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A COMPREHENSIVE RECLAMATION RESEARCH PROGRAM

ON COAL MINING DISTURBED LANDS

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ABSTRACT

Kaiser Resources Ltd. has been conducting an intensive reclamation research program since 1975. Although many of its component projects are long-term, some experiments have already been completed. As a result, methods are now available for predicting the success of thirteen commonly-used revegetation species on Kaiser's disturbed areas. We also know at what elevations and aspects to expect the greatest success with currert reclamation practices. This may be helpful input in designing dumps and re-sloping efforts in the future.

Kaiser's reclamation research group also conducts annual assessments of its former reclamation efforts in an attempt to monitor the development of the new plant communities.

Extensive native and agronomic species test plots have been established in the subalpine zone. These will be augmented in the upcoming season by new treatments, including woody species cuttings, root plantings and grass-plug trials.

A year-long study of the distribution, cycling and retention of plant nutrients has been initiated. This study should yield valuable information concerning future fertilization management as well as the stability of the reclamation plant communities.

INTRODUCTION

Thus far little is known about the reclamation of disturbed lands in the mountains of western Canada (Thirgood and Ziemkiewicz, 1976). This lack of information is evident throughout western North America's mountainous regions, particularly in alpine areas (Brown and Johnston, 1976). To remedy this situation and make reclamation efforts more effective, coal mining companies in British Columbia are required by law to conduct reclamation research programs.

Kaiser Resources Ltd., one of the province's major coal mines, has an active reclamation research program. Since it is in the very earliest stages of progress the research is conducted with immediate field application in mind. Consequently it's trying to answer the most basic questions concerning species selection, fertilization and re-sloping.

The dynamic nature of Kaiser's reclamation research program is the result of a strong commitment on the company's part to produce high-quality reclamation work. In fact, field-scale reclamation work has been practiced since 1969. Therefore, Kaiser's staff has a more than academic acquaintance with field reclamation problems. This kind of experience has served to organize and direct my research. Thus the problems highlighted in practice can be dealt with using techniques familiar to the agronomist and the plant ecologist.

The following studies at Kaiser's property are presented as examples of the kind of research that can result from industry and university cooperation.

DISCUSSION

In 1975 and 1976 a program of vegetation assessment by aerial biomass clipping has been carried out on nine representative reclaimed areas on

Table 1. Yearly production by species (kg/ha) on nine reclamation areas on Kaiser Resources property

Species	Year	'A' Lagoon	Michel Pile	Baldy Face	Erick-son	McGil vray	lower 'C'	'C" seam	'D' seam	Assembly pad
crested wheatgrass	1975	1	348	21	133	106	36	16	26	
	1976	11	208	18	120	169	133	31	112	
intermediate wheatgrass	1975		1	30	137	95	9	3	14	
	1976		1	24	210	134	7	1	24	
redtop	1975		14	21	4	3	9	2	13	
	1976		50		92		18	118	35	2
meadow foxtail	1975									
	1976									56
smooth brome	1975	30	19	119	30	36	39	34	61	4
	1976	300	146	122	32	48	165	16	206	30
orchardgrass	1975			5			229	128	164	20
	1976			2			372	374	659	588
red fescue	1975	10	5	55	19	90	7	19	38	1
	1976	57	8	55	14	193	44	71	284	198
perennial ryegrass	1975			2	124	469	403	231	501	89
	1976				6	4	24	87	470	118
timothy	1975	48	41	30	49	301				15
	1976		1	10	15	202	14	18	4	334
canada bluegrass	1975	19	146	4	28	206				
	1976		226	4	89	71				
kentucky bluegrass	1975									
	1976		110	2	38	1	2			3
alfalfa	1975	4		8	603	1090	1189	738	343	6
	1976	48	1	258	511	1202	1001	1456	1433	67
sweetclover	1975	10		19	41	4	5	16	7	2
	1976	72	341		311	149				
red clover	1975					1	504	209	113	
	1976						589	134	458	
white clover	1975			7	6		226	100	120	
	1976						41	56	517	10
total	1975	123	574	322	1172	2300	2657	1498	1401	136
total	1976	488	1102	524	1455	2160	2422	2358	4202	1406

Kaiser properties. The areas range from 1,158 m to 2,100 m elevation. Their areas range from 27 to 90 ha.

Sampling is conducted by clipping 1 m^2 plots along a permanent samplinggrid on each site. The clipping is done by species, the samples air-dried and weighed. The sampling is done in August of each year.

Table 1 represents the productivity of fifteen revegetation species on nine reclamation areas. The sites are ranked by elevation from 'A' Lagoon in the valley bottom at 1,150 m to the Assembly Pad at 2,100 m elevation. Perhaps the largest areas to be reclaimed in the future are above 2,000 m elevation, therefore the Assembly Pad is of particular interest for future seed mix selections. The table indicates that while many species are unsuccessful at the high elevations others merely develop slowly. For example, red fescue production increased by 200% from 1975 to 1976. Timothy, orchard grass, smooth brome and alfalfa also showed large increases over the year, while perennial ryegrass showed little change and dropped from first to fourth in production ranking. In the mid-elevation areas perennial ryegrass generally showed severe declines from 1975 levels. However, most other species remained steady or increased. Alfalfa, smooth brome and red fescue appeared to be the most consistent performers over the range of conditions represented by the sites.

Total site production levels were up in 1976 over the previous year. The most spectacular improvement was at the Assembly Pad where aerial biomass increased from 136 to 1,400 kg ha. The vegetation on 'A' Lagoon seems to be improving while Baldy Face's development is hindered by steep slopes and dry ravelling. The other sites appear to be quite healthy and are producing large amounts of high-quality forage for the deer and elk herds of the area. On Lower `C' and `D' Seams evidence of heavy grazing of the newly-established plant communities was observed in 1975 and 1976. There were also many signs of deer bedding on Lower 'C' Seam.

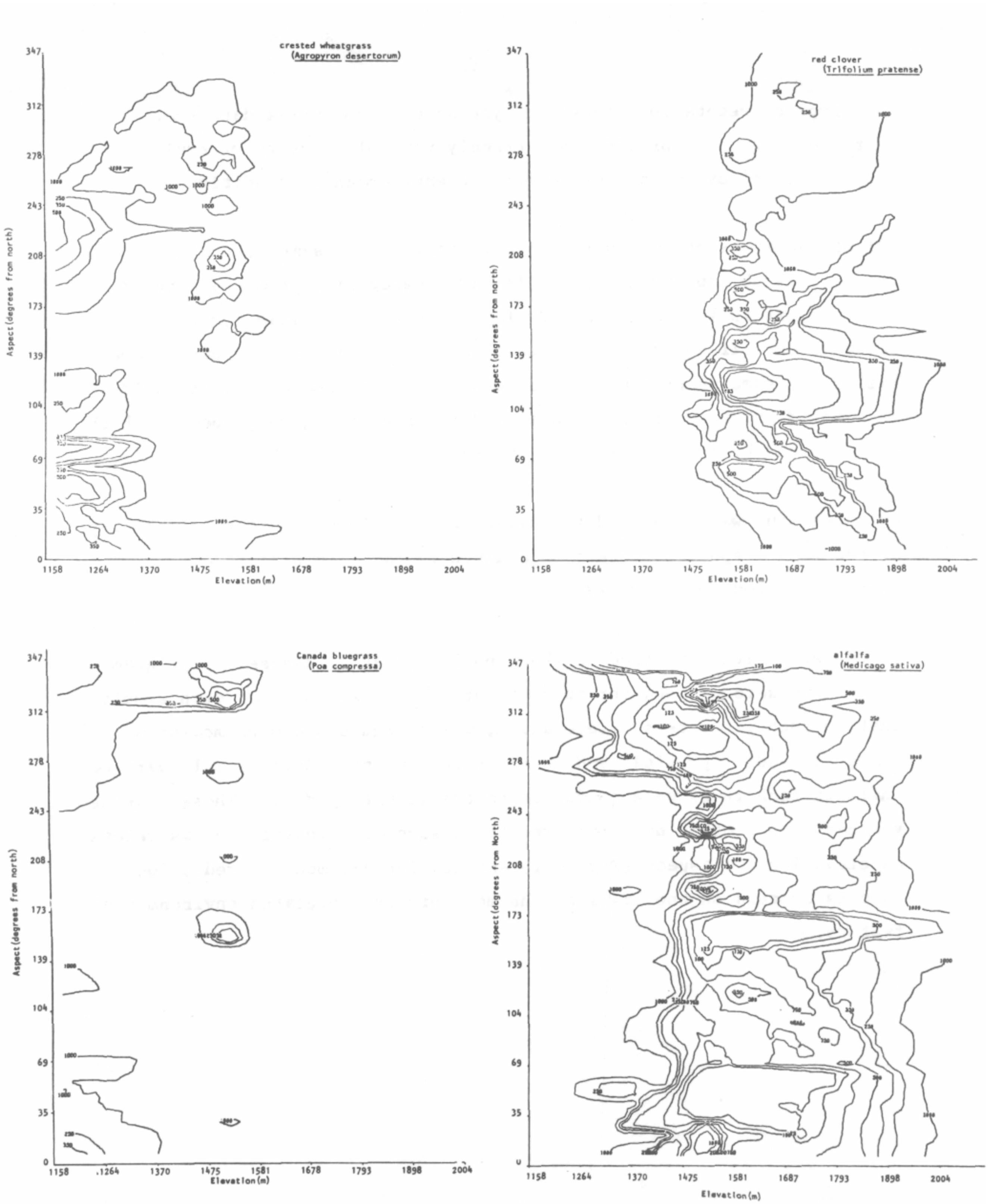
Figure 1 Aerial production of four reclamation species as functions of aspect and elevation. Aerial production is represented on the 'Z[1] axis as a series of contours.

Contour interval legend:

1000=100 kg ha^{-1}
250=250 kg ha^{-1}
350=350 kg ha^{-1}

100=1000 kg ha^{-1}

125=1250 kg ha^{-1}


crested wheatgrass
(Agropyron desertorum)
red clover
(Trifolium pratense)
Canada bluegrass
(Poa compressa)
alfalfa
(Medicago sativa)
Aspect (degrees from north)
Elevation (m)
347
312
278
243
208
173
139
104
69
35
0
1158
1264
1370
1475
1581
1678
1687
1793
1898
2004

This type of vegetation assessment yields non-subjective data that over the years will provide an extremely valuable library of reclamation species' dynamics under different environmental conditions.

All of the areas presented in Table 1 received the same seed mix. While it is obvious that the species are segregating from one site to the next, it is less obvious what factors are responsible for the segregation. If we could learn which environmental factors caused the failure of some species and the success of others these factors could be sampled prior to seeding and a seed mix containing only species which are favoured by the site factors ordered.

An experiment was conducted in August, 1975 to look into the possibility of predicting species success on a given reclamation site (See: Ziemkiewicz and Northway, 1976).

On the same sites examined in the annual vegetation assessment program, 1 m^2 plots were clipped for species aerial biomass while at each sampling station such parameters as elevation, aspect and slope were measured along with soil, physical and nutrient conditions. Several multivariate analysis techniques were conducted on the resulting data. These methods yielded both contour diagrams predicting species standing crop as related to elevation and aspect (Figure 1) and statistical models predicting species success on the basis of the most highly correlated environmental factors.

The elevation/aspect contour diagrams can be used to help design dumps and other disturbances to coincide with those elevations and aspects most likely to support lush revegetation plant communities. For example, if all other factors were equal, it would be foolish to design a dump with a long south-facing slope at 1,300 m elevation, rather than a north-west facing slope at the same elevation.

Since it would be impractical to order *a* different seed mix for each specific site, some generalizing must be done. Perhaps the most significant parameter in species success is elevation (Figures 1-4). It seems that the species sort out into two associations; one from 1,150 m to 1,650 m elevation and another above 1,650 m. The lower elevation seed mix then should be chosen from the following: crested wheatgrass, intermediate wheatgrass, smooth brome, Canada bluegrass and alfalfa. Those species showing the best performances at the upper levels are: alfalfa, smooth brome, orchardgrass, perennial ryegrass, white clover, red clover, timothy, meadow foxtail, red fescue, Kentucky bluegrass and redtop. These selections can be further refined by use of the statistical models in conjunction with the contour diagrams.

In 1972 and again in 1973 species test plots were established on Harmer Knob at an elevation of 2,200 m. These plots have been monitored annually as part of the research program. Although many species were initially sown in these sites, many have by now been virtually eliminated by the harsh environment. Those which have proved most successful thus far have been: red fescue, redtop, smooth brome, meadow foxtail, orchardgrass, timothy, Kentuch bluegrass and Canada bluegrass. Four native species have invaded the plot areas: spike tristetum, slender wheatgrass, fireweed and rough hairgrass.

There has been much discussion among reclamation workers concerning the relative merits of native and agronomic (or introduced) species. The complexity of the problem defies simple generaliztions. Agronomic species have been used for decades in range rehabilitation work in the western U.S. These species have frequently produced stable plant communities capable of supporting large livestock herds. However, agronomic species have often proved unsuccessful in subalpine or alpine areas (Berg, 1974).

Experience at Kaiser's property indicates that some agronomic species perform well at least in the short term, in subalpine conditions. We also know which native species are capable of colonizing the raw, untreated spoils of Harmer Knob.

Entry into native seed production would require considerable capital out-lays either in large-scale seed collection or in a seed increase program. At best one could contract with an established seed grower and expect to pay four to five times the price of agronomic seed. However, if the vigor of the native species is such that maintenance expenses such as repeated fertilizings, and reseeding are unnecessary, then the initial added expenses may be more than justified.

However, the available data on high-level reclamation allows us to make only hypotheses, not decisions that if incorrect could cost hundreds of thousands of dollars needlessly spent. So, to test the hypothesis that native species are more vigorous than agronomics at high elevations on Kaiser property, we first had to collect and clean sufficient seed for testing purposes. This involved locating large populations of the desired species, harvesting, threshing and storing the seed.

Consequently another set of test plots was established at the Harmer II dump area (elevation 2,050 m) in September, 1976. These plots will compare the performance of 17 agronomic species and varieties with 10 native species. Both native and agronomic treatments include grasses and legumes. Each species is duplicated within plots and the plots are duplicated over both south-west and west facing slopes. This was done to see if the southerly slopes are in fact a harsher environment, and if the different environment affects species performance.

These plots will be expanded next season by the addition of a spring planting and with various vegetative and plug planting trials.

It is important to remember that while many of the agronomic species seem to peform well now, four years after seeding, the same may not be true in ten or twenty years.

This finally brings us to the question of stability. For a plant community to be stable it must be able to reproduce itself indefinitely or allow for beneficial community compositional changes. At any rate, biomass production rates should remain at reasonable levels. For this to occur the plant community must be able to capture and recycle enough energy and nutrients to maintain production without artificial inputs.

Currently, Kaiser's reclamation areas receive annual fertilization treatments. This is a costly procedure, however, since there is no hard evidence as to the consequences of discontinuance; the program is maintained as a precaution.

If fertilization was stopped on a test area and aerial growth compared on both fertilized and unfertilized plots it might take years to notice a difference and this approach would tell us little about the fate of plant nutrients in each community. In a plant community, nutrients are stored in the roots, litter and soil as well as in the shoot. In fact, for some nutrients, the shoots contain only a small proportion of the system's total. Also, nutrients can be tied up in unavailable form in the litter and soil, so exchange rates are also critical.

In order to find out where these nutrients reside in the reclaimed areas, a project was initiated in August, 1976 that, over a year, will examine the amounts and rates of transfer for the major nutrients. This study was replicated over both montane (1,650 m elevation) and subalpine (2,100 m elevation) sites representing Krajina's interior Douglas fir and subalpine fir, Engleman spruce zones respectively. This project, which will look at the effects of fertilization vs. non-fertilization on shoot, root, litter and soil nutrient levels, involves an intensive sampling and chemical analysis program and will be completed in October, 1977.

Projects to begin in 1977 will be a study suggested by Robert Gardner, looking at relative rates of nitrogen and phosphorus fertilization and amended to examine the relative value of one heavy application vs. small annual additions of fertilizer. The research group should be able to initiate an experiment using municipal sewage sludge as a slow-release fertilizer and soil-building material. Also, we'll try to initiate a slope angle/mulch hydroseeding study in which slope angles of 22° through 36° will receive various mulch and no mulch treatments applied via hydro-seeder. This will give us some idea of the effectiveness of mulch at high elevations and allow some statement on what slope angles can support the revegetation plant communities.

CONCLUSIONS

Reclamation workers in British Columbia are often in the uncomfortable position of trying to decide 1) if an area is reclaimable; 2) if not, what must be done to make it so; and 3) in terms of cost/benefit what is the most efficient method of reclamation. The questions are complicated by the variety of sites that must be dealt with. The individual charged with making these decisions often has no organization or body of literature to turn to that can help in answering the questions pertaining to his particular site.

Reclamation researchers in British Columbia are just beginning the process of assembling such literature. Perhaps more importantly, a series of techniques is being developed which can provide the kind of data that will enable the reclamationist to make his decisions with greater confidence and, hopefully, avoid costly trial and error.

Mindful of the benefits, Kaiser Resources Ltd. has been conducting an intensive reclamation research program since 1975. Although many of its component projects are long term, some experiments have already been completed. As a result, methods are now available for predicting the success of thirteen commonly-used revegetation species on Kaiser's disturbed areas. We also know at what elevations and aspects to expect the greatest success with current reclamation practices. This may be a helpful input in designing dumps and resloping efforts in the future.

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