Proceedings of the 6th Annual British Columbia Mine Reclamation Symposium in Vernon, BC, 1982.
The Technical and Research Committee on Reclamation

REVEGETATION TRIALS AT SUKUNKA COAL MINE

Paper Presented
by

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ABSTRACT

Revegetation trials were established in 1979 on BP Canada's Sukunka Coal property in the Northeast Coal Block. The trials were designed to test the effects of four levels of fertilizer application on alpine revegetation and to determine the optimum fertilizer treatments for revegetation of subalpine disturbances. The use of native species grown from locally collected seed was also tested in both alpine and subalpine environments. Field assessments were undertaken in August 1980 and 1981. In the alpine the greatest first year response to fertilization was on xeric sites. Heavy first year growth resulted in excessive mulching retarding second year emergence. In the subalpine heavy fertilization resulted in reduced legume establishment, thus, reducing second year cover. Establishment of native species in the alpine was very poor while there was a good establishment in the subalpine. Further assessments are planned as part of BP Canada's ongoing reclamation research program.

INTRODUCTION

BP Canada Inc. holds coal licences known as the Sukunka Coal Property in the Northeast Coal Block. This property has potential for production of coal by underground mining. Programs to evaluate the feasibility of mining these reserves have included several major exploration programs. A network of roads to access drill sites and trenching sites has been developed. Pilot scale mining has been undertaken for bulk sampling and to determine the characteristics of the host rock. These activities have created surface disturbances in the area.

In the summer of 1979 a series of revegetation and fertilizer test plots were established on the Sukunka Coal Property. The objectives of these plots were:

1. to test the effects of various levels of fertilizer application on natural revegetation of exploration disturbances in an alpine setting;

2. to test the use of locally collected native seed for reclamation of alpine sites; and

3. to test the growth and maintenance of both native and agronomic species and the effects of various fertilizer regimes in a subalpine setting similar to that anticipated for the proposed tailings structure.

This paper outlines the results of the 1979, 1980 and 1981 evaluations of test plot performance. Recommendations for the ultimate reclamation of disturbances in the area are made based on the information derived thus far. As this program of field testing has been designed to continue for another three years, these results and recommendations must be regarded as preliminary.

METHODOLOGY

ALPINE FERTILIZER AMD NATIVE SPECIES TRIALS

BP Canada Inc., Coal Division Environmental Group in cooperation with biologists from the B.C. Ministry of Energy, Mines and Petroleum Resources determined the experimental design and established plots on xeric (D), mesic (M) and hygric (W) sites in the alpine region of Bullmoose Mountain. Four test sites (replicates) were located in each of the xeric and mesic moisture regimes, and two in the hygric regime. Pour levels of fertilization, O (Control), 330 kg/ha, 660 kg/ha and 1320 kg/ha 17-17-17 fertilizer were broadcast in July 1979. The plots have received no further treatments.

Two native species seed test plots were located adjacent to each of the xeric and mesic fertilizer test plots, and one plot near the hygric plots. Seeding of these plots, with previously gathered native species seed, took place on September 13, 1979. Prior to seeding all vegetation was removed from the plots. Some species, however, have regenerated from root and rhizome systems.

SUBALPINE TAILINGS DYKE TRIALS

Agronomic and native seed plots were established on waste materials thought to be representative of future tailings dyke materials. Treatments of no fertilizer (Control), 150 kg/ha, 300 kg/ha and 600 kg/ha fertilizer were applied. Each year, for up to four years, one less sub-plot will be fertilized to examine the effectiveness of one-year, two-year, three-year and four-year fertilization maintenance programs.

Agronomic species were broadcast seeded on September 1, 1979 with a mixture consisting (by weight) of Boreal Creeping Red Fescue *(Festuca rubra)* (40%), Climax Timothy *(Phleum pratense)* (20%), Red Top *(Agrostis alba)* (15%) and Alsike Clover *(Trifolum hybridum)* (25%). Native species were collected by vacuum cleaner from areas close to the site and broadcast seeded on separate plots at the same time as the agronomics. Additionally, native seed plots were planted with six hardwood cuttings taken from species growing near the study site.

DATA COLLECTION ~ ALPINE FERTILIZER TRIALS

The alpine fertilizer trial sites were visited in the fall of 1979 and the late summer of 1980 and 1981. Visual estimates of individual species cover, total plant cover, height and vigour were recorded. Photographic records were made.

DATA COLLECTION - TAILINGS DYKE TRIALS

The tailings dyke site was visited at the same time as the Alpine site visits. Photographic records were made. Total cover and cover of individual species was estimated for both agronomic and native seed plots. One-quarter metre square (0.0625 m^) plots were clipped, air-dried and weighed to determine above-ground biomass of the agronomic species.

RESULTS AND DISCUSSION

ALPINE FERTILIZER TRIALS

The mean total percent vegetation cover under four fertilizer treatments at the three moisture regime sites for the three years since treatment is shown in Figure 1. On the mesic sites, adjacent plots, MA/MB and MC/MD are treated separately. Results from the three moisture regimes are presented in the following sections.

Xeric Sites

Percent cover on the xeric sites is illustrated in Figure 2. The application of fertilizer in 1979 produced a significant increase in vegetation cover in 1980. Most of the cover was made up by agronomic species. The greatest percent increase in cover was achieved at the

Figure 1.

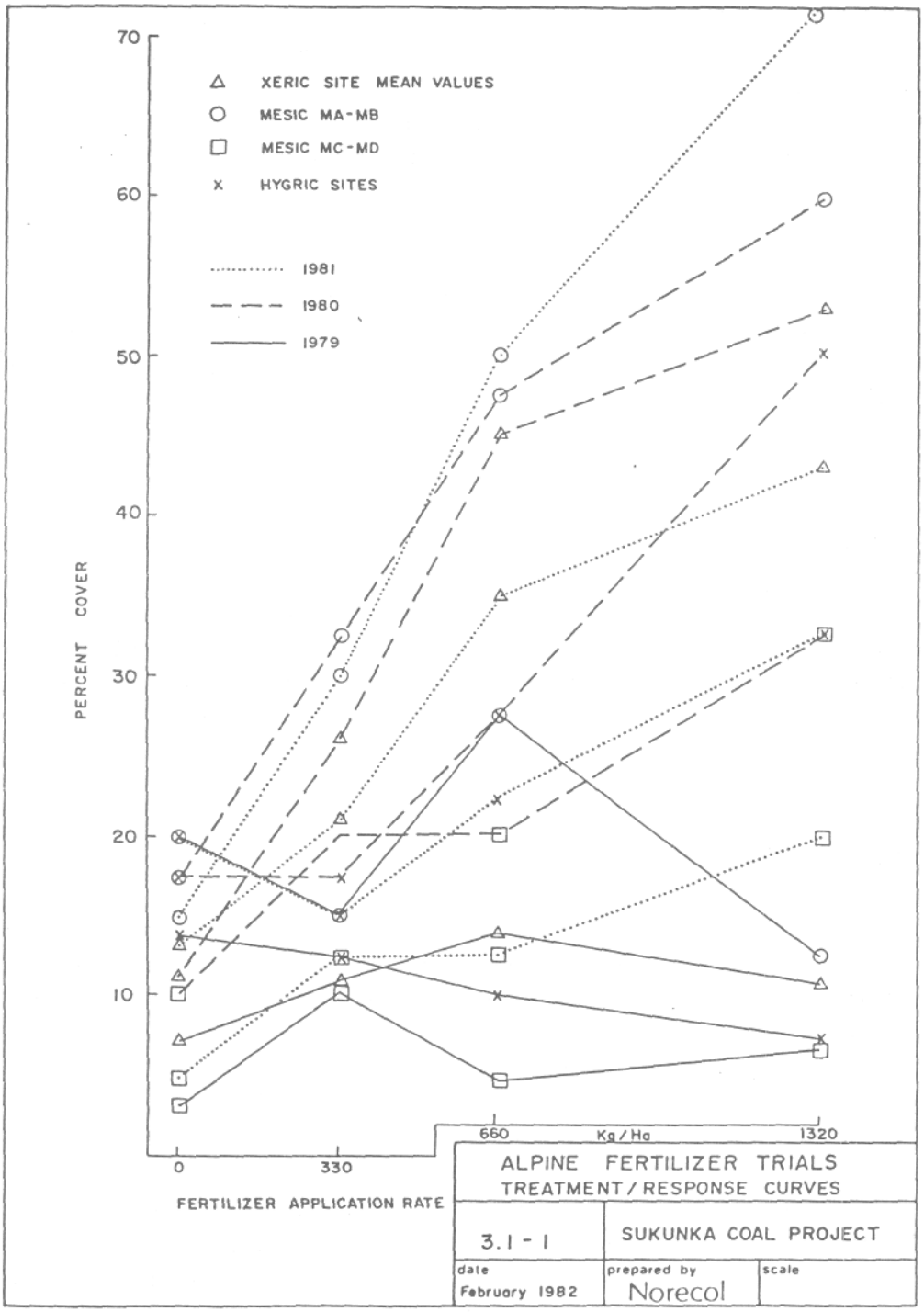
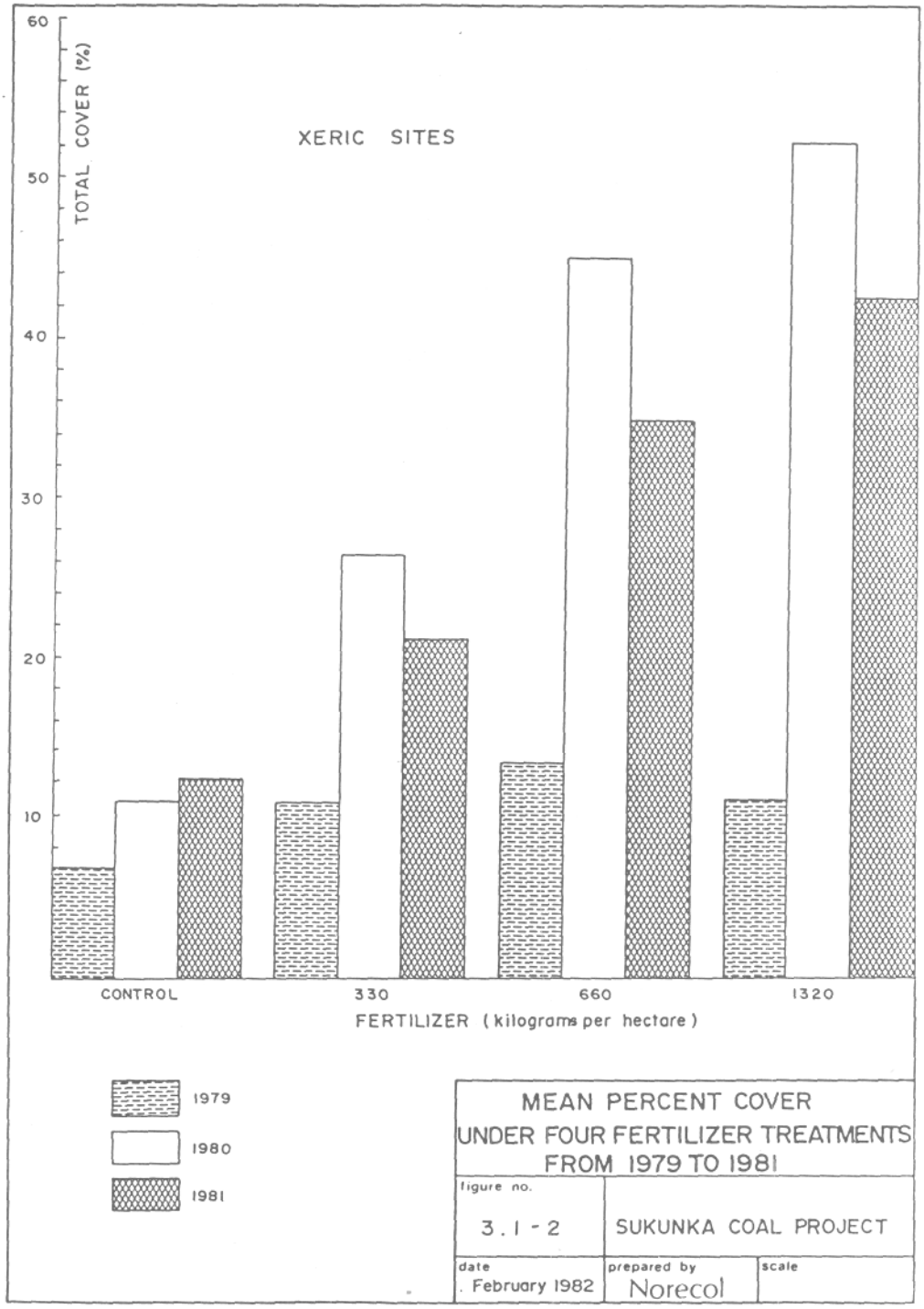

70
60
50
40
30
20
10
PERCENT COVER
XERIC SITE MEAN VALUES
MESIC MA-MB
MESIC MC-MD
HYGRIC SITES
1981
1980
1979
0
330
660
Kg/Ha
1320
FERTILIZER APPLICATION RATE
ALPINE FERTILIZER TRIALS
TREATMENT/RESPONSE CURVES
3.1-1
SUKUNKA COAL PROJECT
date
February 1982
prepared by
Norecol
scale

Figure 2.


60
50
40
30
20
10
TOTAL COVER (%)
XERIC SITES
CONTROL
330
660
1320
FERTILIZER (kilograms per hectare)
1979
1980
1981
MEAN PERCENT COVER
UNDER FOUR FERTILIZER TREATMENTS
FROM 1979 TO 1981
figure no.
3.1-2
SUKUNKA COAL PROJECT
date
February 1982
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scale

330 kg/ha level of fertilization, with response dropping off at the higher applications, indicating a saturation of the fertilizer responses at the higher levels. It is expected that growth limiting factors such as moisture stress and cold temperatures may replace nutrients as the main growth limiting factor. Large amounts of above ground biomass were produced in all of the fertilized plots relative to either the unfertilized control or the adjacent native vegetation.

Vegetation cover on the fertilized plots dropped in 1981 from the 1980 levels. This drop in cover is thought to be due to the excessive mulching caused by the 1980 plant matter. Nutrients may *be* bound up in this mulch which, due to the dryness of the sites, did not break down. In addition, the heavy mulching may have insulated the soil, preventing warming in the spring and hence retarding growth. Compared to 1980 the cover of all major species decreased except for the two native grasses, Alpine Bluegrass *(Poa alpina)* and Broad-Glumed Wheatgrass *(Agropyron violaceum).* Species diversity was greater in the lower fertilizer rates than the higher rates.

The optimum rate of fertilization appears to be the 660 kg/ha rate. Doubling the fertilizer rate to 1320 kg/ha resulted in a 17% increase in cover in 1980 while doubling the 330 kg/ha application to 660 kg/ha resulted in a 73% increase in cover. Similar trends were noted in 1981.

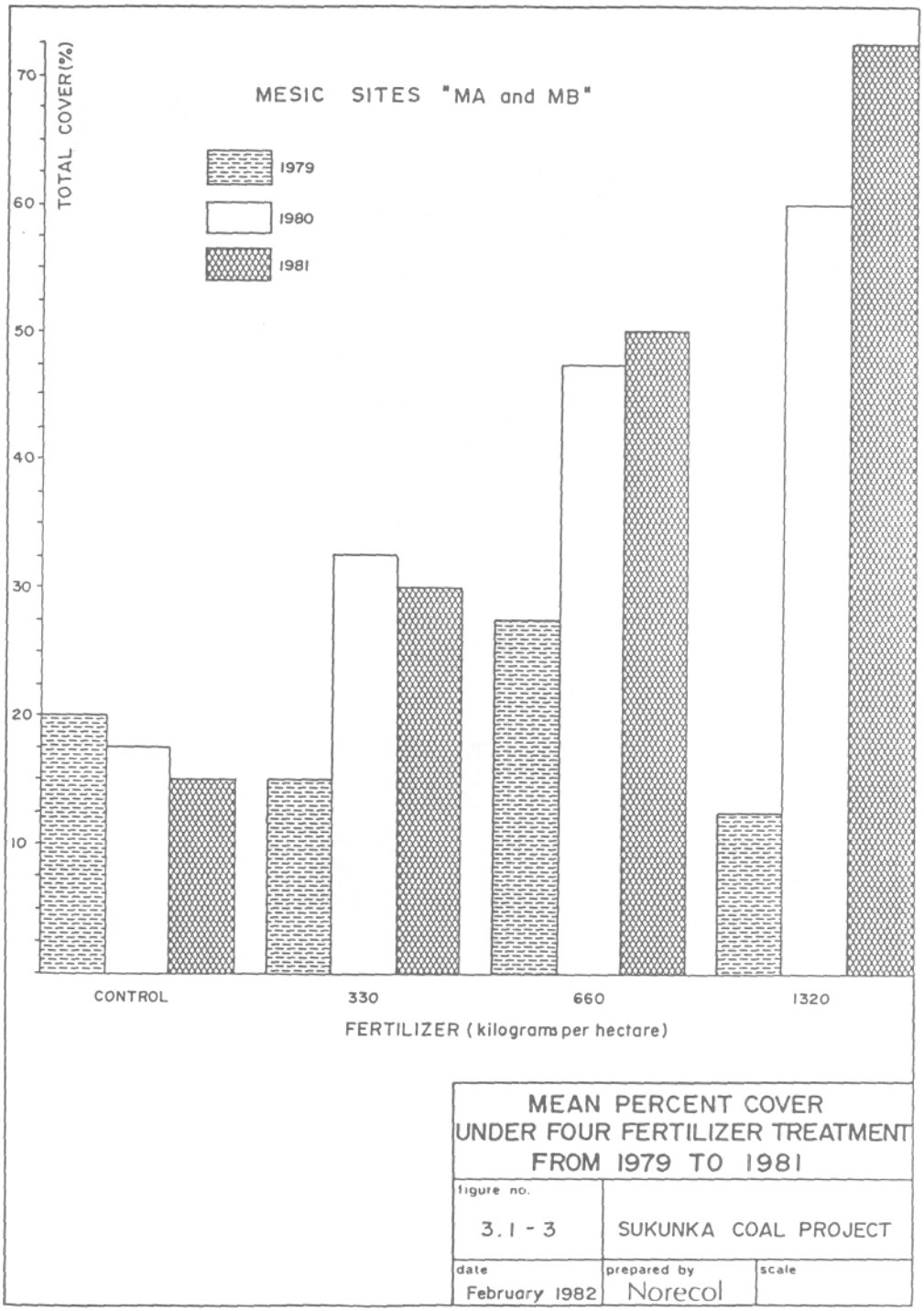
Native vegetation cover in the xeric sites area averages from 20% to 50% depending on specific site condition. It is not realistic to expect that reclaimed cover will be maintainable at greater cover without continual fertilizer maintenance.

Mesic Sites

In 1980 there were significant differences in growth response among non-adjacent plot replicates on the mesic plots. For this reason the results obtained from the two sets of adjacent plots (MA/MB and MC/MD) are presented separately. Figures 3 and 4 show the mean vegetation cover on plots MA/MB and MC/MD respectively for the last three years.

Fertilization resulted in an increase in cover on the MA/MB plots in 1980 and 1981. Unlike the xeric plots, there was a further increase in cover in 1981 at the higher fertilizer application rates, while there was a slight decrease in cover on the control and 330 kg/ha plots. It

Figure 3.


TOTAL COVER (%)
70
60
50
40
30
20
10
MESIC SITES "MA and MB"
1979
1980
1981
CONTROL
330
660
1320
FERTILIZER (kilograms per hectare)
MEAN PERCENT COVER
UNDER FOUR FERTILIZER TREATMENT
FROM 1979 TO 1981
figure no.
3.1 - 3
SUKUNKA COAL PROJECT
date
February 1982
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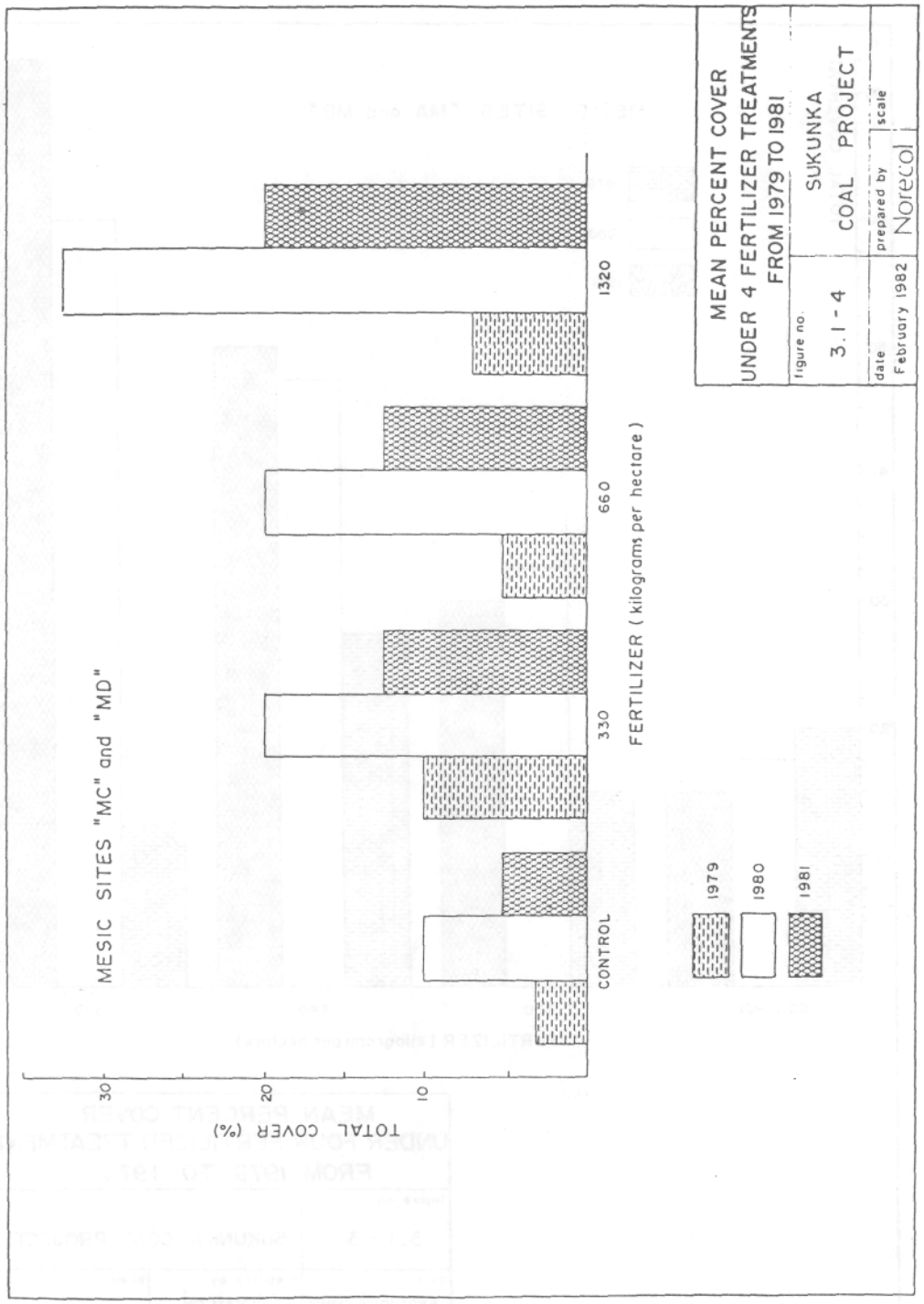

MEAN PERCENT COVER
UNDER 4 FERTILIZER TREATMENTS
FROM 1979 TO 1981
figure no. 3.1-4
SUKUNKA
COAL PROJECT
date February 1982
prepared by Norecol
scale
MESIC SITES "MC" and "MD"
TOTAL COVER (%)
30
20
10
CONTROL
330
660
1320
FERTILIZER (kilograms per hectare)
1979
1980
1981

Figure 4.

is thought that the nutrients held in the dead material may be more available to the new growth on the mesic sites due to an increase in the amount of nutrients being cycled on these sites.

Vegetation cover on the MC/MD plots was about half of that on the MA/MB plots. The MC/MD plot area is subjected to late spring snow cover which may result in a leaching of nutrients or reduced growing season and hence a reduction in cover. There has been a drop in cover on the MC/MD plots from the 1980 levels. As in the other sites agronomic species showed the greatest response to fertilization.

Hygric Sites

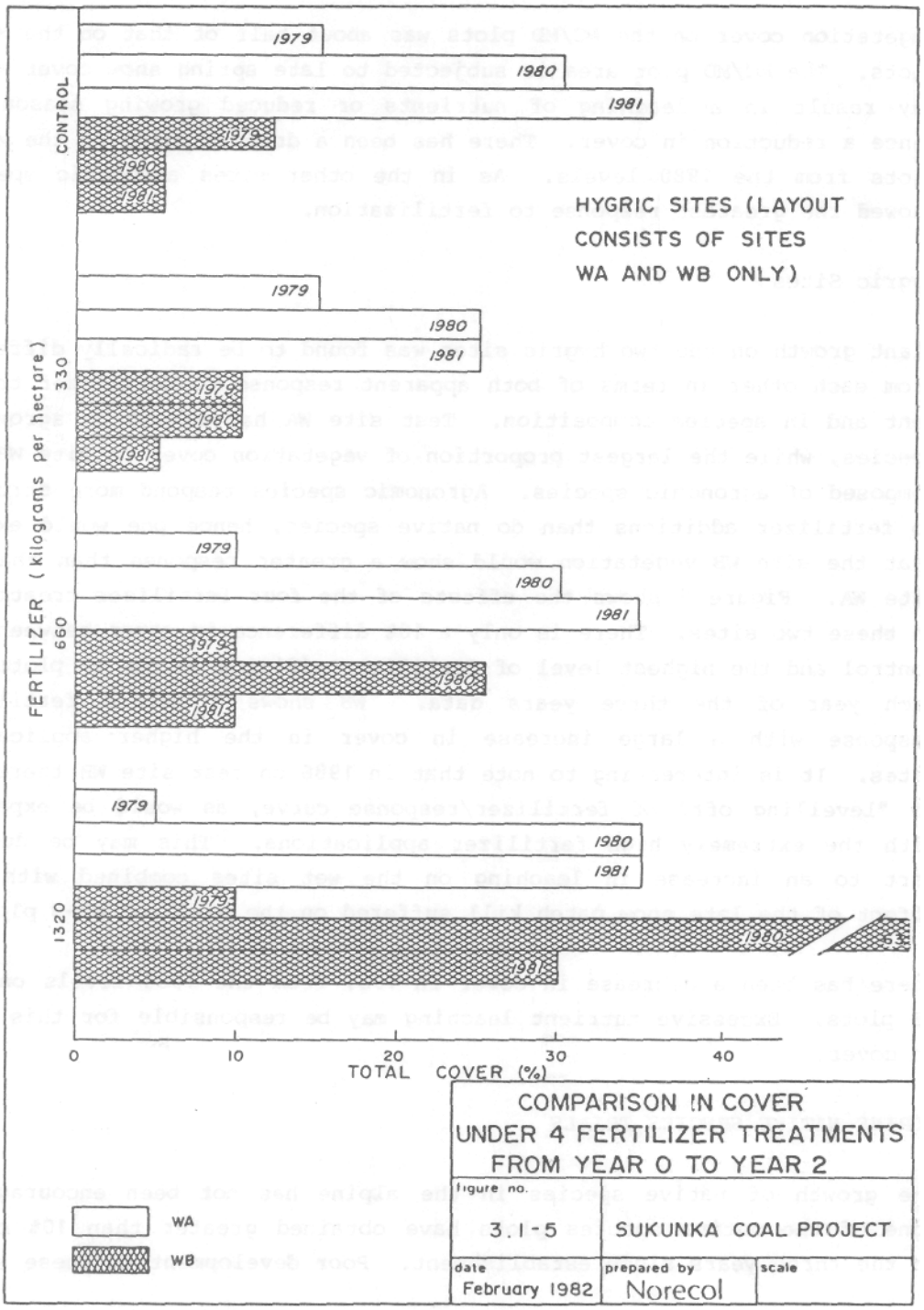
Plant growth on the two hygric sites was found to be radically different from each other in terms of both apparent response to fertilizer treatment and in species composition. Test site WA had almost no agronomic species, while the largest proportion of vegetation cover on site WB was composed of agronomic species. Agronomic species respond more strongly to fertilizer additions than do native species, hence one would expect that the site WB vegetation would show a greater response than that of site WA. Figure 5 shows the effects of the four fertilizer treatments on these two sites. There is only a 10% difference in cover between the control and the highest level of fertilizer addition on the WA plots for each year of the three years data. WB shows a marked fertilizer response with a large increase in cover in the higher application rates. It is interesting to note that in 1980 on test site WB there was no "levelling off" of fertilizer/response curve, as would be expected with the extremely high fertilizer applications. This may be due in part to an increase in leaching on the wet sites combined with the effect of the late snow patch kill suffered on the WB-2 and WB-3 plots.

There has been a decrease in cover in 1981 from the 1980 levels on the WB plots. Excessive nutrient leaching may be responsible for this drop in cover.

ALPINE NATIVE SPECIES TRIALS

The growth of native species in the alpine has not been encouraging. None of the native species plots have obtained *greater* than 10% cover in the three years since establishment. Poor development on these sites

Figure 5.


CONTROL
1979
1980
1981
1979
1980
1981
HYGRIC SITES (LAYOUT CONSISTS OF SITES WA AND WB ONLY)
FERTILIZER (kilograms per hectare)
330
1979
1980
1981
1979
1980
1981
660
1979
1980
1981
1979
1980
1981
1320
1979
1980
1981
0
10
20
30
40
TOTAL COVER (%)
WA
WB
COMPARISON IN COVER UNDER 4 FERTILIZER TREATMENTS FROM YEAR 0 TO YEAR 2
figure no.
3.1-5
SUKUNKA COAL PROJECT
date
February 1982
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Norecol
scale

may be due to poor initial establishment caused by low germination rates and possible loss of seed. Some species such as Stalked-Pod Locoweed *(Oxytropis podocarpa),* Alpine Hedysarum *(Hedysarum alpinum)* and Reed Polar Grass *(Arctagrostis latifolia)* may warrant further assessments as these species appear to be successfully invading the plots.

SUBALPINE TAILINGS DYKE REVEGETATION TRIALS

Agronomic Species Trials

Results of the agronomic species trials are presented in Table 1. Figure 6 shows the above ground biomass for the control and fertilized plots in 1980 and 1981. The fertilized plots established in 1979 have been refertilized in 1980 following the 1980 assessment, and 1981 after the 1981 assessment. The application of 150 kg/ha of fertilizer yielded the greatest percent increase in cover, both in 1980 and 1981. Doubling the fertilizer rate resulted in increases in the absolute cover however, the percent increases were considerably less than the application of 150 kg/ha.

The Year 1 plots have received no fertilizer since the initial fertilization in 1979. Results for Year 1 are shown in Figure 7. Biomass yields generally increased in the first year (1980) for the fertilized plots. In 1981 the highest biomass was found in the control (unfertilized) plot and decreased as the fertilizer application rate increased. This decrease can be attributed to the mulching effect caused by the 1980 growth and by the decrease in clover cover (Table 1). Figure 8 shows the percent clover cover and above ground biomass for the Year 1 plots in 1981.

Fertilization increases the cover and above ground biomass of the agronomic species tested except for alsike clover where only at the lowest level of fertilization were increases noted. Higher rates of fertilization and repeated fertilizer application stimulate the shoot growth for graminoid species, however, clover growth is retarded. In order to achieve an erosion suppressing cover rapidly, and to provide continued cover under minimal maintenance, the application of 150 kg/ha of fertilizer at the time of seeding only is suggested.

Table 1. Tailings dyke plots - agronomic species trials.

Agronomic Species	FERTILIZER Plot 1 (control)					Plot 2 (150 kg/ha)					Plot 3 (300 kg/ha)					Plot 4 (600 kg/ha)				
1980 RESULTS	Year					Year					Year					Year				
	1	2	3	4	$\bar{x}$[1]	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$	1	2	3	4	$\bar{x}$
Total cover	50	45	35	35	41	70	75	50	60	64	60	80	75	75	73	85	90	80	90	86
Above ground biomass (g/m^2)	72	102	83	52	77	165	181	104	160	152	167	257	230	191	211	457	365	354	528	426
Height (cm)	6-8	5-8	5	5	-	10-20	10-15	5-8	10-15	-	10-15	10-15	10-20	15-20	-	15-30	50	60	20-35	-
Cover by species (%)																				
Agrostis alba	10	10ff	10f	10	10	10f	15f	10f	15	12.5	10f	15f	20f	15f	15	25f	20f	25f	20f	22.5
Festuca rubra	10	10	10	15	11.25	15	20	15	15	16.25	10	20	15	10	13.75	20	20	10	15	16.25
Phleum pratense	5	5	5	5	5	15f	5f	5	10	8.75	15f	10f	10f	10ff	11.25	15f	20f	25f	15f	18.75
Trifolium hyoridum	25	20	10	15	17.5	30f	35f	20ff	20	26.25	25ff	35f	30f	40f	32.5	25f	30f	20ff	40f	28.75
1981 RESULTS																				
Total cover (%)	80	65	40	35	47[2]	75	75	60	60	65	55	80	85	85	83	65	95	100	98	98
Above ground biomass (g/m^2)	421	432	226	141	305	338	645	266	312	390	267	498	542	542	462	254	639	888	646	607
Height (cm)	35	10-25	5-15	5-10	-	20-35	15-25	30-35	25-30	-	5-25	15-40	70-80	65-75	-	10-20	25-75	80-100	75-85	-
Cover by species (%)																				
Agrostis alba	20f[3]	10f	10ff	10ff	10	15f	15f	20f	20f	18.33	15ff	25ff	35f	35f	31.67	30f	35f	40f	35f	36.67
Festuca rubra	15ff[4]	15ff	15	15ff	15	15	10ff	10	30ff	16.67	10	25ff	25ff	30	26.67	15ff	30ff	35ff	35	33.33
Phleum pratense	5ff	5	5	2ff	4	5	5	5ff	3f	4.33	5	10ff	5f	10	8.33	5	10f	15f	20f	15.00
Trifloium hybridum	40f	35f	10f	8f	17.67	40f	45f	25f	7f	25.67	20f	20f	20f	10f	16.67	15ff	20f	10f	8f	12.67

1 Mean of all four years.
2 Mean of years 2, 3 and 4 only.
3 f = flowers
4 ff = few flowers

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Figure 6.

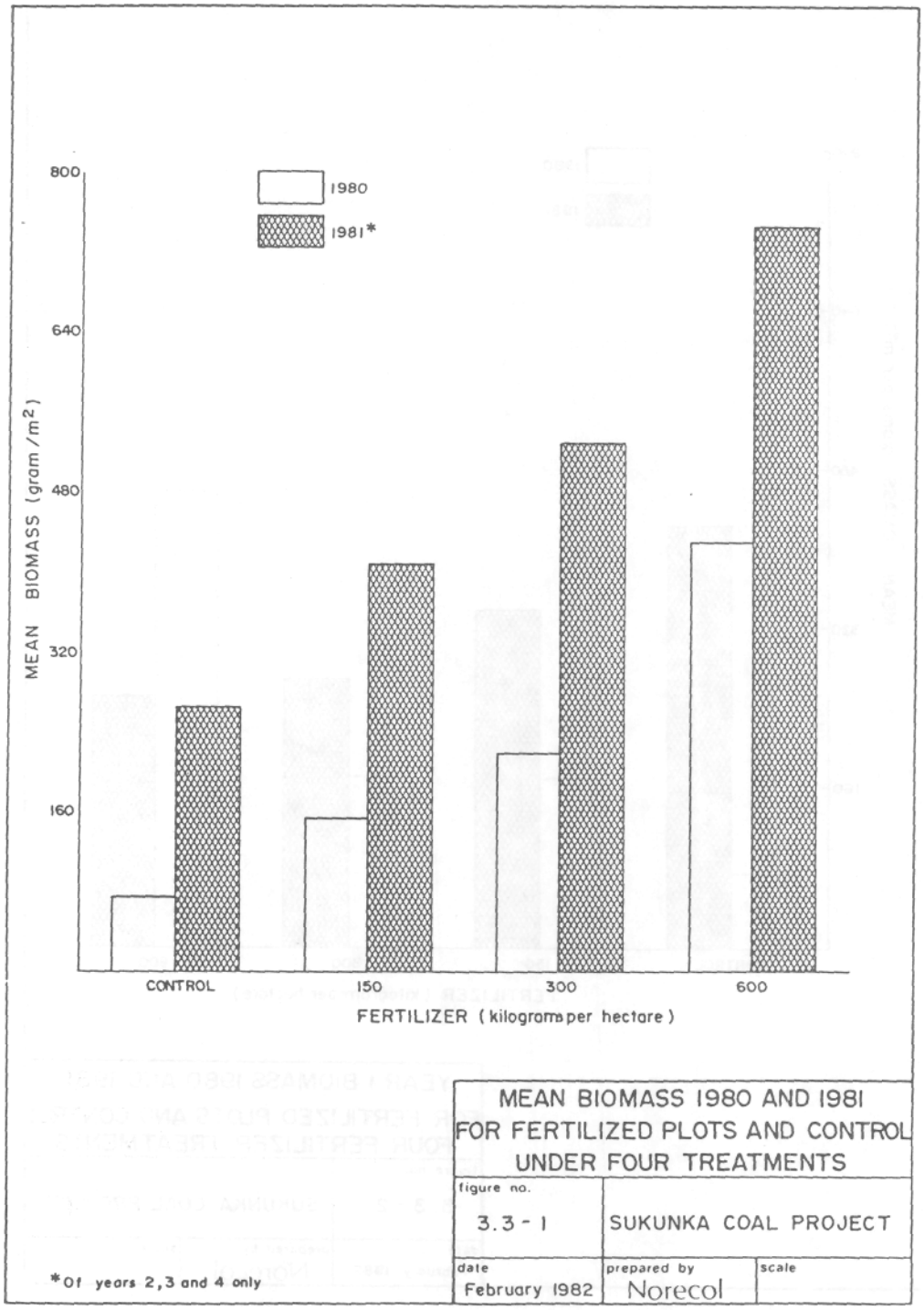
800
640
480
320
160
MEAN BIOMASS (gram/m2)
1980
1981*
CONTROL
150
300
600
FERTILIZER (kilogram per hectare)
*Of years 2,3 and 4 only
MEAN BIOMASS 1980 AND 1981
FOR FERTILIZED PLOTS AND CONTROL
UNDER FOUR TREATMENTS
figure no.
3.3 - 1
SUKUNKA COAL PROJECT
date
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Figure 7.

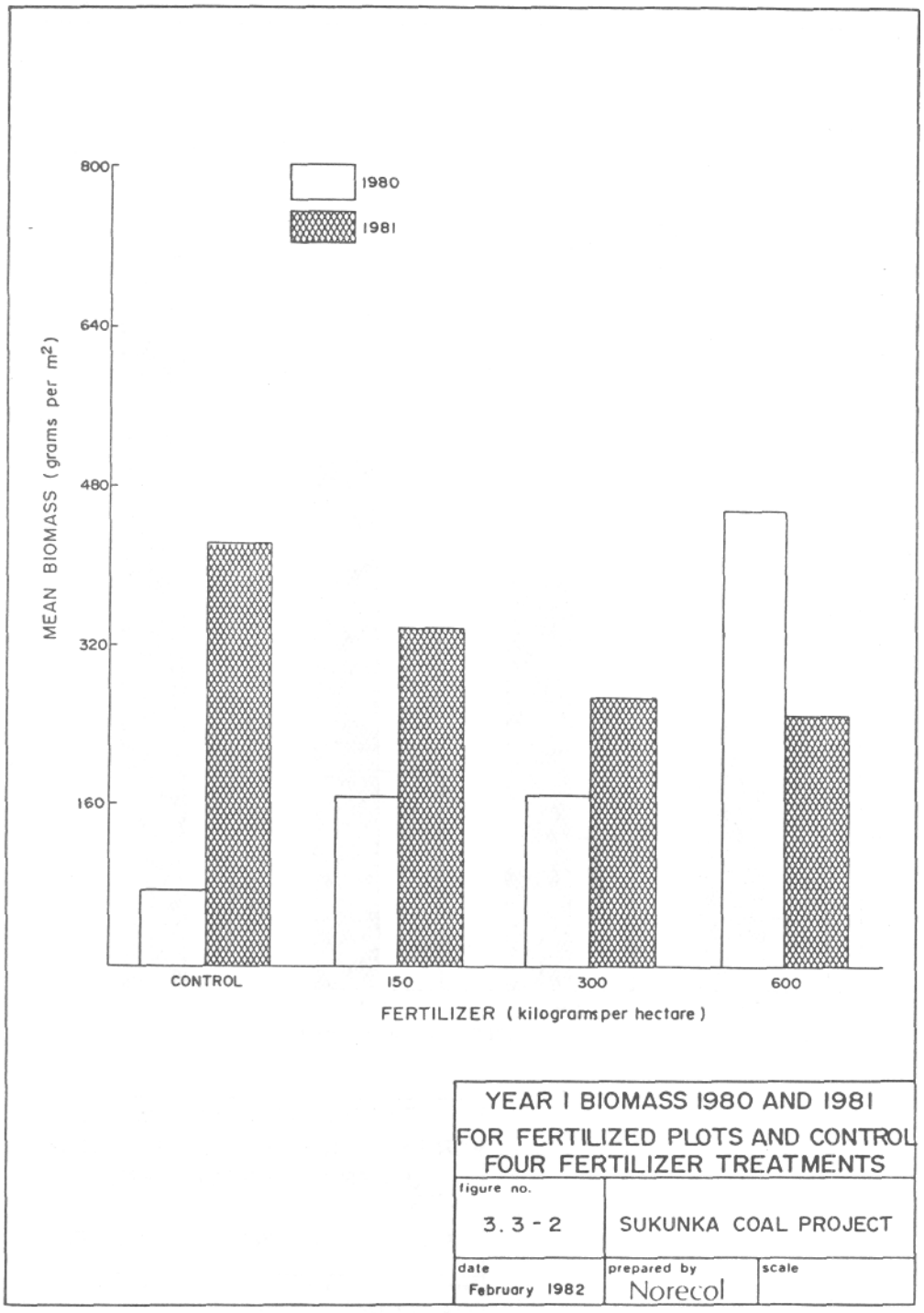
800
640
480
320
160
1980
1981
MEAN BIOMASS (grams per m2)
CONTROL
150
300
600
FERTILIZER (kilograms per hectare)
YEAR I BIOMASS 1980 AND 1981
FOR FERTILIZED PLOTS AND CONTROL
FOUR FERTILIZER TREATMENTS
figure no.
3.3-2
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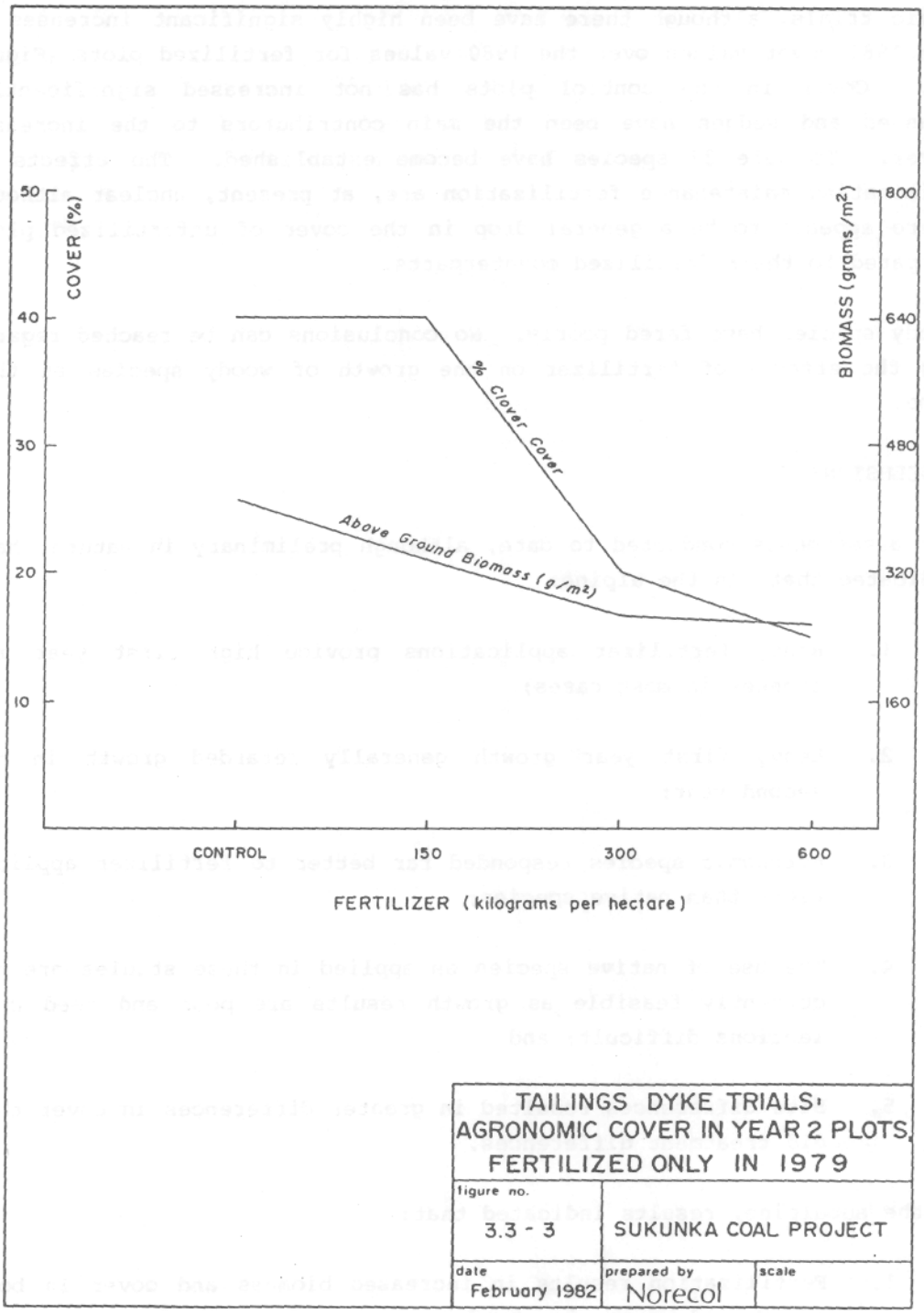
Figure 8.


COVER (%)
BIOMASS (grams/m²)
50
40
30
20
10
800
640
480
320
160
% Clover Cover
Above Ground Biomass (g/m²)
CONTROL
150
300
600
FERTILIZER (kilograms per hectare)
TAILINGS DYKE TRIALS
AGRONOMIC COVER IN YEAR 2 PLOTS.
FERTILIZED ONLY IN 1979
figure no.
3.3 - 3
SUKUNKA COAL PROJECT
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Native Species Trials

The native species trials have developed slowly compared to the agronomic trials, although there have been highly significant increases in the 1981 cover values over the 1980 values for fertilized plots (Figure 9). Cover in the control plots has not increased significantly. Grasses and sedges have been the main contributors to the increased cover. To date 37 species have become established. The effects of eliminating maintenance fertilization are, at present, unclear although there appears to be a general drop in the cover of unfertilized plots compared to their fertilized counterparts.

Woody species have fared poorly. No conclusions can be reached regarding the effects of fertilizer on the growth of woody species at this time.

CONCLUSIONS

The assessments conducted to date, although preliminary in nature, have indicated that, in the alpine:

1. Heavy fertilizer applications provide high first year responses in most cases;

2. Heavy first year growth generally retarded growth in the second year;

3. Agronomic species responded far better to fertilizer applications than native species;

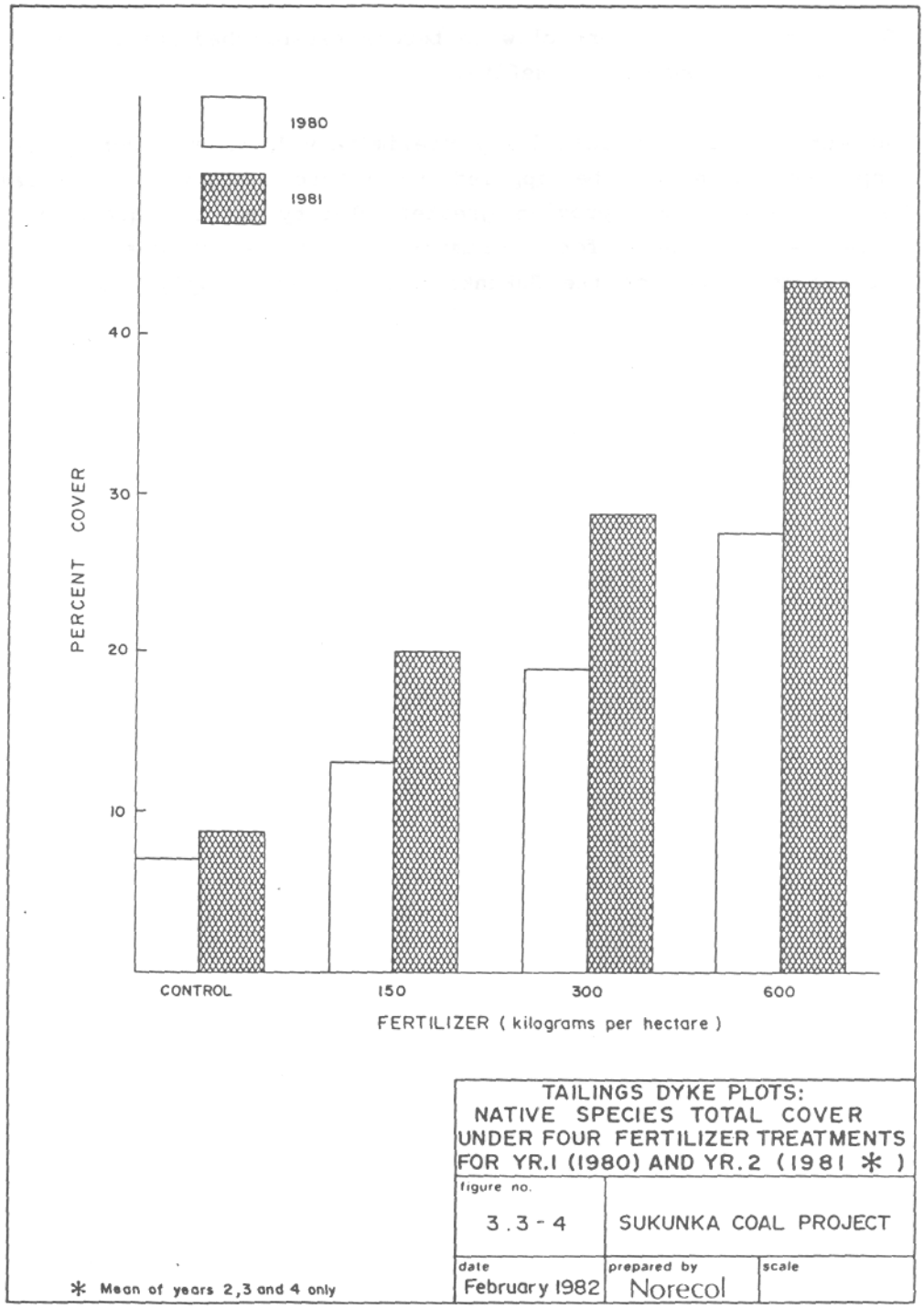
4. The use of native species as applied in these studies are not currently feasible as growth results are poor and seed collections difficult; and

5. Site differences resulted in greater differences in cover than did treatment differences.

In the subalpine, results indicated that:

1. Fertilization results in increased biomass and cover in both native and agronomic stands;

Figure 9.


1980
1981
PERCENT COVER
40
30
20
10
CONTROL
150
300
600
FERTILIZER (kilograms per hectare)
TAILINGS DYKE PLOTS:
NATIVE SPECIES TOTAL COVER
UNDER FOUR FERTILIZER TREATMENTS
FOR YR.1 (1980) AND YR.2 (1981 *)
figure no.
3.3-4
SUKUNKA COAL PROJECT
date
February 1982
prepared by
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scale
* Mean of years 2,3 and 4 only

2. Higher fertilizer application rates reduce the legume cover in agronomic stands resulting in reduced cover upon discontinuation of fertilizer applications; and

3. Native species are slow to become established but may provide greater long-term benefits.

The current results are relatively preliminary however general trends are apparent which may be applied to future reclamation programs. Further assessments may provide greater clarity on the questions of fertilizer effectiveness for reclamation. It is expected that the general trends noted for the Sukunka property will apply elsewhere in B.C.

ACKNOWLEDGEMENTS

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BP Exploration Canada Ltd., Calgary, who provided funding for the project.

B.C. Ministry of Energy, Mines and Petroleum Resources, particularly John Errington and Ted Hall who assisted in test plot design and seed collection.

Techman Engineering Ltd., Calgary, who, under contract to BP, conducted the 1980 and 1981 assessments.

Norecol Environmental Consultants Ltd., Vancouver, who provided drafting and word processing services for the preparation of this paper.

DISCUSSION RELATING TO DAVID POLSTER'S PAPER

Chandler: I was wondering why you chose that particular combination of fertilizer?

Answer: It was chosen as an all-around fertilizer. Basically, they wanted something that would work in most instances, so specific soil tests and assessment of fertilizer requirements for each site were not addressed. Looking at the broader picture was also in keeping with practices suggested for the area by the Ministry of Energy, Mines and Petroleum Resources.

Dr. Weijer, University of Alberta: (Distorted recording. The question related to the method of seed collection.)

Answer: I would fully agree with you that the manner of seed collection (vacuum cleaner) was an idea that might make collection easier. I'd add a few things to what you said. In addition to not knowing the germination rate or the species composition, because the seed was collected from what might be considered climax stands of alpine tundra, we are dealing with climax species rather than invaders. One would expect that the invading species which would not be as predominant in the climax stands, could do considerably better. In fact the arctic bluegrass and alpine bluegrass and one of the wheatgrasses did quite well on some of the sites which were out of our plot area, just invading naturally. So I agree completely that one must look at this in the context of the way in which it was set up. It was a good idea that didn't work out very well.

Harry Quesnel, Ministry of Environment: I was wondering if you were considering doing any further studies to determine the species which have grown on native plots.

Answer: Although I didn't present that data, we have a complete listing by species and cover all species growing on the various plots—those which have grown first year, second year, etc. We are planning to continue the study for another couple of years so that we will eventually have much more information than I have been able to present here. Of course the reports are on file with the Ministry and more information will be included in the proceedings.