for aesthetic and functional purposes: for "visual green-up", to control erosion, and to restore soil structure.

Currently, revegetated areas are dominated by weeds and agronomic grasses and legumes of European origin. Inexpen-sive and fast growing, agronomic species are sown every year on thousands of hectares of disturbed land.

It would be pref-erable to use native plant seed to reveg-etate degraded land. However, a major limitation to the use of native plants is the poor availability and great expense of seed. Native herbaceous plant seed generally has to be collected by hand in the wild. Another major limitation to using native plants for ground cover and site amelioration is that only limited information is available on germination rates, appropriate seeding densities, optimal seeding times and growth requirements.

Objectives

This project addresses the issue of optimal seeding densities of native seed and the degree to which higher densities can be offset through the use of artificial fertilization. Specifically, we ask, "What minimum density of seed, or what combination of seed density and fertilizer, will achieve a target level (e.g., 70%) of plant cover?"

Methods

Five sites recently degraded through industrial forest activities, road construction, log loading and log sorting were selected for seeding in October, 1999. Sites had little or no topsoil, were heavily compacted, and were generally free of woody plants. Trials were installed at six locations spanning a large area of northwestern British Columbia. Preliminary results from three sites located close to Smithers, B.C., are reported here.

All sites were first cleared of rocks and any existing vegetation. In order to provide a uniform and favourable seedbed, a 75m^2 area was first rototilled to loosen the compacted soil, and was then hand raked. Each site was divided into twelve 2.5m x 2.5m plots, demarcated with spikes and flagging

The seed mix employed at all densities consisted of 20% *Achillea millefolium* L., 20% *Carex aenea* Fern., 20% *Elymus glaucus* Bukl., 20% *Festuca occidentalis* Hook., 16% *Geum macrophyllum* Willd. and 4% *Lupinus polyphyllus* Lindl., measured as pure live seed (PLS). The first consideration in choosing species was reliable germination in lab tests. Other goals were to include a balance of grasses, sedges and forbs, fast and slow germinators, rhizomatous species and a nitrogen fixer. Seeds were grown in cultivation as part of a program to provide a reliable source of native plant seed designed to maintain high genetic diversity (Burton and Burton 1998).

Densities sown were chosen based on literature suggesting that effective erosion control requires plant cover of 70 to 80% after the first growing season (Carr 1980). Such levels are at least three times greater than observed in preliminary trials sown at an average rate of 561 PLS/m^2, approximately the rate recommended for rangeland seeding (Holechek et al. 1998). By comparison, Schwab (1991) recommends 1500 to 3000 PLS/m^2 for degraded soils. We selected a geometric series of five treatments (plus a control with no seed) which would broadly bracket 1500 PLS/m^2, hypothesized to be the minimally acceptable density.

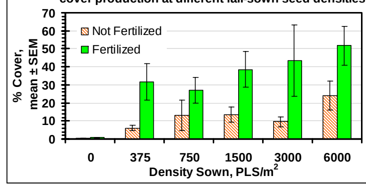
Density and fertilizer treatments were ran-domly allocated to plots at each site. Two plots at each site were sown by hand with densities con-sisting of: 0, 375, 750, 1500, 3000, or 6000 PLS/m^2. Fertilizer (18-18-18) was then applied to one plot of each density at a rate of 184.5 g per plot. This application rate is equivalent to 295 kg/ha, or 53 kg N/ha, as per provincial recommendations for roadside seeding of agronomic species (Carr 1980).

Plots were lightly raked again after seeding. Each plot was sub-sampled in early August, 2000, at three non-overlap-ping random locations using a 0.25 m^2 quadrat. Individual plants were counted and their cover was estimated by species in each quadrat.

Results and Discussion

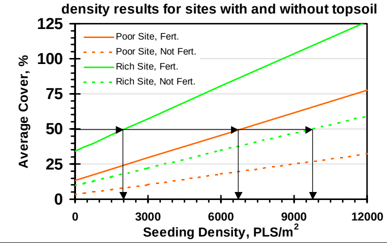
None of our treatments had achieved the target coverage of 70% at the time of first monitoring; this is not surprising for the establishment of perennials from seed in a northern climate after only 3 months growth. Nevertheless, plant cover was greater where sown at higher densities, and this effect was more pronounced in the fertilized plots (Figure 1). In unfer-tilized plots, cover remained relatively constant (12 ± 3%) across the range from 750 to 3000 PLS/m^2, and increased to an average of only 24% cover at the highest density tested. Fertilized plots had 2 to 5 times the cover of unfertilized plots at all densities tested.

Figure 1. Early effects (mid-summer) of fertilizer on cover production at different fall-sown seed densities



We were better to interpret the efficiencies gained, through using fertilizer, by lowering our target cover level to 50% and extending the relationships to higher densities (Figure 2). Much of the variability in our data was due to the difference between plots with and without topsoil, so separate linear regressions, of cover vs. seeding density, were conducted for rich (topsoiled) and poor (no topsoil) sites. To achieve 50% cover in unfertilized plots, seeding density needs to be increased to 19,306 PLS/m^2 on poor sites and to 9,750 PLS/m^2 on rich sites. With 18-18-18 fertilizer applied at 295 kg/ha, seed can be sown at much lower densities (6,849 PLS/m^2 on poor sites and only 2,048 PLS/m^2 on rich sites) to achieve the same cover. Seeding densities of more than 19,000 PLS/m^2 are especially impractical, making fertilization an essential treatment for achieving even minimal revegetation of sites having no topsoil.

Figure 2. Extrapolation of fertilization and seed density results for sites with and without topsoil



There is evidence that interference among individual plants is limiting their growth at high densities. As shown for *Elymus glaucus* (Figure 3), mean cover per plant declined over the range of 375 to 1500 PLS/m^2 and then leveled out at higher densities. At low seeding density, individual plants are able to produce more cover, and this efficient use of seeds is further enhanced by the use of fertilizer.

Seedling emergence and/or survival also appear to be com-promised by sowing at high densities, as shown in Figure 4 for *Festuca occidentalis*. This can be offset somewhat with the use of fertilizer, so we believe there may have been early competition for soil nutrients (and probably moisture), which lead to extensive density-dependent mortality in some plots.

Figure 3. Effects of seeding density and fertilization on mean size of *Elymus glaucus* individuals

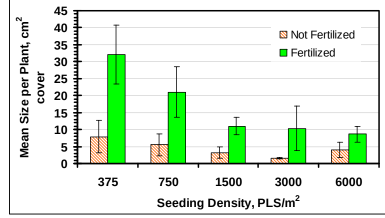
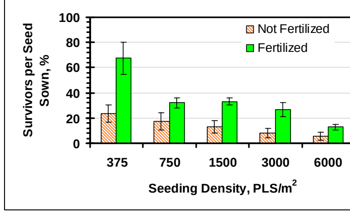


Figure 4. Effects of seeding density and fertilization on the effective emergence of *Festuca occidentalis*



Preliminary observations at other sites suggest that fertilizer is counter-productive in the presence of weedy species, especially fast-growing annuals such as *Chenopodium album* and *Poa annua*. In such situations, higher seed densities and a reduced level of nutrient addition may be more effective in promoting native plant establishment.

Conclusions

These results indicate that the most efficient use of seed is achieved at low densities. But in order to achieve desired levels of cover with low seed inputs in a reasonable length of time, fertilizer treatments should usually be included when attempting to revegetate degraded sites. In addition to making up for nutrient deficiencies, fertilizer also allows one to stretch supplies of valuable seed 2.8 to 4.8 times farther. These findings will re-sult in the more efficient and ef-fective use of native plant mat-erials for reveg-etating disturbed areas in the nor-thern Interior of British Columbia and elsewhere.

Acknowledgements

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