FACTORS INFLUENCING THE NATIVE SPECIES INVASION OF A RECLAIMED SUBALPINE MINESITE NEAR GRANDE CACHE, ALBERTA

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ABSTRACT

Factors affecting native species invasion were studied on a subalpine minesite (Smoky River Coal Limited No. 8 Mine) in the vicinity of Grande Cache, Alberta. The site had been revegetated with agronomic species in the early 1970s. Data collection involved cover estimations at 220 sampling locations predetermined by applying a 60 m interval grid pattern to a 1:3000 aerial photograph of the study site. Covariance analyses were conducted to identify variables significant in the native species invasion. Significant variables included coarse fragment content, distance from the nearest upwind seed source, alfalfa cover and slope. Ranking of independent variables indicated that coarse fragment content was the most important variable contributing to native species occurrence. Aspect and distance from the nearest upwind seed source ranked second.

INTRODUCTION

The Terrain Sciences Department of the Alberta Research Council has been conducting a reclamation research program in the Grande Cache area on behalf of Smoky River Coal Limited since 1972. The No. 8 Mine area was revegetated primarily with agronomic species during the period of 1973 to 1976. During the years since the area was seeded a gradual increase in the number and extent of native species present on the minesite was observed. Some documentation of the native species types observed was maintained. In 1984 some work was undertaken to begin quantification of the extent of native species invasion (Macyk 1984).

The Alberta Research Council, in cooperation with Montana State University and Smoky River Coal Limited agreed to fund additional research to learn more about the factors associated with the native species invasion.

OBJECTIVE

The objective of this study was to identify and rank factors affecting the areal extent and distribution of native species at the No. 8 Mine site.

MATERIALS AND METHODS

Site Description

The study site which is about 100 ha in size is located 13 km north of Grande Cache, Alberta in the Rocky Mountain Foothills. The elevation is approximately 1600 m and mean annual precipitation varies from 50 to 65 cm. Frost-free period is quite variable ranging from 45 to 107 days over the years of 1984 to 1987 (Macyk and Widtman 1988).

Following mining in the 1970s, the area was regraded, coversoiled, seeded to agronomic species and fertilized. Agronomic species included smooth brome (Bromus inermis var. Carlton), creeping red fescue (Festuca rubra var. Boreal), timothy (Phleum pratense var. Climax), crested wheatgrass (Agropyron Cristatum var Fairway), alfalfa (Medicago sativa var. Rambler) and alsike clover (Trifolium hybridum).

Data Collection

Sampling point locations were predetermined by randomly applying a 60 m interval grid pattern to a 1:3000 aerial photograph of the site. Grid intersections falling on the study site represented individual sampling points.

At each of the 220 sample point locations, a 10 m tape was laid out due west and 20 x 50 cm frames were placed at the 2, 4, 6, 8 and 10 m points (Daubenmire 1959). Ocular estimates of percent cover (aerial) were recorded for each species present within the frames. Additional data recorded for each sampling location included percent slope, aspect in degrees and estimates of coarse fragment and coal waste cover. Percent coarse fragments were recorded by class: 0(0 to 1% cover); 1(2 to 5% cover); 2(6 to 20% cover); and 3(>20% cover).

Statistical Analyses

Data used in statistical analyses included that collected on the site and additional data available from previous site studies by Alberta Research Council researchers (Macyk 1976; Macyk and Widtman 1984). Additional data included fertilization and seeding treatments, number of times fertilized, number of times seeded, coversoil depth, distance from the nearest undisturbed area and distance from the nearest upwind undisturbed area.

Statistical analyses of data consisted primarily of covariance analyses. Dependent variables were percent cover values for native species identified within Daubenmire frames. Independent variables included percent slope, aspect, topsoil depth, fertilization and seeding treatments, number of times fertilized, number of times seeded, coarse fragment rating, coal waste rating, distance from the nearest undisturbed area and distance from the nearest upwind seed source. Coarse fragment and coal waste ratings were treated as class variables.

Decisions regarding deletion of variables from covariance analyses involved examination of individual variable P-values and F-tests of full versus reduced models. Confidence levels of 80% or higher were considered significant. Ranking of variables was achieved by setting variables under comparison at unity at their means and then comparing their values one standard deviation unit above their means.

RESULTS AND DISCUSSION

Table 1 contains a list of native species observed on the minesite. The dependent variable 'percent cover of native species excluding moss' refers to the total percent cover of any of the species listed in Table 1 excluding moss (Dicranum spp.). 'Native tree species' comprises all woody species observed on the minesite, including shrubs. The species included in this dependent variable were river alder (Alnus tenuifolia), Canada buffaloberry (Shepherdia canadensis), white-flowered Rhododendron (Rhododendron albiflorum), tall billberry (Vaccinium membranaceum), Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), balsam poplar (Populus balsamifera), quaking aspen (Populus tremuloides) and willow (Salix spp.). 'Native nitrogen-fixing species' included river alder, bearberry (Arctostaphylos uva-ursi), and all Fabaceae species.

Coarse Fragments

'Coarse fragment rating' was a significant variable for most covariance analyses. It was significant for moss, native species (both excluding and including moss) and tree species. A clear linear relationship between percent cover and coarse fragment rating did not exist. Least Significant Difference tests indicated that not all rating levels were significantly different from each other. While it was clear that coarse fragments significantly affected cover of native species, it was impossible to satisfactorily explain the relationship based on these results and analyses.

There was a positive linear relationship between coarse fragment rating and number of native species observations. Several factors are likely to have contributed to this relationship. Thinner coversoil mantles on sites of higher coarse fragment ratings were expected to decrease competition from seeded agronomic species, thus improving viability opportunities for encroaching native species. Coarse fragments may have created favorable microsites for native species by providing a variable ground surface with depressional areas of moisture and soil collection. Minimum compaction probably occurred on high relief areas, which were also areas of maximum coarse fragment cover at the ground surface.

Coversoil Depth

Coversoil depth did not contribute to native species cover. Failure to achieve a significant linear relationship may have resulted from the absence of control areas lacking coversoil. The implication is that

Table 1. Native species identified at No. 8 Mine.

Family	Scientific Binomial	Common Name
Asteraceae	Achillea millefolium L.	western yarrow
Asteraceae	Agoseris Aurantiaca (Hook.) Greene	orange-flowered false dandelion*
Asteraceae	Arnica cordifolia Hook.	heart-leaved arnica
Asteraceae	Aster conspicuous Lindl.	showy aster
Asteraceae	Erigeron peregrinus (Pursh) Greene	
Asteraceae	Senecio triangularis Hook.	triangle-leaved ragwort
Asteraceae	Solidago spathulata DC.	
Asteraceae	Sonchus sp.	sow thistle
Asteraceae	Taraxacum officinale Weber	dandelion*
Betulaceae	Alnus tenuifolia Nutt.	river alder
Boraginaceae	Mertensia paniculata (Ait.) G. Don	tall mertensia
Brassicaceae	Lepidium bourgeauanum Thell.	peppergrass
Campanulaceae	Campanula rotundifolia L.	bluebell; harebell
Caprifoliaceae	Linnaea borealis L.	twinflower
Caprifoliaceae	Sambucus racemosa L.	elderberry
Cornaceae	Cornus canadensis L.	bunchberry
Cyperaceae	Carex bebbii Olney	
Elaeagnaceae	Shepherdia canadensis (L.) Nutt.	Canada buffaloberry
Equisetaceae	Equisetum arvense L.	common horsetail
Ericaceae	Arctostaphylos uva-ursi L. Spreng	bearberry
Ericaceae	Rhododendron albiflorum Hook.	white-flowered Rhododendron
Ericaceae	Vaccinium membranaceum Dougl.	tall bilberry
Fabaceae	Astragalus americanus (Hook.) M.E. Jones	
Fabaceae	Astragalus robbinsii (Oakes) A. Gray	
Fabaceae	Hedysarum alpinum L.	
Fabaceae	Hedysarum boreale Nut. var. mackenzii	(Richards) C.L. Hitchc
Fabaceae	Lupinus argenteus Pursch.	parennial lupine

continued . . .

Table 1. Continued.

Family	Scientific Binomial	Common Name
Fabaceae	Onobrychis viciifolia Scop.	sainfoin
Fabaceae	Oxytropis sericea Nutt.	early yellow locoweed
Fabaceae	Oxytropis splendens Dougl. ex Hook.	showy locoweed*
Fabaceae	Vicia smericana Muhl.	wild vetch
Fumariaceae	Corydalis aurea Willd.	golden Corydalis*
Fumariaceae	Corydalis sempervirens (L.) Pers.	pink Corydalis
Gentianaceae	Gentianella amarella (L.) Borner	felwort
Juncaceae	Luzula piperi (Cov.) Jones	
Liliaceae	Zigadenus elegans Pursh.	white camas
Onagraceae	Epilobium angustifolium L.	fireweed
Orchidaceae	Habenaria hyperborea (L.) R.Br.	northern green bog orchid
Pinaceae	Picea engelmannii Parry ex Engelm.	Engelmann spruce*
Pinaceae	Pinus contorta Loudon var. latifolia Engelm.	lodgepole pine*
Poaceae	Calamagrostis purpurescens R. Br.	purple reedgrass
Poaceae	Critesion jubatum (L.) Nevski	foxtail barley
Poaceae	Leymus innovatus (Beal) Pilger	hairy wildrye
Poaceae	Poa alpine L.	alpine bluegrass*
Pyrolaceae	Moneses uniflora (L.) A. Gray	one-flowered wintergreen
Pyrolaceae	Pyrola asarifolia Michx.	common pink wintergreen
Ranunculaceae	Anemone multifida Poir.	cut-leaved Anemone
Ranunculaceae	Aquilegia flavescens S. Wats.	yellow columbine
Rosaceae	Fragaria virginiana Duchesne	wild strawberry
Rosaceae	Potentilla norvegica L.	rough cinquefoil
Rosaceae	Rubus idaeus L.	wild red raspberry
Rosaceae	Rubus pedatus J.E. Smith	

continued . . .

Table 1. Concluded.

Family	Scientific Binomial	Common Name
Rubiaceae	Galium boreale L.	northern bedstraw
Salicaceae	Populus balsamifera L.	balsam poplar
Salicaceae	Populus tremuloides Michx.	quaking aspen
Salicaceae	Salix drummondiana Barr. ex Hook	*
Saxifragaceae	Parnassia palustris L.	grass of Parnassus
Scrophulariaceae	Castilleja miniata Dougl. ex Hook	common red paint brush
Scrophulariaceae	Pedicularis bracteosa Benth.	western lousewort*
Scrophulariaceae	Penstemon procerus Dougl. ex Grah.	slender blue beard tongue
Scrophulariaceae	Rhinanthus minor L.	yellow rattle*

* Not verified.
Specimens verified by Dr. J.H. Rumely, Professor of Botany, Montana State University.

coversoil depths of 5 to 35 cm (the range found on the study area) have no effect on native species cover. But, any amount of coversoil exceeding 5 cm may be beneficial to native species growth. The effect could be similar to that of a threshold value, where there are marked differences below the threshold, but where resource increases beyond this level fail to yield similar response changes.

Fertilization

Coding of fertilization and seeding treatments into 13 fertilization and seeding treatment combinations failed to yield significant results. Conversion of these treatment combinations to 'number of times fertilized' and 'number of times seeded' also yielded no significant relationship. Analysis results could probably be attributed to the absence of areas lacking fertilization and seeding.

Slope

Analyses indicated a positive relationship between moss cover and slope. Aside from decreased interspecific competition, benefits of steeper slopes could have included favorable microsites for moss establishment. Slope probably interacted with other variables such as aspect. Slope shape may have been more important than slope angle.

Aspect

Moss cover was higher on northwest aspects than any other aspect. Native species excluding moss exhibited greater cover on northwest and southwest aspects, with northwest aspects resulting in the strongest positive effect. Nitrogen-fixing species were the only major native species group to favor east aspects, with northeast aspects preferred.

Observed trends can be attributed to a combination of aspect effects on seed and moisture availability. Strong predominance of winds from the west in this area provided west-facing slopes with more wind disseminated spores and seeds. Northwest aspects could receive a significant proportion of wind disseminated spores and seeds while being sufficiently protected from drying forces of wind and sunlight for favorable growing conditions. Although wind-disseminated seeds would tend to reach northeast aspects less frequently in this area, nitrogen-fixing species were found to favor this aspect. Moisture conditions were probably the primary reason for their existence on these aspects.

Distance from the Nearest Undisturbed Area

This variable was not significant for any native species variables. Site-specific characteristics confounding this variable could have included slope trends, site shape and prevailing wind direction. Potential wind-disseminated seed on eastern edges of the minesite had to disperse against prevailing winds and a slope gradient.

Distance from the Nearest Upwind Undisturbed Area

There was a negative correlation between distance from the nearest westerly seed source and percent cover of native species excluding moss. The effect was strongest for tree species. Most native species observed on the study area rely heavily on wind for seed dissemination.

Percent Alfalfa Cover

Increases in alfalfa cover had significant negative effects on moss and Asteraceae species cover. The negative relationship could have been a result of shading by alfalfa. Also, increased available nitrogen in the vicinity of alfalfa plants may have enhanced agronomic species growth, resulting in outcompeting of moss and Asteraceae species by agronomics.

SUMMARY

Ranking of independent variables indicated that coarse fragment rating was the most important variable contributing to native species cover. Northwest versus southeast aspect and distance from the nearest westerly undisturbed area ranked second, followed by percent cover of alfalfa. Percent slope and soil depth ranked relatively low.

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TABLE OF CONTENTS

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