Monitoring Restoration of the Vaseux-Bighorn National Wildlife Area Following Pipeline Construction

Lynne B. Atwood
Genoa Environmental Consulting
Box 20282, Smithers, BC, V0J 3P0, Canada
latwood@bulkley.net

ABSTRACT

A native plant restoration program at the Vaseux-Bighorn National Wildlife Area included 4 treatments: (1) collection and hand broadcast of native herb and shrub seed; (2) salvage and transplant of native perennial grasses, herbs, and shrubs; (3) hydroseeding of native grasses; and (4) application of microbiotic crust. Early monitoring identified successful re-establishment techniques for many native species and a list of herbs and shrubs that should be considered for dryland native seed mixes.

Key words: microbiotic crust, native vegetation, Okanagan, pipeline construction, restoration, Vaseux-Bighorn National Wildlife Area.

BC Gas Utility Ltd. (BC Gas) constructed a natural gas pipeline in the South Okanagan in 1994. The pipeline crossed the Vaseux-Bighorn National Wildlife Area on the west side of Vaseux Lake approximately 5 km south of Okanagan Falls. The South Okanagan is recognized federally as a biodiversity hot spot (Mosquin et al. 1995) and the National Wildlife Area is one of the largest protected areas in the region. The wildlife area is critical habitat for Red- and Blue-listed wildlife and a key component of the South Okanagan Conservation Strategy (Bryan 1996). The native plant restoration program designed for the Vaseux-Bighorn National Wildlife Area represents one of the largest and most complex native plant restoration projects in British Columbia.

This study summarizes the results of a monitoring program carried out in 1996 (Atwood 1996). I discuss 4 components of the program: 1) collection and hand broadcast of native herb and shrub seed; 2) salvage and transplant of native perennial grasses, herbs, and shrubs; 3) hydroseeding of native grasses; and 4) application of microbiotic crust.

METHODS

The wildlife area was divided into 7 geographic areas (GA 1 to GA 7) based on preconstruction vegetation surveys and soil characteristics. Restoration prescriptions were devised for each geographic zone. Construction schedules divided the restoration into 2 stages: GA 6 and GA 7 were revegetated in November 1994 and GA 1 to GA 5 were replanted in March 1995.

Native herb and shrub seed was broadcast into predesignated broadleaf zones if the species was recorded in the local area before construction. In 1996, the effect of broadcast seeding was determined by recording the species in the planted zones. The broadleaf areas were also inventoried for the survival of whole plants, which were salvaged from the right-of-way before construction and replanted in March 1995.

To assess the hydroseeding component of the restoration program, data were collected from 3 1-m^2 quadrats that were systematically located along 18-m transects. These transects crossed the disturbed portion of the right-of-way and were spaced 150 m apart. Data collected included vascular plant species and percent cover, as well as percent cover of litter and bare ground.

The success of seeding microbiotic crust was tested in a split-plot experimental design. There were 2 treatments, with and without microbiotic crust. The crust was applied at 3 different rates (0.55, 0.7, and 0.9 L/m^2), with 3 replications/application rate. Six replications were located in GA 6 (north Plot 1 and 2, seeded in November 1994) and 3 replications were installed in GA 3 (south Plot, seeded in March 1995). Data for percent cover of microbiotic crust and vascular plant species and the number of individuals of each vascular species were collected. Analysis of variance (ANOVA) was used to test for differences between treatment means.

RESULTS

Broadcast Seeding

Over 360 kg of native seed was collected from local antelope-brush (*Purshia tridentata*) shrub-steppe and ponderosa pine (*Pinus ponderosa*) dry forest habitats. The collected

Table 1. The percent survival of the salvaged plant species and the percent of broadleaf areas with germinants for the broadcast species.

Species	Whole plant salvage (% survival)	Broadcast seeding (% of broadleaf areas with germinants)
Achillea millefolium	not salvaged	94
Amelanchier alnifolia	75.8	1
Antennaria spp.	68.2	11
Apocynum androsaemifolium	not salvaged	5
Arabis holboellii	not salvaged	17
Artemisia campestris	91.7	14
Artemisia dracunculus	73.3	29
Artemisia frigida	97.7	94
Astragalus purshii	25.0	18
Astragalus tenellus	not salvaged	3
Balsamorhiza sagittata	not salvaged	17
Bunchgrasses (5 perennial spp.)	76.0	not seeded
Chrysopsis villosa	60.0	12
Chrysothamnus nauseosus	not salvaged	34
Clematis ligusticifolia	0.0	not seeded
Erigeron corymbosus	not salvaged	51
Eriogonum heracleoides	72.7	8
Eriogonum niveum	90.0	16
Gaillardia aristata	not salvaged	88
Leptodactylon pungens	75.0	not seeded
Lithospermum ruderale	0.0	8
Mahonia aquifolium	42.9	not seeded
Penstemon fruticosus	100.0	not seeded
Phacelia hastata	66.7	8
Phacelia linearis	not salvaged	39
Philadelphus lewisii	100.0	not seeded
Plantago patagonica	not salvaged	49
Purshia tridentata	75.7	not seeded
Rhus glabra	100.0	not seeded
Ribes cereum	100.0	8
Rosa woodsii	79.3	not seeded
Symphoricarpus albus	82.6	not seeded
Zigadenus venenosus	not salvaged	4

shrub and herb seed was broadcast into the designated broadleaf areas in November 1994 and March 1995. Herb and shrub establishment was very selective. Of the 23 species broadcast, only 7 established in >25% of their sown areas (Table 1). Pasture sage (*Artemisia frigida*), yarrow (*Achillea millefolium*), brown-eyed Susan (*Gaillardia aristata*), long-leaved daisy (*Erigeron corymbosus)*, and woolly plantain (*Plantago patagonica*) showed no selectivity between geographic areas and may be good candidates for a dryland native plant restoration seed mix.

Little information is available on seed handling techniques for native herbs and shrubs (i.e., collecting, cleaning, storing, stratifying, and germinating). Other broadcast herb and shrub species may have had higher establishment rates if handled differently.

Whole Plant Salvage

During the summer of 1994, 7,600 plants were salvaged from the BC Gas right-of-way in the Vaseux-Bighorn Wildlife Area. The plants were stored over winter and replanted in March 1995. The salvaged species included 12 shrub, 9 herb, and 5 perennial bunchgrasses. Re-establishment success was high. Shrubs averaged 77% survival, bunchgrasses 76%, and herbs 61% (Table 1). Although average survival was high, the timing of the salvage proved critical. Red three-awn (*Aristida longiseta*), a C4 bunchgrass, was actively growing during the salvage and its survival was very low.

Many species responded well to salvage and transplant but not to broadcast seeding. The costs associated with salvage projects could be reduced if species that are difficult to propagate are targeted. For example, saskatoon (*Amelanchier alnifolia*), squaw currant (*Ribes cereum*), and snowberry

Table 2. Five perennial native grasses and 1 annual agronomic grass used in the hydroseed mix.

Grass species used in the hydroseed mix	
Bluebunch wheatgrass (*Elymus spicata*)	Native perennial
Junegrass (*Koeleria macrantha*)	Native perennial
Needle-and-thread grass (*Stipa comata*)	Native perennial
Red three-awn (*Aristida longiseta*)	Native perennial
Sand dropseed (*Sporobolus cryptandrus*)	Native perennial
Annual ryegrass (*Lolium multiflorum*)	Agronomic annual

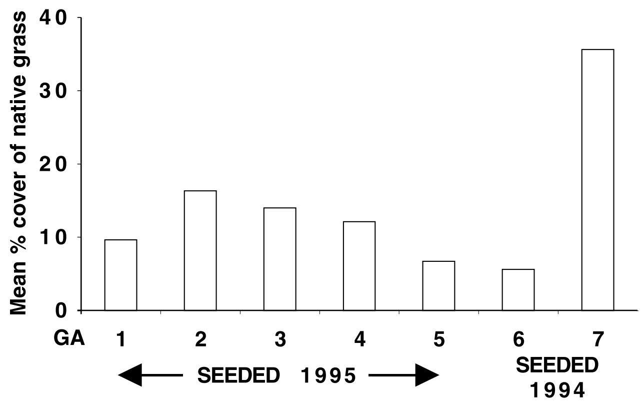

Figure 1. Percent cover of hydroseeded native grasses 1 year after restoration (1996) for the geographic areas seeded in 1994 (GA 6, GA 7) and 1995 (GA 1 to GA 5).

(*Symphoricarpus albus*) are important species for wildlife, but their stratification and germination requirements are difficult and time consuming (Hudson and Carlson 1998, Rose et al. 1998). Salvaging and replanting the shrubs ensures the high wildlife values are returned to the habitat.

Hydroseeding with Native Grasses

The hydroseed mix contained native species that were recorded in the geographic area before construction. Five mixes that differed in species composition and proportions were used and seeding rates varied from 1,747 to 2,078 seeds/m^2. The seed mix contained grasses only, a combination of 5 native perennials and 1 annual agronomic (Table 2). A grass mix was used because broadleaf weeds were a serious problem before construction and grasses would survive any required herbicide applications. In addition to the hydroseed mix, nursery-produced bluebunch wheatgrass plugs were planted throughout the right-of-way.

One year after restoration the percent cover of native grasses and the dominant weed species varied by geographic area. The percent cover of grasses ranged from 5.6% in GA 6 to 35.6% in GA 7; cover in the areas seeded in 1995 fell between the extremes (Fig. 1). The bluebunch wheatgrass plugs established in all areas and were particularly successful in GA 7, which received both bluebunch seed and plugs. Annual ryegrass provided the highest cover of the seeded grasses in GA 2 to GA 5 and GA 7, while sand dropseed dominated the grass cover in GA 1 and GA 6 (Table 3).

Crested wheatgrass (*Agropyron cristatum*) was in GA 7 before construction and was the primary weed in the area 1 year after restoration (16.7%). In all other areas, cheatgrass (*Bromus tectorum*) and diffuse knapweed (*Centaurea diffusa*) were the prevalent weeds. Cheatgrass dominated GA 1 to GA 4 and GA 6 and cover ranged from 6.5% (GA 4) to 31.4% (GA 6). Diffuse knapweed dominated GA 5 (14.6%) but also contributed much of the cover in GA 6 (26.2%) and GA 7 (10.2%).

An extensive weed control program for diffuse knapweed occurred before construction. After restoration, the percent

Table 3. Percent cover of seeded grasses in each of the geographic areas 1 year after restoration.

	% cover of seeded grasses in 1996					
	Aristida longiseta	*Elymus spicata*	*Koeleria macrantha*	*Stipa comata*	*Sporobolus cryptandrus*	*Lolium multiflorum*
GA 1	ns[a]	3.5	ns	2.4	2.6	1.1
GA 2	0.0	2.2	ns	1.8	1.5	10.8
GA 3	ns	5.1	ns	1.0	2.6	5.2
GA 4	1.0	3.4[b]	ns	0.0	0.8	6.9
GA 5	ns	1.3	ns	1.7	1.1	2.7
GA 6	ns	1.1	ns	1.4	2.8	0.2
GA 7	ns	23.3[b]	3.9	1.7	1.0	5.7

[a] ns: not seeded in geographic area.
[b] Geographic area received both seed and plugs. All other areas received plugs only.

cover of the biennial weed was lower in areas seeded in 1995, but higher in areas seeded in 1994 (Fig. 2). The weed control program appeared to reduce competition during the initial vegetation establishment phase. However, the benefits were short lived, likely because the surrounding area was infested with diffuse knapweed.

Cheatgrass was not controlled—more attention should have been paid to this weedy annual. One year after restoration the cover of cheatgrass was equal to or higher than preconstruction surveys (Fig. 3). Cheatgrass germinates early and competes fiercely for soil moisture and nutrients (Martens et al. 1994). Native grass establishment may have been higher if the cheatgrass had been controlled.

Seeding Microbiotic Crust

Fifty-six hundred litres of microbiotic crust were collected from the right-of-way before construction and reapplied with a hydroseeder in 2 areas in November 1994 (north plots 1 and 2) and 1 area in March 1995 (south plot).

Plots inoculated with microbiotic crust propagules averaged 92% higher cover of crust species than plots that did not receive the inoculant. Percent cover ranged from 3.6% in the south plot to 10.7% in north plot 1 and 24.1% in north plot 2. The south plot and north plot 2 also contained a significantly higher cover of vascular plant species in the inoculated plots (south: $F = 19.0$, df = 1, 82, $P = 0.0004$; north plot 2: $F = 4.68$, df = 1, 31, $P = 0.04$).

Three grasses were associated with the inoculated areas in the south plot and north plot 2. Cheatgrass density averaged 129.2 $\pm$ 33.1 individuals/m^2 in inoculated plots compared with 20.5 $\pm$ 3.2 individuals/m^2 in areas that did not receive microbiotic crust. Needle-and-thread grass (*Stipa comata*), a native perennial, averaged 5.0 $\pm$ 0.8 individuals/m^2 compared with 2.9 $\pm$ 0.4 individuals/m^2 in non-inoculated areas. Six-weeks fescue (*Vulpia octoflora*), a native annual, averaged 8.0 $\pm$ 4.9 individuals/m^2 in inoculated areas and only 0.03 $\pm$ 0.03 individuals/m^2 in plots that were not inoculated. The 3 species have similar florets; all are relatively long and slender with hairy or rough lemmas that are awned. The physical characteristics enabled the florets to cling to the mosses in the microbiotic crust.

Microbiotic crust is linked to several ecological functions (Atwood and Krannitz 2000) and its reintroduction expedites colonization. However, the tendency for the crust to store seed immediately benefits habitat restoration, but only if the reintroduced species are native. Species in the microbiotic crust should be identified and weed seeds should be treated before reintroducing the microbiotic crust.

DISCUSSION

The restoration project on the Vaseux-Bighorn National Wildlife Area was a tremendous undertaking because information on the South Okanagan native plant communities was limited and dryland restoration techniques rudimentary. The 1996 monitoring program occurred early in the

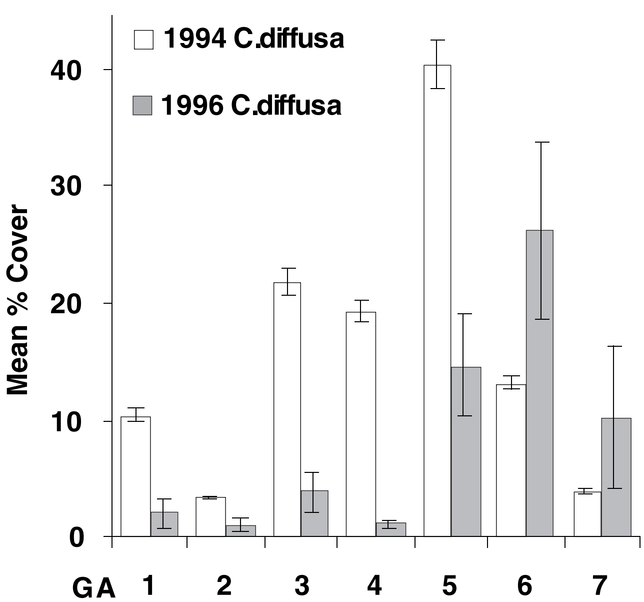

Figure 2. Percent cover of diffuse knapweed (*Centaurea difusa*) in each geographic area before construction (1994) and 1 year after restoration (1996) (1994 data courtesy of T. Duralia).

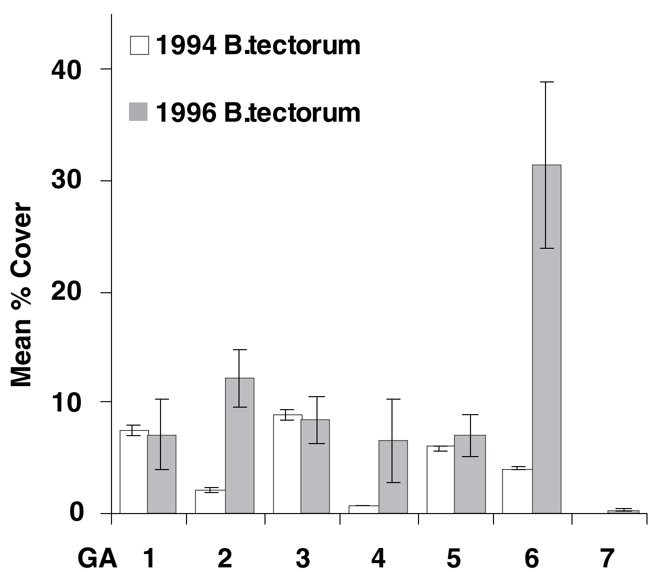

Figure 3. Percent cover of cheatgrass (*Bromus tectorum*) in each geographic area before construction (1994) and 1 year after restoration (1996) (1994 data courtesy of T. Duralia).

recolonization process; judging the overall success of the restoration project is impossible from this single monitoring event. However, the early monitoring identified successful re-establishment techniques for many native species and a list of herbs and shrubs that should be considered for dryland native seed mixes. The program also highlighted differences in the recolonization ability of native perennial bunchgrasses. This project is the first to document the successful re-establishment of the microbiotic crust.

BC Gas recognized the experimental nature of this project and encouraged the documentation of information and techniques that have subsequently increased ecological restoration knowledge for British Columbia's dryland habitats. Questions raised during the project and the early monitoring program are now being tested in an antelope-brush community outside Osoyoos (Atwood and Osoyoos Desert Society 2000).

The natural habitats of the South Okanagan are disappearing at an alarming rate and those that remain are severely fragmented and extremely vulnerable to weed invasion. Retaining these rare habitats will require restoration, but information on native species phenology, seed biology, and species-specific propagation techniques is lacking. We also lack technical expertise on when to collect seed and what proportions to collect without depleting donor habitats, as well as how best to clean, test, and store the seed. Many of the technical issues could be addressed if provincial standards for native seed were developed. An adequate quantity of high quality native seed is the most limiting factor to habitat restoration today. Without it, re-establishment techniques cannot be tested.

ACKNOWLEDGEMENTS

I thank BC Gas Utility Ltd. for undertaking such a challenging restoration project and funding this monitoring program. Westland Resource Group and Carex Environmental Restoration Group contributed extensively to this project. I also thank T. Duralia (Ph.D. candidate, University of British Columbia) for providing preconstruction vegetation data.

LITERATURE CITED

Atwood, L. B. 1996. South Okanagan natural gas pipeline restoration project: 1996 vegetation monitoring of the Vaseux-Bighorn National Wildlife Area. BC Gas Utility Ltd. 54pp.

_____, and P. Krannitz. 2000. Effect of the microbiotic crust of the antelope-brush (*Purshia tridentata*) shrub-steppe on soil moisture. Pp. 809–812 *in* L. M. Darling, ed. Proc. Conf. Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 Feb. 1999. Vol. Two. B.C. Minist. Environ., Lands and Parks, Victoria, BC, and Univ. College of the Cariboo, Kamloops, BC. 520pp.

_____, and Osoyoos Desert Society. 2000. Ecological restoration and habitat renewal of the South Okanagan Shrub-Steppe. Pp. 803–806 *in* L. M. Darling, ed. Proc. Conf. Biology and Management of Species and Habitats at Risk, Kamloops, BC, 15-19 Feb. 1999. Vol. Two. B.C. Minist. Environ., Lands and Parks, Victoria, BC, and Univ. College of the Cariboo, Kamloops, BC. 520pp.

Bryan, A. 1996. Vaseux Lake habitat management plan. South Okanagan conservation strategy. B.C. Minist. Environ., Lands and Parks, Penticton, BC. 93pp.

Hudson, S., and M. Carlson. 1998. Propagation of interior British Columbia native plants from seed. B.C. Minist. For., Res. Branch, Victoria, BC. 29pp.

Martens, E., D. Palmquist, and J. A. Young. 1994. Temperature profiles for germination of cheatgrass versus native perennial bunchgrasses. Pp. 238–243 *in* S. B. Monsen, and S. G. Kitchen, eds. Proc. Ecology and management of annual rangeland. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. INT-313.

Mosquin, T., P. G. Whiting, and D. E. McAllister. 1995. Canada's biodiversity: the variety of life, its status, economic benefits, conservation costs and unmet needs. Can. Museum of Nature, Ottawa, ON.

Rose, R., C. E. C. Chachulski, and D. L. Haase. 1998. Propagation of Pacific Northwest native plants. Oreg. State Univ. Press, Corvallis, OR.