RECLAMATION RESEARCH METHODS ON COAL MINE WASTES

WITH PARTICULAR REFERENCE TO SPECIES EVALUATION AND ASSESSMENT

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Summary and Conclusions

The question of what species to plant on devastated lands is of critical importance to the success or failure of a reclamation program. This paper outlines some methods that may enable the reclamation officer to make that decision with greater confidence.

The forage production data of thirteen revegetation species on nine disturbed areas treated by Kaiser Resources' Environmental Services Department were presented. These were compared with forage production data of various natural communities floristically similar to those adjacent to the disturbed areas. Since these lands are classified as big game winter range, forage production seems a reasonable criterion for assessing reclamation success. Methods for estimating forage production were discussed.

This is an interim report, therefore many of the study's objectives remain unattained: can species' performance be predicted by measuring the site factors prior to planting? If so, can a valid prediction model be formed for each species? In addition to these questions many more demand study. To what extent are our nutrient inputs being recycled by the plant community? If significant internal cycling is taking place then further fertilization is unnecessary. On the other hand, we do not know whether the agronomic species currently in use can survive without intensive resource inputs. It may be more economical in the long run to plant native species at the start of the revegetation program. If our reclamation programs are to become more efficient, these questions should be answered.

In conclusion, future reclamation efforts, particularly in high-altitude areas of British Columbia, will depend on the availability of species capable of colonizing the harshest of sites with a minimum of maintenance. Native, as well as introduced species should be tested under rigorous conditions and certified on the basis of their durability.

Introduction and Review of Literature

When confronted with a new piece of devastated land the reclamation officer must assess the site conditions and prepare a list of the species for planting. Brink (1974) suggests the following considerations in basing the initial stages of revegetation on herbaceous or woody species:

1) rapidity and ease of establishment to provide rooting and canopy to reduce erosion of soil,

2) economy,

3) availability of plant materials,

4) fire control (exclusion of annual weeds),

5) possibility of secondary harvest for domestic and/or native ungulates, and

6) to provide pioneer cover for the establishment of shrubs and trees.

If the decision is for herbaceous vegetation, then which species should be used?

Greater knowledge of revegetation species' tolerances to environmental stresses will help us make more efficient species lists in the future. Two pathways of research may lead us to this end:

1) evaluation of previously treated revegetation areas, and

2) establishment of species trial plots.

Each procedure has its advantages and disadvantages. This paper will discuss both procedures and examine the current work being done in evaluating species performance on Kaiser's properties in the East Kootenays. In evaluating previously treated revegetation areas it is possible to examine the long-term responses of the species to a wide range of physical variables.

In areas where mine reclamation has been practiced and observed for long periods of time it has been possible to qualitatively assess the fitness of many species to the likely range of critical environmental factors. Miles, et.al. (1973) and Medvick (1973) have done so for Pennsylvania and Indiana, respectively, with observations spanning several decades. Unfortunately, in general, Canada lacks a long history of reclamation efforts. Therefore, in attempting to assess the factors responsible for species performance on coal reclamation sites in the East Kootenays of British Columbia, it is necessary to quantify performance, i.e., in terms of aerial production as well as the physical variables; slope, elevation, aspect, soil chemical status, etc.

Quantification of the environmental parameters and their correlation to species vigor is a complex procedure. In addition, the history of such areas is often poorly understood and uncontrolled factors such as wild ungulate grazing, fires and non-normality of factor distribution may contribute to error. Establishment of species trial plots permits us to examine independently the responses of many species to a variety of treatments such as fertilizer and mulch. Although the degree of control over variables is greater, the range of variation is often limited, i.e., it would be very difficult to reproduce the effects of four 300-meter elevation levels within a one-hectare trial plot. Obviously, four trial plots and a four-fold resource expenditure would be required. Also, firm conclusions regarding the fitness of species could only be obtained after many years to ensure that the species will either endure or enable native species to become established.

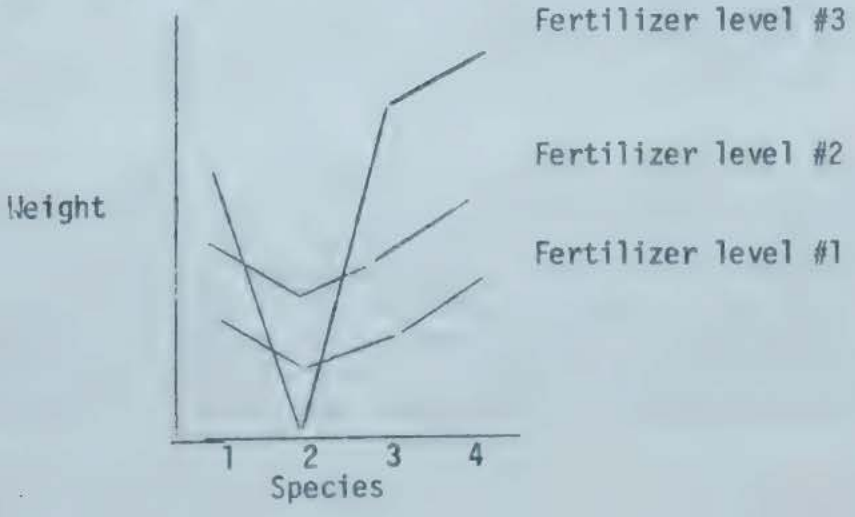
The trial plot method is widely used in mine reclamation (Farmer, et.al., 1974) and most agronomic research. By isolating effects this method enables the researcher to study them, independently and as interactions with other effects. For example, if we wish to study four species and three fertilizer levels, we can set up the following trial plot design:

	Species			
Fertilizer levels	1	2	3	4
1	11	12	13	14
2	21	22	23	24
3	31	32	33	34

Randomization might yield the following treatment combinations:

12	22	21	34
31	33	14	24
32	23	13	11

This pattern is then repeated in perhaps four replications, and might produce the following results:



It would then be obvious that species #2 cannot tolerate fertilizer level #3. Results are then subjected to analysis of variance (Ostle, 1963) to test for significance.

It seems that the evaluation of previously treated areas will yield quick, widely applicable but general information, while the trial plot method will provide long-term, narrowly applicable but rigorous results.

Methods

Evaluation of previously treated areas on Kaiser property in the East Kootenays, British Columbia

Reclamation research in British Columbia, with conditions unique among Canadian provinces, is in the early stages of development. Two important biological questions remain unanswered. What is the ecological amplitude of each of the revegetation species? And, what is the best method of sampling the vegetation?

The purpose of this study is to identify and perhaps define the physical factors influencing growth of thirteen revegetation species on former coal mine sites. If the proposed procedure proves successful, it could provide a technique for species selection in future revegetation efforts.

Nine revegetation sites on Kaiser Resources' properties near Sparwood, B.C. were chosen for this study. Each site had been seeded two and three years ago with a very broad seed mix. On each site aerial biomass data was collected in August, 1975 by sampling at 46 m. intervals on a two-dimensional grid on each area. At each of the resulting 189 sampling stations a labelled stake was driven, and at five points or, in very heavy vegetation, two points about this stake a $1m.^2$ frame was dropped and the enclosed aerial growth clipped by species. The labelled sample bags were then air dried and weighed. At the central point of each station the soil colour, per cent rockiness, elevation, slope and aspect were recorded and a 12 cm. deep soil sample taken. The soil sample was analyzed for pH, organic matter, cation exchange capacity, NO^-_3, K, Ca, Mg, S and particle size distribution.

These physical parameters will serve as the independent variables in a regression analysis (Ostle, 1963) while species dry weights will be the dependent variables. If valid correlations are found between the subsequent statistical models and the species' standing crop, then not only could species vigor be predicted on a given site but its ecological amplitude would be suggested.

The limitations of regression analysis must be remembered. Resultant correlations do not necessarily imply cause and effect relationships. Also, the information gained from the analysis is of a descriptive nature. Thus, whatever correlations do appear should be tested under controlled conditions to learn the specific nature of the species response, if any, to the limiting factors suggested by the regression analysis. If correlations are obtained, the regression equation could be used as a guide to preparation of a seed mix for specific revegetation areas upon measurement of the suggested limiting factors.

Results and Discussion

Unfortunately the soil nutrient analyses haven't been completed at the time of this writing so, of course, there are no regression models to present. However, the aerial biomass data is complete (Table 1). Although all thirteen species were sown on all of the disturbed sites there is a strong segregation of species with sites. The regression analyses will, hopefully, explain the parameters along which this segregation occurred.

More germane to this discussion is evaluation of the revegetation efforts and species performance on a qualitative basis. Have these lands indeed been reclaimed? The Canada Land Inventory lists the disturbed areas studied as prime big bame winter range. From this perspective we might consider the reclamation efforts in terms of their depletion or enhancement of the winter ranges' forage production.

Since we presently have no forage production figures for the undisturbed lands adjacent to the reclaimed areas, we must rely on studies conducted on floristically similar areas. These are summarized in Table 2. Comparison with reclaimed areas suggests which areas are "reclaimed" and those which need further work. Since the initial seeding, all of the areas have been fertilized with about 225 $kg.ha.^{-1}$ of an N, P, K mixture annually. We do not know whether the current vegetation can be maintained without annual fertilization. Therefore, not until we know more about the stability of the revegetation communities can we assert that the reclamation areas are, in fact, "reclaimed".

Methods of sampling vegetation.

This is one of the thornier problems facing the reclamationist. Care must be taken not only to employ sound statistical design but also to measure the vegetation in a meaningful way. The method of measurement employed, of course, depends on the objectives of the study. If forage production data is desired then direct clipping and weighing the plants' annual production yields the most reliable estimate. However, this can be very time consuming and, if the vegetation on small trial plots is to be assessed, prohibitively self-destructive. Farmer, et.al.(1974) successfully used the Neal Capacitance Meter, Model 18-1000 (Neal and Neal, 1973) to measure the aerial production on their trial plots at the Decker coal mine in southeastern Montana. This instrument greatly reduces both time and labour, though clipping of every sixth sample is necessary for calibration.

Table 1

AERIAL PRODUCTION AS OF LATE JULY/EARLY AUGUST, 1975

OF THIRTEEN REVEGETATION SPECIES ON EIGHT RECLAMATION AREAS.

Area Elevation(m) Aspect	Michel Pile 1,176 E. to N.	Baldy 1,413 S. W.	Erickson 1,610 South	McGilvary 1,610 North	Lower C 1,674 S. W.	C seam 1,771 West	D seam 1,868 West	Assembly Pad 2,190 0-West
Agropyron desertorum	347.9	21.2	133.4	106.2	36.4	16.3	26.0	0
Agropyron intermedium	0.5	29.8	137.0	95.1	9.4	3.4	14.4	0.1
Agrostis alba	14.3	21.4	4.3	2.7	9.4	2.3	12.9	0
Bromus inermis	18.8	118.8	30.1	36.4	38.7	33.7	61.3	3.9
Dactylis glomerata	0.4	5.1	0.4	0	228.9	127.7	164.3	19.7
Festuca rubra	4.9	55.4	19.4	89.9	7.4	18.9	37.7	0.6
Lolium perenne	0	2.3	124.3	469.1	402.9	230.8	501.3	88.6
Phleum pratense	41.3	29.9	49.3	300.8	0	0.4	0.1	15.1
Poa compressa	145.7	3.5	28.3	205.5	0	0	0	0
Medicago sativa	0.1	8.2	602.9	1,090.2	1,189.5	738.5	343.2	6.3
Melilotus officinalis	0	19.1	40.9	4.3	5.0	16.4	7.2	1.7
Trifolium pratense	0	0.5	0	0.6	504.4	209.5	112.6	0
Trifolium repens	0	7.0	6.4	0	226.4	99.6	119.5	0.3
Totals	573.9	322.2	1,176.7	2,392.8	2,658.4	1,497.5	1,400.5	136.3

Table 2

FORAGE PRODUCTION DATA OF SOME RANGE TYPES FLORISTICALLY SIMILAR TO THOSE FOUND ADJACENT TO THE EIGHT RECLAMATION AREAS. 1/

Range type	Aerial Production (kg ha $^{-1}$)	Source	Reclamation area	Aerial production (kg ha $^{-1}$)
Mixed prairie (Manyberries, Alta.	623	Smoliak, 1965	Michel Pile	573.9
Lodgepole Pine - Pinegrass (near Kamloops, B.C.)	561	Freyman and Van Ryswyk, 1969	Baldy	322.2
			Erickson	1,176.7
			McGilvary	2,392.8
			Lower C	2,658.4
			C seam	1,497.5
			D seam	1,400.5
Mountain grassland (S.W.aspect, Montana)	813	Mueggler, 1972	Assembly Pad	136.3

1/ The data are presented only to aid in interpretation of the reclamation area production data and do not necessarily represent the true forage production on the adjacent undisturbed areas.

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Proceedings of the Inaugural Meeting Canadian Land Reclamation Association

DECEMBER 1975

Crop Science Department
Ontario Agricultural College
University Of Guelph
uelph, Ontario, Canada
March 1976

FORMERLY
PROCEEDINGS OF
THE ONTARIO COVER CROP COMMITTEE

PROCEEDINGS OF THE INAUGURAL MEETING
OF THE
CANADIAN LAND RECLAMATION ASSOCIATION

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