lies, 53 and 53 genera, and 83 and 87 species (Appendix H).

DISCUSSION

Modifying Gravel Fill

The most significant changes measured on gravel fill thus far resulted from adding topsoil. By design, this nearly doubled the amount of fines in the surface portion of the gravel. That, in turn, lowered bulk density and increased the amount of soil moisture retained in the upper 10 cm of the gravel pad. Much of this moisture was presumed to be available for plants, but moisture desorption curves are required to actually evaluate the proportions of the water held at various tensions in the matrix. Because it was assumed there was a low amount of clay in the soil, much of the moisture was probably held at relatively low tensions and therefore available for plant uptake. Particle size analyses, in combination with analyses of cation exchange capacity and available nutrient, will assist in quantifying relative influences from this treatment.

Soil moisture was measured only once, and that was incidental to the bulk density sampling. It was expected that there would be less soil moisture in areas with greater plant cover, because use by plants should have reduced supplies in the soil. Just the opposite was found in the botanical garden. We found the highest soil moisture content in the vicinity of the largest plants. There are three possible reasons for this discrepancy. First, the sampling may have been inadequate to give a reliable estimate of the real soil moisture conditions. Second, the soil with the lowest moisture percentage was disturbed about eight weeks prior to sampling. In contrast, the soil with the highest moisture percentage had not been disturbed for approximately 18 months. Disturbance of soil encourages evaporation, which could have affected the results. And third, the plant biomass was relatively low; hence, soil moisture usage was probably also low. Further monitoring of that variable is considered important to this project.

Topsoil additions were associated with increased concentrations of nitrogen and calcium in plant tissues, according to preliminary data. These responses are only early indications from a limited number of samples, but the responses are reasonable. Cations of nitrogen and calcium are taken from the soil by plant roots. If the gravel had a low cation exchange capacity because of limited quantities of clay, silt, and organic matter, the addition of topsoil would enhance that capacity and provide a greater pool of available nutrients for plant uptake. Further monitoring of tissues and gravel chemistry may provide definitive information on this topic.

It was apparent that plants grown in gravel only (no topsoil) were probably deficient in nitrogen. Phosphorus concentration was low in these plant tissues, relative to concentrations typical of vigorously growing plants. However, guidelines for interpreting tissue mineral data with respect to plant vitality in the Arctic are scarce.

Tillage in the gravel plots appeared to reduce soil bulk densities and improve conditions for plant growth. Tillage may have improved either the uptake or availability of soil phosphorus, because plant tissues in tilled experimental units contained more phosphorus than those grown on untilled experimental units, according to preliminary data. If tillage caused a reduction in soil moisture, that could have, in turn, reduced plant growth relative to plants on untilled plots. Occasionally, there is a tendency for nutrient concentrations to be higher in plants experiencing drought stress, relative to plants not stressed by drought. Tillage may also have decreased the uptake and/or availability of sodium and magnesium, according to tissue analyses from samples taken in September, 1991. Plant cover produced from the 1990 seeding mixture increased with the tillage treatment.

From initial observations, it is clear that the fencing provided a significant trap for snow (Fig. 24). After even light snowfalls that were either accompanied with or followed by wind, snow cover in the fenced plots was markedly greater than in the non-fenced plots. This difference was apparent at both ends of the growing season. On 7 May 1991, we measured snow cover on these plots and found 1.09 m accumulated in the fenced area. This accumulation contained 42 cm of water. Snow cover on unfenced plots averaged between none and 25 cm, with the least accumulation on portions of the 1.5-m lifts. Maximum moisture accumulated on these unprotected plots was 3.8 cm and averaged less than 1.3 cm.

The plots in the treated area were still snow-covered until late in June, while the other portions of the experimental area were snow-free much earlier (Fig. 24). If too much snow cover is created, the length of the growing season may be reduced, thus affecting plant survival. It was noted that the snow fence treatment had no measurable effect on plant cover in the gravel vegetation plots after the first year. A longer observation period will be needed to measure the influences of snow fences on the formation of plant communities in these plots.

The tendency for plants to perform better at the east end of rows in the botanical garden compared to the west end may have been due to differential snow melting rates. Slowing the start of spring growth would be detrimental to plants in this region, where growing seasons are naturally brief. The later melting may have retarded initiation of plant growth at the west end of the rows because a snow fence at that end shaded that section during the warmest period of the day. Snow fencing at the east end of the rows may have provided a heat sink and radiation effect, which helped to melt snow at that end of the row. That is, late-afternoon solar radiation was striking the snow fence fabric and was either reradiated or otherwise reflected onto the snow immediately west of the fence.

Significant amounts of soil and plant particles carried by the wind were deposited in areas behind snow fences, coating the gravel surface after only one winter (Fig. 25). In the autumn of 1991, pans were placed in a snow-fenced block and on a block without snow fences to measure the fallout of soil and plant materials between treatments. Also, it has been noted that very small changes in elevation on the surface of the pad are important. Without snow fences to create drifts, the 8-cm lift of topsoil was often cleared of snow by wind while the adjacent gravel retained a slight snow covering.

At least three growing seasons are needed before seedlings in this region develop into mature plants. Therefore, the basal and canopy cover data obtained in 1991 are simply a preliminary measure to document canopy and basal cover after the second growing season. Repeating these measurements will become increasingly more useful after planted and volunteer stands of vegetation have had the opportunity to mature. These data will be helpful in projecting trends of seedings on actual rehabilitation projects.

Germination and subsequent plant growth in these first two plantings (1990 and 1991) on the gravel plots, as well as the botanical garden, were encouraging. A variety of plant species seemed to be germinating, and the potential for the formation of diverse communities was promising. However, long-term survival is most important.

The high seed application for 1990 was selected because the laboratory seed evaluations were not completed before spring planting. Had these laboratory data been available, we would have selected a lower application. Instead, we decided to use all the available seed minus amounts needed for the botanical garden, divided equally among the 144 plots to give maximum possible opportunity for seedling establishment from our collection efforts. The 1990 seed application of 9,469 PLS seed/m^2 is excessive and undoubtedly set up conditions for inter- and intraspecific plant competition. How this competition will eventually influence the species composition of the stands in these gravel plots remains to be seen.

We have observed naturally occurring dense stands of new seedlings on a disturbance 2.8 km northeast of the BP Put River No. 1 gravel pad (Mitchell and McKendrick 1975). These stands consisted of a single species, *Braya purpurascens*. As the dense stand aged, the competition not only reduced the density of the individuals, but also inhibited flowering and seed production. In 1991, after nearly 20 years, the stands have thinned considerably as the *Braya purpurascens* died and other species of grasses and forbs invaded the surface of this abandoned winter haul road. This road, coincidentally, was constructed to bring drilling equipment to the BP Put River No. 1 gravel pad. It is likely a similar pattern of thinning through competition will occur on the current experimental plots. The stand best adapted to the soil conditions will develop from among the seeded species and natural colonizers. Drought and other stresses, e.g., intense geese grazing, will hasten this realignment of plant densities and species composition.

To rank importance of species, point data should have been recorded by plant species. However, the plants were immature on the 1990 planting in 1991, and distinguishing among grass species was difficult. Canopy and basal cover categories were thus recorded either as grass or forb. Ultimately, the ranking of importance for individual species will be most valuable after plant communities have had an opportunity to mature and separate the survivors from those that could not compete.

Gravel thickness appeared to be affecting plant cover in the 1990 planting. Thicknesses greater than 0.6 m sustained less canopy cover than the 0.6-m thickness. Moisture available to plant roots may have been the major factor for this response. We observed that some experimental units on 0.6-m lifts appeared wetter than at other locations on the gravel pad, but our preliminary gravel moisture sampling did not include each thickness of gravel fill. Therefore, it was not possible to compare soil moisture percentages among lifts. It would be instructive to quantify the available soil moisture among gravel thicknesses and between snow-fenced and non-snow-fenced treatments.

At the time basal and canopy covers were measured (early September 1991), many of the plants had already senesced, and vegetative parts had begun to dry and shrivel. This probably lowered the canopy cover estimate with respect to that which would have been obtained had the sampling occurred at the peak of growth. Future cover sampling should be consistent among years, with respect to the phenological stage of the plants. Sampling during or soon after the first week in August is recommended, because it generally coincides with peak canopy development for the current growing season.

One aspect of the 1991 cover point data should be viewed with caution. The 1990 planting consisted overwhelmingly of graminoid species. Sixty-one percent of the cover data and 88% of the seeds planted were graminoids. The remaining 12% of seeds planted in 1990 were forbs. This, in association with the grass cover treatment, meant that graminoid species most likely suppressed the forb component in the 1990 seeding mixture. The 1991 seeding mixture was purposefully reversed, with forbs comprising the majority of the species (70% of all seeds planted). Grasses and shrubs each contributed 15% to the 1991 planting. Comparing these two plantings should prove interesting in future years.

The basal cover values of 10% or more, which were recorded in the 1990 seedings on the gravel plots, were quite high. This resulted primarily from sampling error, since live leaves at the surface of the ground were recorded as basal cover rather than canopy cover.

Comparing soil temperatures between the foothills site and the coastal plain was informative. The soil temperatures on the coastal site were consistently warmer than the soils in the foothills, and cumulatively higher temperatures were recorded at the coast. This difference was ascribed to variation of insulation at the soil surface. The coastal soil was nearly barren, while that in the foothills had a cover of tussock tundra vegetation and litter. During most of July and August, maximum and mean air temperatures were higher at the foothill site than on the coastal plain. Apparently, the insulating effects of the tussock tundra vegetation were great enough to prevent the soil in the foothills from warming, even though the heating of the air was obviously greater in the foothills than near the seacoast.

Variation in seed production among years and between the coastal and foothill locations appeared related to variations in air temperatures. Overall, better seed production consistently occurred in the location with the warmer air temperatures (foothills). Significant seed production on the coastal plain also coincided with the occurrence of warmer growing seasons. At the foothill location, *Arctophila fulva* consistently produced mature ovules among years, but mature seed was only abundantly produced on the coastal plain in 1989, which was an unusually warm growing season (McKendrick 1990). This affect was also recorded for *Bromus pumpellianus* seedlots collected from coastal and foothill locations in September 1990. Seed from two coastal plain sites, one near the coast at Big Skookum and the other about 10 miles inland (Kuparuk River Bridge), did not germinate (0%). In contrast, seed collected that same year from *Bromus pumpellianus* growing at a foothill location (MP 356 Dalton Highway) germinated with a maximum equal to 93%. The fact that collection from the foothill site was taken earlier in the season than on the coastal plain presumably should have placed the foothill seedlot at a disadvantage.

The differences in responses by vascular plants relative to air temperatures and soil temperatures between the coastal sites and the foothills suggested air temperature was probably more influential than soil temperature on plant growth and seed production in this region. Plants exposed to the lowest soil temperature and warmest air temperatures (foothills) outproduced those exposed to the coolest air temperatures and warmest soil temperatures (coastal). This was consistent with observations from agricultural and horticultural experiences in Alaska. Warm-season crop plants (corn, beans, tomatoes) introduced to Alaska from warmer climates generally respond favorably to treatments that warm the soil. In contrast, crop plants evolving in cold regions benefit less from such treatments.

Plant flowering in the area seemed to be above normal for many species in 1990. This was probably a carry-over effect from the 1989 growing season, when temperatures were unusually favorable. Abundant carbohydrate reserves were probably produced in 1989 and therefore were available for metabolism the following year. Also, floral parts undoubtedly differentiated in the 1989 growing season and developed into flowers during 1990, a normal pattern for bud and flower formation in the Arctic.

Identifying Plants to Colonize Gravel Fill

At least 125 vascular plant species were identified on the ten gravel sites examined in Phase III of this study. In addition to these plants, seed was identified and harvested from approximately 35 other species that were not recorded in that survey. Approximately 100 vascular plant species will be tested at the BP Put River No. 1 location during the course of this 10-year research project.

Considering the scope of this species list, it must be realized there is a substantial variety in the genetic array of plant materials in the Arctic. When major oil field production was starting at Prudhoe Bay, the arctic plant communities were considered to be under great threat, because they were believed to contain few species capable of colonizing disturbed sites. This was based partially on the lack of annual species, which normally quickly invade and colonize disturbed soils in temperate and warmer climates. That may be a mistaken notion. It is true there are few, if any, annuals in the Alaska Arctic. No annuals were found during this survey of plants occurring on gravel fill, and there were only two biennials, *Androsace septentrionalis* and *Descurainia sophioides*. All the rest were perennials. However, in spite of an absence of annuals in the indigenous plant communities, plant succession in the Arctic does exist, but it differs in aspect from that in warmer climates.

In the Arctic, the perennial plant species invade and initially form open and often inconspicuous communities. This is partially why the process seems to require more time in the Arctic, compared to temperate-zone plant succession. In warmer climates, canopy cover is quickly provided by annuals, which are absent in the Arctic. Temperate-zone perennials then invade, expand slowly, and simultaneously compete with annuals. The competition between annuals and perennials in stressful environments, such as the Arctic, would impede the succession process. Instead, succession by perennials occurs gradually, but steadily, over time in the absence of competition from aggressive annual vascular plant species. A dense seeding of grasses can give the impression of rapid recovery, but those very dense grass stands persist and undoubtedly present significant competition to the indigenous colonizers. There are, of course, management reasons for quickly establishing grass stands to protect soils, provide animal habitat, and improve aesthetics.

Currently, rehabilitation success of disturbed sites in the Alaska Arctic is evaluated primarily by measuring the canopy cover of vascular plants. Canopy cover is a feature selected for its simplicity to judge seeding success and may or may not relate to either the long-term stability of the vegetation community or to the aesthetic value of the stand. As the Trans-Alaska Pipeline was being completed in the late 1970's, the U.S. Department of the Interior's Alaska Pipeline Office introduced vascular plant canopy cover as the standard to be used with regard to revegetation. This method is now used routinely in judging rehabilitation success, despite its weaknesses in adequately predicting success on either gravel sites or rocky soils, which are inherently limited in their production potential.

It is important for land managers in the Arctic to recognize that differences exist in site *potential* for plant species composition as well as cover among various gravel fills. Such differences are governed by the local environmental conditions, i.e., proximity to the coast, elevation, regional climate, etc. Site potential is also governed by specific conditions of the gravel substrate itself. The amount of cobbles, sand, silt, and clay; organic matter; pH; available nutrients; depth of fill; and compaction (bulk density) of gravel fills vary from site to site. All sites cannot support the same kinds and amounts of vegetation. This was evident in this study, where no single species was found on all ten gravel fill locations examined.

Site *condition* is the present state of the vegetation (botanical composition and cover) in relation to the potential for that site. Cover and botanical composition characteristics may be rated excellent or good for one site, and those same values might be regarded as poor condition for another site which has a higher potential. As information is collected from numerous gravel fill sites, a database will emerge that can be used for determining site potential and rating vegetation condition of gravel fills in the Arctic. Currently, such information is unavailable. The third phase of this study is directed toward accumulating the necessary information to bring about a better understanding of site potential for various gravel fills in the Alaska Arctic.

Trend is a more sensitive indicator of change than condition and is probably more useful for rating both short- and long-term attributes of a site. Trend indicates the direction a community is proceeding with respect to the climax stage. Features such as the abundance of seedlings and young plants, presence of lichens and mosses as well as woody plants, amount of plant residues, plant vigor, species diversity, extent of bare ground, absence of soil erosion, and condition of the gravel surface should all be considered when evaluating trend. Trend is a tool that can be immediately utilized to determine whether a site is improving or deteriorating. Trend data should be obtained and used in conjunction with botanical composition and canopy cover for site evaluations.

The botanical species composition and hence aspect of communities forming on gravel pads will differ from that of the surrounding landscape whenever there are stark contrasts in the soil moisture and nutrient conditions between those two areas, i.e., differences in site potential. In other words, when the site potentials for the gravel fill and the adjacent landscape differ markedly, the resulting vegetation on the two sites will reflect that difference. As the soil environmental conditions become similar between gravel fill and the adjacent habitats (disturbed and undisturbed sites), the plant communities will also become similar. Therefore, it is necessary to consider the site *potential* when evaluating site *condition*, as opposed to using an arbitrary standard for gauging all rehabilitation projects. For evaluating the direction a community is moving, *trend* should be included in the assessment.

SUMMARY AND CONCLUSIONS

The major conclusions of the 1989 through 1991 field seasons of the Long-Term Gravel Vegetation Project are summarized below

- The amount of soil fines ≤2 mm improves soil bulk density, moisture content, and plant growth on gravel fill.
- Snow cover was significantly improved by the addition of snow fences. However, the snow cover remained late in spring and may have retarded growth of plants in snow-fenced areas.
- Over 125 vascular plant species have been found colonizing gravel fill in the Alaska Arctic. In terms of numbers of species colonizing gravel fill, the leading families of plants are: Gramineae, Compositae, Leguminosae, and Salicaceae. *Epilobium latifolium*, a member of the Onagraceae family, was found at more sites than any other species.
- Seed production by vascular plants in the Arctic was found to vary widely among years and locations and appears to be influenced mainly by air temperature. Cool temperatures coincided with poor seed production.
- One hundred and forty-four plots (experimental units) have been established on the BP Put River No. 1 gravel pad to evaluate influences of gravel thickness, topsoil addition, tilling, winter snow cover, and seeding *Poa glauca* lightly on plant colonization. Mixtures of indigenous plant seeds were applied to 1/5 of each plot in 1990 and 1991. The final planting is scheduled for 1993, because insufficient seed was obtained in the 1991 collections. Two subunits, each 1/5 of an experimental unit in size, will remain as unseeded control plots. This will result in a total of 720 subplots when the final planting occurs.
- Sixty-three species of indigenous vascular plants have been seeded in rows in the botanical garden on the BP Put River No. 1 gravel pad. Thirty-three were seeded in 1990, and 30 were seeded in 1991.
- Some plants appeared to be suffering from nutrient deficiencies after two growing seasons on the BP Put River No. 1 gravel pad, according to vigor and laboratory tests. Nitrogen appeared to be the most deficient macro-nutrient.
- Development of indigenous vascular plants in test plots and the botanical garden on the BP Put River No. 1 gravel pad was quite slow. Some species required more than one growing season to emerge. After emergence, top growth was slowly developing. At least three, and perhaps more, growing seasons are required before objective evaluations of indigenous colonizers are possible.
- Canopy cover averaged 47%, 34%, and 35%, respectively on gravel fill 0.6, 0.9, and 1.5 m in thickness after two growing seasons.
- Canopy cover averaged 51% and 32%, respectively, on test plots with and without 8 cm of topsoil after two growing seasons.
- Canopy cover averaged 46% and 26% on tilled and untilled test plots, respectively, after two growing seasons.

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Appendices

APPENDIX A

1990 GRAVEL COLLECTION DATA

Table A-1 presents the results of the sieve analyses for substrate samples collected from each of the 144 experimental plots at the BP Put River No. 1 gravel pad in 1990. Weights of each particle size are given to the nearest 0.0 g for each of three replicates sieved.

Table A-1. Sieve analysis of substrate samples taken from unplanted plots at the BP Put River No. 1 gravel pad in 1990

							Percent												
Block	Snow Fence	Poa Glauca	Repl	Height	Soil	Tilled	3.0"	2.5"	2.0"	1.5"	1.0"	3/4"	1/2"	3/8"	1/4"	#4	#10	Pan	Lost
1	1	1	1	5	0	1	0.0	0.0	0.0	0.0	6.3	10.0	14.4	15.7	13.0	6.9	9.9	23.8	0.1
1	1	1	1	5	0	0	0.0	0.0	0.0	1.1	6.1	6.1	13.3	12.5	15.3	7.6	11.3	26.5	0.1
1	1	1	1	5	1	1	0.0	0.0	0.0	0.0	4.5	4.5	6.6	8.4	8.3	4.7	7.2	55.4	0.3
1	1	1	1	5	1	0	0.0	0.0	0.0	2.3	0.5	4.1	6.5	6.8	6.8	3.9	6.1	62.7	0.3
1	1	1	1	3	0	1	0.0	0.0	0.0	0.0	4.6	5.8	13.4	14.9	15.0	8.4	11.4	26.6	0.0
1	1	1	1	3	0	0	0.0	0.0	0.0	1.0	4.3	8.0	14.0	12.3	14.4	7.7	11.3	27.1	0.0
1	1	1	1	3	1	1	0.0	0.0	0.0	1.3	3.6	3.0	7.9	7.0	7.5	4.1	6.3	59.0	0.2
1	1	1	1	3	1	0	0.0	0.0	0.0	0.0	0.4	1.7	4.4	5.3	6.7	3.9	5.7	71.5	0.4
1	1	1	1	2	0	1	0.0	0.0	0.0	0.0	5.4	8.6	17.8	13.9	14.4	7.3	10.1	22.4	0.0
1	1	1	1	2	0	0	0.0	0.0	0.0	3.5	5.0	9.0	13.9	13.1	14.1	7.3	10.5	23.6	0.0
1	1	1	1	2	1	1	0.0	0.0	0.0	0.0	5.3	3.6	8.9	7.4	7.7	4.2	6.1	56.7	0.2
1	1	1	1	2	1	0	0.0	0.0	0.0	0.0	3.8	1.3	5.2	4.9	6.1	3.6	5.2	69.6	0.3
1	1	1	2	5	0	1	0.0	0.0	0.0	0.0	4.6	9.8	16.0	14.2	13.6	7.4	10.0	24.2	0.1
1	1	1	2	5	0	0	0.0	0.0	0.0	2.2	3.1	6.6	15.3	13.0	15.1	7.7	11.1	25.8	0.0
1	1	1	2	5	1	1	0.0	0.0	0.0	0.0	2.5	5.1	9.9	9.4	8.3	4.6	7.1	52.9	0.2
1	1	1	2	5	1	0	0.0	0.0	0.0	0.0	2.4	3.1	8.3	6.7	7.7	4.4	6.6	60.5	0.2
1	1	1	2	3	0	1	0.0	0.0	0.0	0.0	4.1	7.8	14.9	14.9	15.8	7.7	10.6	24.3	0.0
1	1	1	2	3	0	0	0.0	0.0	3.1	0.0	6.1	5.6	14.6	13.0	13.0	7.2	11.1	26.2	0.1
1	1	1	2	3	1	1	0.0	0.0	0.0	0.0	2.4	6.3	10.6	8.3	9.5	5.0	7.7	50.0	0.2
1	1	1	2	3	1	0	0.0	0.0	0.0	0.0	0.0	0.9	5.4	6.3	6.4	3.6	5.9	71.4	0.1
1	1	1	2	2	0	1	0.0	0.0	0.0	0.0	7.0	9.6	17.7	14.3	14.4	6.2	9.1	21.6	0.0
1	1	1	2	2	0	0	0.0	0.0	0.0	0.0	7.8	6.4	16.1	12.9	12.9	7.2	10.8	26.0	0.0
1	1	1	2	2	1	1	0.0	0.0	0.0	0.0	1.7	3.8	4.9	6.4	6.7	3.9	5.4	66.8	0.2
1	1	1	2	2	1	0	0.0	0.0	0.0	0.0	1.3	2.1	3.7	3.6	5.0	3.1	4.6	76.4	0.2
1	1	1	3	5	0	1	0.0	0.0	0.0	0.0	6.0	9.4	15.7	12.6	14.6	7.3	10.1	24.3	0.0
1	1	1	3	5	0	0	0.0	0.0	0.0	2.5	7.6	8.6	13.0	12.3	14.3	6.9	10.5	24.3	0.1
1	1	1	3	5	1	1	0.0	0.0	0.0	4.3	2.1	5.5	8.9	7.0	7.9	4.1	6.5	53.4	0.2
1	1	1	3	5	1	0	0.0	0.0	0.0	0.0	2.8	2.8	5.5	5.9	6.4	3.8	5.9	66.8	0.3
1	1	1	3	3	0	1	0.0	0.0	0.0	0.0	6.1	7.8	15.6	13.2	14.4	7.3	10.8	24.6	0.1
1	1	1	3	3	0	0	0.0	0.0	2.7	1.8	7.1	6.1	14.3	10.0	12.3	7.2	11.3	27.2	0.1
1	1	1	3	3	1	1	0.0	0.0	0.0	0.0	4.4	4.4	8.2	7.5	7.7	4.4	6.2	57.2	0.1
1	1	1	3	3	1	0	0.0	0.0	0.0	2.7	1.1	1.1	4.2	6.0	6.5	3.6	5.8	68.7	0.3
1	1	1	3	2	0	1	0.0	0.0	0.0	0.0	3.9	9.5	16.6	12.5	13.9	7.2	10.6	25.7	0.1
1	1	1	3	2	0	0	0.0	0.0	0.0	0.0	9.7	7.9	12.4	12.4	13.4	7.3	10.9	26.0	0.1
1	1	1	3	2	1	1	0.0	0.0	0.0	2.3	0.9	3.7	9.0	7.7	8.0	4.0	6.0	58.2	0.2
1	1	1	3	2	1	0	0.0	0.0	0.0	0.0	1.1	2.6	3.9	4.8	6.0	3.5	5.1	72.7	0.2
2	0	1	1	5	0	1	0.0	0.0	0.0	1.1	15.6	12.2	15.3	11.4	10.3	4.8	7.2	21.8	0.1
2	0	1	1	5	0	0	0.0	0.0	0.0	3.8	9.3	8.9	17.7	11.4	11.3	5.5	7.7	24.5	0.1
2	0	1	1	5	1	1	0.0	0.0	0.0	0.0	3.0	4.7	7.2	6.6	7.3	4.0	5.6	61.5	0.2
2	0	1	1	5	1	0	0.0	0.0	0.0	0.0	2.9	3.6	5.3	6.0	6.5	4.2	6.1	65.3	0.2
2	0	1	1	3	0	1	0.0	0.0	0.0	3.7	11.2	13.3	16.0	11.4	10.7	5.0	7.0	21.7	0.1
2	0	1	1	3	0	0	0.0	0.0	0.0	0.0	7.7	11.7	15.8	12.9	12.8	5.8	9.1	24.1	0.1
2	0	1	1	3	1	1	0.0	0.0	0.0	0.0	2.2	4.4	10.5	7.2	7.4	4.5	6.1	57.5	0.2
2	0	1	1	3	1	0	0.0	0.0	0.0	0.0	1.5	1.5	4.9	4.4	5.9	3.1	5.1	73.4	0.2
2	0	1	1	2	0	1	0.0	0.0	0.0	1.5	13.7	10.4	15.8	11.0	11.0	5.2	7.2	24.1	0.1
2	0	1	1	2	0	0	0.0	0.0	0.0	0.0	8.3	9.0	17.3	11.5	12.4	5.6	8.4	27.5	0.0
2	0	1	1	2	1	1	0.0	0.0	0.0	0.0	1.8	3.4	8.6	6.0	6.9	3.8	5.7	63.6	0.2
2	0	1	1	2	1	0	0.0	0.0	0.0	0.0	0.4	1.2	5.0	4.0	6.3	3.2	5.1	74.8	0.2
2	0	1	2	5	0	1	0.0	0.0	0.0	2.1	9.6	11.3	17.2	11.7	11.0	5.5	7.7	23.8	0.1
2	0	1	2	5	0	0	0.0	0.0	3.4	4.0	7.9	7.6	12.6	11.2	11.7	6.4	8.8	26.3	0.1
2	0	1	2	5	1	1	0.0	0.0	5.2	0.0	4.1	5.9	7.3	6.8	6.5	3.6	5.2	55.2	0.2
2	0	1	2	5	1	0	0.0	0.0	0.0	0.0	0.4	2.9	5.5	5.9	7.3	3.9	5.7	68.1	0.3

Table A-1. (Cont.) Sieve analysis of substrate samples taken from unplanted plots at the BP Put River No. 1 gravel pad in 1990

Block	Snow Fence	Poa Glauca	Repl	Height	Soil	Tilled	Percent 3.0"	2.5"	2.0"	1.5"	1.0"	3/4"	1/2"	3/8"	1/4"	#4	#10	Pan	Lost
2	0	1	2	3	0	1	0.0	0.0	0.0	1.9	9.3	8.9	17.4	11.7	11.9	6.2	10.3	22.4	0.1
2	0	1	2	3	0	0	9.8	0.0	0.0	3.3	7.1	7.7	13.4	11.5	10.4	5.2	8.3	23.2	0.1
2	0	1	2	3	1	1	0.0	0.0	0.0	3.2	1.9	1.2	6.0	6.1	6.3	3.8	6.1	65.1	0.3
2	0	1	2	3	1	0	0.0	0.0	0.0	0.0	2.0	4.4	6.3	6.7	8.7	4.5	6.3	60.9	0.2
2	0	1	2	2	0	1	0.0	0.0	0.0	0.0	6.5	9.1	15.4	11.4	12.6	6.4	9.7	28.8	0.1
2	0	1	2	2	0	0	0.0	0.0	0.0	4.2	3.8	8.9	15.6	10.5	12.1	6.4	9.5	28.9	0.0
2	0	1	2	2	1	1	0.0	0.0	0.0	0.0	2.2	3.7	10.5	8.3	9.7	5.0	6.9	53.5	0.1
2	0	1	2	2	1	0	0.0	0.0	0.0	0.0	3.4	4.8	4.3	4.9	6.4	3.2	5.7	67.1	0.3
2	0	1	3	5	0	1	0.0	0.0	4.2	5.0	6.9	10.5	15.4	11.7	11.2	5.2	7.0	22.7	0.1
2	0	1	3	5	0	0	0.0	0.0	3.0	1.7	7.8	9.5	14.8	11.2	11.7	5.9	8.6	25.7	0.1
2	0	1	3	5	1	1	0.0	0.0	0.0	0.0	2.6	3.3	5.9	4.2	6.5	3.4	5.1	68.6	0.3
2	0	1	3	5	1	0	0.0	0.0	0.0	0.0	2.7	1.7	4.9	5.7	5.9	3.6	5.2	70.0	0.3
2	0	1	3	3	0	1	0.0	3.9	0.0	1.4	7.6	10.5	16.8	11.5	11.6	5.8	8.5	22.4	0.1
2	0	1	3	3	0	0	0.0	0.0	0.0	2.6	6.7	10.5	16.3	12.6	12.0	6.1	9.1	24.0	0.1
2	0	1	3	3	1	1	0.0	0.0	0.0	0.0	1.4	2.8	7.1	5.3	7.3	3.7	5.8	66.4	0.2
2	0	1	3	3	1	0	0.0	0.0	0.0	0.0	2.6	2.7	4.3	3.8	5.6	3.5	5.3	72.2	0.2
2	0	1	3	2	0	1	0.0	0.0	0.0	1.2	3.1	8.6	13.4	11.9	13.0	6.2	9.9	32.7	0.0
2	0	1	3	2	0	0	0.0	0.0	0.0	1.6	6.6	7.9	14.2	10.8	12.5	6.2	9.4	30.7	0.1
2	0	1	3	2	1	1	0.0	0.0	0.0	0.0	6.1	2.5	4.5	5.1	6.1	3.3	5.4	66.7	0.2
2	0	1	3	2	1	0	0.0	0.0	0.0	0.0	0.6	2.5	5.0	5.7	6.3	3.5	6.0	70.1	0.2
3	1	0	1	5	0	1	0.0	0.0	0.0	0.0	9.4	11.4	16.3	11.3	11.2	5.6	8.1	26.6	0.1
3	1	0	1	5	0	0	0.0	0.0	0.0	3.3	6.1	7.7	13.4	11.7	13.2	6.1	9.6	28.9	0.1
3	1	0	1	5	1	1	0.0	0.0	0.0	0.0	1.6	2.6	8.0	9.4	10.0	5.3	8.4	54.4	0.3
3	1	0	1	5	1	0	0.0	0.0	0.0	0.0	2.4	2.7	8.4	8.4	9.9	5.1	7.8	55.1	0.3
3	1	0	1	3	0	1	0.0	0.0	0.0	0.0	7.2	7.4	15.4	13.0	14.2	7.2	10.4	25.1	0.1
3	1	0	1	3	0	0	0.0	0.0	0.0	0.0	5.2	7.6	13.8	12.9	15.0	7.4	11.2	26.8	0.1
3	1	0	1	3	1	1	0.0	0.0	0.0	0.0	3.0	2.9	6.7	6.2	7.3	4.0	6.1	63.5	0.3
3	1	0	1	3	1	0	0.0	0.0	0.0	1.2	0.0	2.7	5.1	6.0	8.4	4.4	6.6	65.4	0.2
3	1	0	1	2	0	1	0.0	0.0	0.0	0.9	5.7	5.9	15.2	13.0	16.3	7.6	10.8	24.4	0.2
3	1	0	1	2	0	0	0.0	0.0	0.0	0.0	3.3	6.3	15.4	13.4	14.9	8.1	11.4	27.2	0.1
3	1	0	1	2	1	1	0.0	0.0	0.0	0.0	4.5	4.3	7.1	7.3	9.3	5.0	7.2	55.2	0.2
3	1	0	1	2	1	0	0.0	0.0	0.0	0.0	1.8	4.1	7.6	9.0	9.3	4.9	7.1	55.9	0.2
3	1	0	2	5	0	1	0.0	0.0	0.0	4.4	5.5	9.0	16.3	11.8	12.4	6.3	9.2	24.9	0.1
3	1	0	2	5	0	0	0.0	0.0	0.0	1.0	7.2	6.4	15.3	11.6	13.7	6.8	10.4	27.5	0.0
3	1	0	2	5	1	1	0.0	0.0	0.0	0.0	2.8	1.3	5.6	6.1	8.0	4.0	6.7	65.3	0.2
3	1	0	2	5	1	0	0.0	0.0	0.0	0.0	1.4	2.7	5.8	5.1	6.1	3.6	5.6	69.3	0.3
3	1	0	2	3	0	1	0.0	0.0	0.0	0.0	6.6	7.8	13.7	12.6	15.2	7.7	11.0	25.2	0.1
3	1	0	2	3	0	0	0.0	0.0	0.0	0.0	5.0	6.7	14.2	13.8	15.5	7.3	11.2	26.2	0.1
3	1	0	2	3	1	1	0.0	0.0	0.0	0.0	1.2	2.3	4.1	4.5	6.2	3.7	5.8	71.5	0.6
3	1	0	2	3	1	0	0.0	0.0	0.0	1.3	1.4	1.9	6.8	5.1	6.6	3.9	6.1	66.7	0.2
3	1	0	2	2	0	1	0.0	0.0	0.0	2.8	4.2	7.6	15.7	13.7	14.6	7.5	10.5	23.3	0.0
3	1	0	2	2	0	0	0.0	0.0	0.0	1.1	5.5	9.1	12.9	12.5	14.2	7.8	11.1	25.7	0.1
3	1	0	2	2	1	1	0.0	0.0	0.0	0.0	5.9	2.2	9.9	8.6	9.7	5.1	7.4	51.0	0.3
3	1	0	2	2	1	0	0.0	0.0	0.0	2.1	2.8	2.6	8.5	6.3	8.2	4.6	6.7	57.8	0.2
3	1	0	3	5	0	1	0.0	0.0	0.0	1.8	10.1	9.3	15.6	11.0	12.4	6.1	8.7	25.0	0.1
3	1	0	3	5	0	0	0.0	0.0	2.9	4.8	6.3	8.3	13.6	11.5	12.0	6.0	8.9	25.7	0.0
3	1	0	3	5	1	1	0.0	0.0	0.0	0.0	2.0	2.2	4.4	5.2	6.8	3.8	5.6	69.6	0.3
3	1	0	3	5	1	0	0.0	0.0	0.0	0.0	2.4	1.3	4.6	6.7	7.0	3.7	5.8	68.2	0.4
3	1	0	3	3	0	1	0.0	0.0	0.0	1.3	3.1	8.5	17.0	13.5	13.5	7.3	10.5	25.0	0.1
3	1	0	3	3	0	0	0.0	0.0	0.0	1.0	5.7	7.1	12.3	13.3	14.1	7.3	10.7	28.3	0.1
3	1	0	3	3	1	1	0.0	0.0	0.0	0.0	0.0	1.2	3.4	5.0	6.3	3.8	6.0	74.1	0.2
3	1	0	3	3	1	0	0.0	0.0	0.0	0.0	0.7	1.3	5.2	5.8	7.4	3.9	6.2	69.2	0.2

Table A-1. (Cont.) Sieve analysis of substrate samples taken from unplanted plots at the BP Put River No. 1 gravel pad in 1990

Block	Snow Fence	Poa Glauca	Repl	Height	Soil	Tilled	Percent 3.0"	2.5"	2.0"	1.5"	1.0"	3/4"	1/2"	3/8"	1/4"	#4	#10	Pan	Lost
3	1	0	3	2	0	1	0.0	0.0	0.0	2.0	6.1	8.8	14.3	14.4	14.6	7.1	10.0	22.7	0.1
3	1	0	3	2	0	0	0.0	0.0	0.0	1.6	2.9	5.8	14.2	14.7	15.7	7.9	11.4	25.6	0.2
3	1	0	3	2	1	1	0.0	0.0	0.0	2.2	2.2	4.9	8.7	7.8	9.2	4.9	6.9	53.0	0.3
3	1	0	3	2	1	0	0.0	0.0	0.0	0.0	1.2	6.2	5.9	7.1	8.9	4.7	6.5	59.1	0.3
4	0	0	1	5	0	1	0.0	0.0	2.5	5.0	15.7	10.6	14.2	10.6	9.9	4.7	7.0	19.6	0.2
4	0	0	1	5	0	0	0.0	0.0	0.0	8.1	7.6	9.6	13.9	11.3	12.0	5.7	8.4	23.4	0.1
4	0	0	1	5	1	1	0.0	0.0	0.0	0.0	4.7	2.7	7.5	6.9	7.3	3.7	6.1	60.7	0.3
4	0	0	1	5	1	0	0.0	0.0	5.5	0.0	2.9	2.2	5.9	6.0	6.7	3.8	5.6	61.1	0.3
4	0	0	1	3	0	1	0.0	0.0	0.0	3.7	10.2	9.0	15.9	11.5	11.7	5.6	7.9	24.4	0.0
4	0	0	1	3	0	0	0.0	0.0	4.8	0.0	8.0	10.9	15.0	10.9	11.3	5.2	8.3	25.5	0.1
4	0	0	1	3	1	1	0.0	0.0	0.0	0.0	5.3	5.8	9.6	5.0	8.3	4.7	6.2	55.0	0.1
4	0	0	1	3	1	0	0.0	0.0	0.0	3.6	1.7	3.2	5.6	5.9	6.2	4.1	5.7	63.7	0.2
4	0	0	1	2	0	1	0.0	0.0	0.0	0.0	11.0	11.1	18.8	12.3	12.3	5.5	8.0	21.0	0.0
4	0	0	1	2	0	0	0.0	0.0	0.0	1.8	7.1	12.2	16.9	12.7	12.6	5.9	8.9	21.8	0.1
4	0	0	1	2	1	1	0.0	0.0	0.0	0.0	4.0	4.4	7.5	5.8	7.2	3.7	6.2	60.9	0.3
4	0	0	1	2	1	0	0.0	0.0	0.0	0.0	1.7	3.6	4.9	5.5	6.2	3.7	6.3	67.9	0.3
4	0	0	2	5	0	1	0.0	0.0	0.0	2.3	8.9	11.8	17.0	11.0	12.1	5.5	8.1	23.3	0.1
4	0	0	2	5	0	0	0.0	0.0	0.0	2.1	6.0	8.1	16.9	12.3	12.5	6.1	9.0	26.9	0.1
4	0	0	2	5	1	1	0.0	0.0	0.0	0.0	3.8	3.2	8.7	7.0	8.4	4.1	6.4	58.0	0.3
4	0	0	2	5	1	0	0.0	0.0	0.0	0.0	1.5	2.7	5.9	5.9	7.3	4.0	6.1	66.5	0.2
4	0	0	2	3	0	1	0.0	0.0	0.0	0.0	9.7	9.0	16.8	12.4	12.6	5.8	8.2	25.5	0.0
4	0	0	2	3	0	0	0.0	0.0	0.0	4.5	7.3	6.5	14.8	11.8	12.8	5.3	9.6	27.4	0.0
4	0	0	2	3	1	1	0.0	0.0	0.0	2.4	3.8	5.2	9.3	7.1	7.8	3.8	5.5	55.1	0.0
4	0	0	2	3	1	0	0.0	0.0	0.0	0.0	2.2	1.1	4.3	5.1	6.5	3.9	5.5	71.1	0.2
4	0	0	2	2	0	1	0.0	0.0	0.0	3.4	12.9	14.7	16.3	10.5	10.0	4.5	6.7	21.0	0.1
4	0	0	2	2	0	0	0.0	0.0	0.0	3.6	7.4	13.6	14.0	11.4	12.4	5.8	8.8	22.9	0.0
4	0	0	2	2	1	1	0.0	0.0	0.0	0.0	3.2	3.7	4.4	6.4	7.0	3.8	5.9	65.4	0.4
4	0	0	2	2	1	0	0.0	0.0	0.0	0.0	1.4	1.8	5.8	4.2	6.7	3.6	6.0	70.2	0.3
4	0	0	3	5	0	1	0.0	0.0	0.0	0.0	6.1	8.7	14.5	12.6	13.7	6.8	9.8	27.6	0.2
4	0	0	3	5	0	0	0.0	0.0	0.0	1.6	5.8	6.7	13.6	12.5	13.2	6.7	10.2	29.5	0.1
4	0	0	3	5	1	1	0.0	0.0	0.0	0.0	5.2	3.2	5.9	7.2	8.2	4.5	6.8	58.8	0.2
4	0	0	3	5	1	0	0.0	0.0	0.0	1.9	3.0	0.9	5.5	5.5	6.7	3.7	6.4	66.0	0.3
4	0	0	3	3	0	1	0.0	0.0	0.0	1.0	6.4	10.8	13.3	13.5	13.5	6.7	9.3	25.6	0.0
4	0	0	3	3	0	0	0.0	0.0	0.0	1.5	8.7	10.1	13.6	12.5	12.5	6.1	8.8	26.2	0.0
4	0	0	3	3	1	1	0.0	0.0	0.0	0.0	1.5	3.2	7.0	6.7	7.9	3.9	5.8	63.8	0.2
4	0	0	3	3	1	0	0.0	0.0	0.0	3.5	0.0	2.9	5.5	5.6	6.5	3.8	5.7	66.2	0.2
4	0	0	3	2	0	1	0.0	0.0	0.0	7.7	9.7	12.8	15.9	11.3	10.3	4.8	6.8	20.6	0.0
4	0	0	3	2	0	0	0.0	0.0	0.0	2.5	8.8	10.1	16.7	12.6	12.0	6.0	8.9	22.3	0.0
4	0	0	3	2	1	1	0.0	0.0	0.0	3.9	1.8	5.8	6.5	6.9	7.6	4.4	6.6	56.4	0.1
4	0	0	3	2	1	0	0.0	0.0	0.0	0.0	3.4	2.2	6.6	6.4	7.0	3.8	6.5	63.8	0.4

Table A-2. Means of sieve analysis of substrate samples taken from unplanted plots at the BP Put River No. 1 gravel pad in 1990

Block	Snow Fence	Poa Glauca	Height	Soil	Tilled	Percent 3.0"	2.5"	2.0"	1.5"	1.0"	3/4"	1/2"	3.8"	1/4"	#4	#10	Pan	Lost
1	1	1	5	0	1	0.0	0.0	0.0	0.0	5.6	9.7	15.4	14.2	13.7	7.2	10.0	24.1	0.1
1	1	1	5	0	0	0.0	0.0	0.0	1.9	5.6	7.1	13.9	12.6	14.9	7.4	11.0	25.5	0.1
1	1	1	5	1	1	0.0	0.0	0.0	1.4	3.0	5.0	8.5	8.3	8.2	4.5	6.9	53.9	0.2
1	1	1	5	1	0	0.0	0.0	0.0	0.8	1.9	3.3	6.8	6.5	7.0	4.0	6.2	63.3	0.3
1	1	1	3	0	1	0.0	0.0	0.0	0.0	4.9	7.1	14.6	14.3	15.1	7.8	10.9	25.2	0.0
1	1	1	3	0	0	0.0	0.0	1.9	0.9	5.8	6.6	14.3	11.8	13.2	7.4	11.2	26.8	0.1
1	1	1	3	1	1	0.0	0.0	0.0	0.4	3.5	4.6	8.9	7.6	8.2	4.5	6.7	55.4	0.2
1	1	1	3	1	0	0.0	0.0	0.0	0.9	0.5	1.2	4.7	5.9	6.5	3.7	5.8	70.5	0.3
1	1	1	2	0	1	0.0	0.0	0.0	0.0	5.4	9.2	17.4	13.6	14.2	6.9	9.9	23.2	0.0
1	1	1	2	0	0	0.0	0.0	0.0	1.2	7.5	7.8	14.1	12.8	13.5	7.3	10.7	25.2	0.0
1	1	1	2	1	1	0.0	0.0	0.0	0.8	2.6	3.7	7.6	7.2	7.5	4.0	5.8	60.6	0.2
1	1	1	2	1	0	0.0	0.0	0.0	0.0	2.1	2.0	4.3	4.4	5.7	3.4	5.0	72.9	0.2
2	0	1	5	0	1	0.0	0.0	1.4	2.7	10.7	11.3	16.0	11.6	10.8	5.2	7.3	22.8	0.1
2	0	1	5	0	0	0.0	0.0	2.1	3.2	8.3	8.7	15.0	11.3	11.6	5.9	8.4	25.5	0.1
2	0	1	5	1	1	0.0	0.0	1.7	0.0	3.2	4.6	6.8	5.9	6.8	3.7	5.3	61.8	0.2
2	0	1	5	1	0	0.0	0.0	0.0	0.0	2.0	2.7	5.2	5.9	6.6	3.9	5.7	67.8	0.3
2	0	1	3	0	1	0.0	1.3	0.0	2.3	9.4	10.9	16.7	11.5	11.4	5.7	8.6	22.2	0.1
2	0	1	3	0	0	3.3	0.0	0.0	2.0	7.2	10.0	15.2	12.3	11.7	5.7	8.8	23.8	0.1
2	0	1	3	1	1	0.0	0.0	0.0	1.1	1.8	2.8	7.9	6.2	7.0	4.0	6.0	63.0	0.2
2	0	1	3	1	0	0.0	0.0	0.0	0.0	2.0	2.9	5.2	5.0	6.7	3.7	5.6	68.8	0.2
2	0	1	2	0	1	0.0	0.0	0.0	0.9	7.8	9.4	14.9	11.4	12.2	5.9	8.9	28.5	0.1
2	0	1	2	0	0	0.0	0.0	0.0	1.9	6.2	8.6	15.7	10.9	12.3	6.1	9.1	29.0	0.0
2	0	1	2	1	1	0.0	0.0	0.0	0.0	3.4	3.2	7.9	6.5	7.6	4.0	6.0	61.3	0.2
2	0	1	2	1	0	0.0	0.0	0.0	0.0	1.5	2.8	4.8	4.9	6.3	3.3	5.6	70.7	0.2
3	1	0	5	0	1	0.0	0.0	0.0	2.1	8.3	9.9	16.1	11.4	12.0	6.0	8.7	25.5	0.1
3	1	0	5	0	0	0.0	0.0	1.0	3.0	6.5	7.5	14.1	11.6	13.0	6.3	9.6	27.4	0.0
3	1	0	5	1	1	0.0	0.0	0.0	0.0	2.1	2.0	6.0	6.9	8.3	4.4	6.9	63.1	0.3
3	1	0	5	1	0	0.0	0.0	0.0	0.0	2.1	2.2	6.3	6.7	7.7	4.1	6.4	64.2	0.3
3	1	0	3	0	1	0.0	0.0	0.0	0.4	5.6	7.9	15.4	13.0	14.3	7.4	10.6	25.1	0.1
3	1	0	3	0	0	0.0	0.0	0.0	0.3	5.3	7.1	13.4	13.3	14.9	7.3	11.0	27.1	0.1
3	1	0	3	1	1	0.0	0.0	0.0	0.0	1.4	2.1	4.7	5.2	6.6	3.8.	6.0	69.7	0.4
3	1	0	3	1	0	0.0	0.0	0.0	0.8	0.7	2.0	5.7	5.6	7.5	4.1	6.3	67.1	0.2
3	1	0	2	0	1	0.0	0.0	0.0	1.9	5.3	7.4	15.1	13.7	15.2	7.4	10.4	23.5	0.1
3	1	0	2	0	0	0.0	0.0	0.0	0.9	3.9	7.1	14.2	13.5	14.9	7.9	11.3	26.2	0.1
3	1	0	2	1	1	0.0	0.0	0.0	0.7	4.2	3.8	8.6	7.9	9.4	5.0	7.2	53.1	0.3
3	1	0	2	1	0	0.0	0.0	0.0	0.7	1.9	4.3	7.3	7.5	8.8	4.7	6.8	57.6	0.2
4	0	0	5	0	1	0.0	0.0	0.8	2.4	10.2	10.4	15.2	11.4	11.9	5.7	8.3	23.5	0.2
4	0	0	5	0	0	0.0	0.0	0.0	3.9	6.5	8.1	14.8	12.0	12.6	6.2	9.2	26.6	0.1
4	0	0	5	1	1	0.0	0.0	0.0	0.0	4.6	3.0	7.4	7.0	8.0	4.1	6.4	59.2	0.3
4	0	0	5	1	0	0.0	0.0	1.8	0.6	2.5	1.9	5.8	5.8	6.9	3.8	6.0	64.5	0.3
4	0	0	3	0	1	0.0	0.0	0.0	1.6	8.8	9.6	15.3	12.5	12.6	6.0	8.5	25.2	0.0
4	0	0	3	0	0	0.0	0.0	1.6	2.0	8.0	9.2	14.5	11.7	12.2	5.5	8.9	26.4	0.0
4	0	0	3	1	1	0.0	0.0	0.0	0.8	3.5	4.7	8.6	6.3	8.0	4.1	5.8	58.0	0.1
4	0	0	3	1	0	0.0	0.0	0.0	2.4	1.3	2.4	5.1	5.5	6.4	3.9	5.6	67.0	0.2
4	0	0	2	0	1	0.0	0.0	0.0	3.7	11.2	12.9	17.0	11.4	10.9	4.9	7.2	20.9	0.0
4	0	0	2	0	0	0.0	0.0	0.0	2.6	7.8	12.0	15.9	12.2	12.3	5.9	8.9	22.3	0.0
4	0	0	2	1	1	0.0	0.0	0.0	1.3	3.0	4.6	6.1	6.4	7.3	4.0	6.2	60.9	0.3
4	0	0	2	1	0	0.0	0.0	0.0	0.0	2.2	2.5	5.8	5.4	6.6	3.7	6.3	67.3	0.3

Table A-3. Results of sieve analysis of substrate samples taken from unplanted plots at the BP Put River No. 1 gravel pad in 1990

						Percent												
Block	Snow Fence	Poa Glauca	Height	Soil	Tilled	3.0"	2.5"	2.0"	1.5"	1.0"	3/4"	1/2"	3.8"	1/4"	#4	#10	Pan	Lost
1	1	1				0.0	0.0	0.2	0.7	4.0	5.6	10.9	9.9	10.6	5.7	8.4	43.9	0.1
1	1	1	5			0.0	0.0	0.0	1.0	4.0	6.3	11.1	10.4	10.9	5.8	8.5	41.7	0.2
1	1	1	3			0.0	0.0	0.5	0.6	3.7	4.9	10.6	9.9	10.8	5.8	8.7	44.5	0.1
1	1	1	2			0.0	0.0	0.0	0.5	4.4	5.7	10.8	9.5	10.2	5.4	7.9	45.5	0.1
1	1	1		0		0.0	0.0	0.3	0.7	5.8	7.9	14.9	13.2	14.1	7.3	10.6	25.0	0.1
1	1	1		1		0.0	0.0	0.0	0.7	2.3	3.3	6.8	6.6	7.2	4.0	6.1	62.8	0.2
1	1	1			0	0.0	0.0	0.3	1.0	3.9	4.7	9.7	9.0	10.1	5.5	8.3	47.4	0.2
1	1	1			1	0.0	0.0	0.0	0.4	4.2	6.6	12.1	10.9	11.2	5.8	8.4	40.4	0.1
2	0	1				0.3	0.1	0.4	1.2	5.3	6.5	10.9	8.6	9.3	4.8	7.1	45.4	0.2
2	0	1	5			0.0	0.0	1.3	1.5	6.1	6.8	10.8	8.7	8.9	4.7	6.7	44.5	0.2
2	0	1	3			0.8	0.3	0.0	1.3	5.1	6.6	11.2	8.8	9.2	4.8	7.3	44.4	0.2
2	0	1	2			0.0	0.0	0.0	0.7	4.7	6.0	10.8	8.4	9.6	4.8	7.4	47.4	0.1
2	0	1		0		0.5	0.2	0.6	2.2	8.3	9.8	15.6	11.5	11.7	5.7	8.5	25.3	0.1
2	0	1		1		0.0	0.0	0.3	0.2	2.3	3.2	6.3	5.7	6.8	3.8	5.7	65.6	0.2
2	0	1			0	0.5	0.0	0.4	1.2	4.5	5.9	10.2	8.4	9.2	4.8	7.2	47.6	0.2
2	0	1			1	0.0	0.2	0.5	1.2	6.0	7.0	11.7	8.9	9.3	4.7	7.0	43.3	0.2
3	1	0				0.0	0.0	0.1	0.9	4.0	5.3	10.6	9.7	11.0	5.7	8.4	44.1	0.2
3	1	0	5			0.0	0.0	0.2	1.3	4.8	5.4	10.6	9.2	10.2	5.2	7.9	45.0	0.2
3	1	0	3			0.0	0.0	0.0	0.4	3.3	4.8	9.8	9.3	10.8	5.7	8.5	47.3	0.2
3	1	0	2			0.0	0.0	0.0	1.1	3.8	5.7	11.3	10.7	12.1	6.3	8.9	40.1	0.2
3	1	0		0		0.0	0.0	0.2	1.4	5.8	7.8	14.7	12.8	14.0	7.1	10.3	25.8	0.1
3	1	0		1		0.0	0.0	0.0	0.4	2.1	2.7	6.4	6.6	8.0	4.4	6.6	62.5	0.3
3	1	0			0	0.0	0.0	0.2	1.0	3.4	5.0	10.2	9.7	11.1	5.8	8.6	44.9	0.2
3	1	0			1	0.0	0.0	0.0	0.9	4.5	5.5	11.0	9.7	11.0	5.7	8.3	43.3	0.2
4	0	0				0.0	0.0	0.4	1.8	5.8	6.8	11.0	9.0	9.6	4.8	7.3	43.5	0.2
4	0	0	5			0.0	0.0	0.7	1.8	5.9	5.9	10.8	9.1	9.8	4.9	7.5	43.5	0.2
4	0	0	3			0.0	0.0	0.4	1.7	5.4	6.5	10.9	9.0	9.8	4.9	7.2	44.1	0.1
4	0	0	2			0.0	0.0	0.0	1.9	6.0	8.0	11.2	8.8	9.3	4.6	7.1	42.9	0.2
4	0	0		0		0.0	0.0	0.4	2.7	8.7	10.4	15.5	11.9	12.1	5.7	8.5	24.1	0.1
4	0	0		1		0.0	0.0	0.3	0.9	2.8	3.2	6.5	6.1	7.2	3.9	6.1	62.8	0.2
4	0	0			0	0.0	0.0	0.6	1.9	4.7	6.0	10.3	8.8	9.5	4.8	7.5	45.7	0.2
4	0	0			1	0.0	0.0	0.1	1.6	6.9	7.5	11.6	9.2	9.8	4.8	7.1	41.3	0.1