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"FLY ASH REVEGETATION - A CASE HISTORY IN RECLAIMING EASTERN AND WESTERN FLY ASH"

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FLY ASH REVEGETATION - A CASE HISTORY IN RECLAIMING EASTERN AND WESTERN FLY ASH

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INTRODUCTION

Traditional fly ash disposal and reclamation techniques have called for the use of two-feet to four-feet of suitable cover material (soil) to ensure that adequate stands of vegetation could be established. Over the past 10 to 15 years, it has become increasingly evident that these larger volumes of cover material are expensive and may not be required to develop acceptable stands of vegetation in the reclamation process. Numerous studies and research efforts during this recent 10 to 15 year period have pointed to the fact that fly ash can be a "vegetable soup" of trace elements and chemical compounds, beneficial to plant growth and, accordingly, can play a significant role in its own reclamation process.

Gilbert/Commonwealth, working for a major midwestern utility, has recently completed a five-year program to study "minimal" revegetation techniques to reclaim eastern and western coal fly ash. The study was based on the premise that suitable stands of herbaceous and woody vegetation could be established on fly ash with only minimal applications of add mixtures, such as topsoil and sewage sludges. Based on the results of this revegetation program, it is apparent that the old standards of two-feet to four-feet of cover material may not be necessary to ensure acceptable revegetation of fly ash disposal areas.

BACKGROUND

The revegetation study presented in this paper stresses a minimal approach to fly ash reclamation. More specifically, only minimal applications of amending materials were utilized in this study and no exotic plant species, watering or reseeding techniques were utilized.

Various materials were studied for use in treating the ash without resorting to expensive two-foot to four-foot quantities of cover (soil) material. Based on research literature from previous studies and available "in field" materials, it was decided to test top dressings of topsoil and incinerated municipal sewage sludge. Both of these materials were locally available and both would suitably fit the criteria of minimal add mixture treatment techniques.

Irrigation or periodic watering at the outset or during the study was dismissed as being costly and yielding artificially stimulated data. Such irrigation practices would also be inconsistent with the program's intent of minimal treatments and, therefore, were not incorporated into the methodology.

Plant species selected for the revegetation program were those with a high probability of survival in drastically disturbed areas. These selected species all demonstrated a history of strong survival performance in documented reclamation efforts. Based on such survival criteria, the following grasses, legumes, and woody plants were chosen for the program:

Grasses:

Kentucky Bluegrass *(Poa pratensis)*
Kentucky 31 Tall Fescue *(Festuca arundinacea)*
Perennial Rye *(Lolium perenne)*
Orchard Grass *(Dactylis glomerata)*

Legumes:

- Alsike Clover *(Trifolium hybridum)*
- Birdsfoot Trefoil *(Lotus corniculatus)*
- Crownvetch *(Coronilla varia)*
- White Sweet Clover *(Melitotus alba)*
- Sericea Lespedeza *(Lespedeza cuneata)*

Woody Plants:

- Paper Birch *(Betula papyifera)*
- Green Ash *(Fraxinus lanceolata)*
- Austrian Pine *(Pinus nigra)*
- Washington Hawthorn *(Crataegus phaenopyrum)*
- Russian Olive *(Eleagnus angustifolia)*
- European Alder *(Alnus glutenosa)*

The configuration of the test plots to be used for the study was established on one acre of an existing fly ash disposal area. The area, approximately 150 feet by 300 feet, was excavated to a depth of 36 inches to 42 inches. One-half of this area was then refilled to original grade with eastern fly ash and the other half with western fly ash.

Twelve plots, each 25 feet by 50 feet, were established on the fly ash areas (six eastern and six western). These plots were further subdivided into eight subplots to accommodate the various seeding mixture and fertilizer combinations chosen for study. (See Figure 1.) The twelve plots were then topdressed with either topsoil or incinerated sewage sludge at the following rates:

Plot 1	-	No topdressing (control plot)
Plot 2	-	two-inch topsoil
Plot 3	-	six-inch topsoil
Plot 4	-	two-inch sludge
Plot 5	-	six-inch sludge
Plot 6	-	No treatment (woody species)

Add mixtures were tilled into the top 12 inches of both eastern and western plots with an agricultural rototiller. All plots were then leveled and cultipacked to establish an acceptable seedbed.

Each of the subplots within Plots 1 through 5 was seeded with mixtures A, B, C and A/C (see Table 1) and one-half of each subplot was fertilized with the other half remaining unfertilized. All plots were mulched with straw at the rate of two tons/acre and water sprayed (one time only) to reduce wind disturbance to the seedbed. An agricultural grade, 14-14-14, fertilizer was utilized for the first three years of the study program (once a growing season) to ensure the effects of fertilization could be measured against the unfertilized subplots.

Woody species, as previously identified, were planted in Plot 6 in both fly ash test areas. The plant materials installed were either balled and burlapped or container grown stock. The woody species plot was not treated with the soil/sludge add mixtures, nor was it fertilized, mulched or watered. However, prior to plant installation the plots were rototilled for ease in installing the material and to ensure that the fly ash was permeable for rainfall infiltration.

Once the test plots were in place, a systematic five-year study program was implemented to monitor the results of the revegetation efforts. Two primary parameters were selected to measure results: percent of vegetative cover and herbage production (plant growth).

Observations for vegetative cover were made on a weekly basis during initial germination and monthly thereafter for the first three years. The final two years of study observation were made once during the spring, mid-summer and late-summer growing seasons. The same observer was used for the entire five-year period to assure consistency in the percent cover estimates. The results of these observations were utilized to determine cover statistics for the five-year period.

Herbage production was accomplished every October for the entire five-year study period. Herbage production was determined by clipping random vegetation samples using a 12-inch by 24-inch quadrat within each subplot. The clipped foliage was separated by species, dried for 24 hours at 105^{O}C and weighed. The results were recorded and tabulated to provide the basis of herbage production results.

During the herbage production task each fall, subsurface samples of the growing medium were also tested for pH, conductivity (salinity) and trace elements, particularly Boron and Silenium. These tests were conducted to monitor chemical changes in the growing medium that resulted over the five-year study period.

RESULTS

Although extensive climatological/meteorological studies were not incorporated as part of the testing program, prior to presenting the program results, it should be noted that precipitation levels for the five-year period were approximately 15 percent to 20 percent below normal seasonal averages.

During the initial year of study, the add mixtures in both eastern and western ash test plots exhibited high levels of Boron, excessive salinity and variable pH values. After the first year, the Boron levels decreased from high early readings (11.7 PPM) to well below the toxic level (0.5 PPM to 1.5 PPM) in both eastern and western plots. No other trace elements tested yielded readings above the toxic level in any of the five yearly analyses.

In the first year, pH averaged 7.23 for eastern ash and 7.83 for western ash. After the five-year period, the average eastern plots pH rose to 8.20 and the average western plots increased to 8.60. (See Figure 2.)

Salinity during the period demonstrated a substantial drop for both the eastern and western plots. Initial year average study readings for eastern ash were 840 UMHOS/CM and 1247 UMHOS/CM for the western plots. After five years, these readings have dropped to 375 UMHOS/CM on the eastern plots and 215 UMHOS/CM for the western plots. (See Figure 3.)

Considering the listed factors (Boron, pH and salinity), the growing medium was considered to be adequate for vegetation growth during and at the end of the five-year program.

Throughout the five-year study, foliage cover and herbage production on the eastern ash test plots far outdistanced the western plots. (See Figure 4.) At the conclusion of the five-year program, foliage cover was estimated to average 70 percent for eastern ash and 43 percent for western ash. Accordingly, herbage production also exhibited a similar difference between the two test plots (17 grams/sq. ft. for eastern to 6 grams/sq. ft. for western).

Probably the most significant result of the study program was the comparison of vegetation on the untreated control plots (Plot 1) versus the amended plots (Plots 2 through 6). For the eastern amended plots, cover was 46 percent greater than the untreated control plot, while herbage production was 185 percent greater. On the western ash treated plots, the difference was even more dramatic. After five years, the control plot remained relatively barren while the amended plots (2 through 5) exhibited substantial stands of vegetation.

In comparing the effect of the two amending treatments, topsoil and sludge, a distinct difference resulted between the eastern and western test plots. On the eastern ash plots, the topsoil and the sludge treatments were very close in total percent cover throughout the five-year period, with the topsoil plots slightly higher than the sludge. On the western plots, a slightly different result occurred. During the first three years, the topsoil plots also out performed the sludge amended plots. However, during the last two years of study the sludge plots easily out performed the topsoil plots by at least 25 percent.

During the first two years of study, the six-inch treatment of both topsoil and sludge produced substantially more vegetation than the two-inch plots on both eastern and western test areas. However, after this initial period and throughout the remaining three years of study, very little difference was noted between the six-inch and two-inch applications of add mixtures.

Likewise, the effect of fertilizer was most pronounced during the first year. After this initial period, little difference was noted between the fertilized and unfertilized subplots. Accordingly, fertilization was dropped after the third year of study because of the limited difference between the fertilized and unfertilized areas.

For the most part, no significant difference was noted between the four seed mixtures utilized during the five-year program. (See Figure 5.) Although only slightly higher, mixture C produced the most cover on both the eastern and western plots and was the highest average cover for both test areas combined.

Individual species performance was also recorded during the five-year study period. On eastern ash test plots, Orchard Grass far out performed the other grasses and legumes, with Kentucky 31 Fescue and Birdsfoot Trefoil also producing good stands of vegetation. Kentucky Bluegrass was the best individual species on the western ash test plots, followed by Alsike Clover and Birdsfoot Trefoil. Of all the species tested, Crownvetch and Sericea Lespedeza performed most poorly; by the final year of study, neither of these two species was present in any of the test plots. This situation was most surprising in that both species have excellent past histories in adapting to adverse soil conditions.

Due to below normal precipitation conditions during the study period, substantial losses in the woody species occurred. Therefore, these losses have been attributed more to the climatic conditions than to the growing medium. Of the species planted, the Russian Olive and European Alder had the best success rates on both eastern and western ash test plots; whereas the Paper Birch failed in the shortest time period (within two years). Of all species tested the surviving Russian Olive trees most closely exhibited the normal growth characteristics expected of the trees studied under routine conditions. The surviving Alder and a few surviving Pines appeared stunted and lacking in new growth. Overall, the surviving eastern woody species appeared to be much superior, healthwise, when compared to the western woody plants. This difference was attributed to the greater rainfall infiltration potential of the eastern fly ash plot as compared to the western ash test area.

At the conclusion of the final year of study, random test pits were dug to examine root growth and patterns within both eastern and western test plots. This investigation revealed considerable differences between the two test areas. Root systems in the eastern ash were numerous and extended to a depth of 24 inches to 30 inches. No appreciable difference was noted between the control and amended (topsoil and sludge) plots. The western ash plots were drastically different in root development when compared to the eastern plots. The control plot, which was almost devoid of vegetation, experienced practically no root development at all. Examinations throughout the remaining amended western plots indicated that all root development remained in a mat-like layer near the surface, with little penetration below six inches. It should be noted that excavating the pits in the western ash plots was extremely difficult because of the cementing action of the western ash; below a depth of six inches to eight inches, the western ash was of a virtual "concrete" hardened condition.

CONCLUSIONS

Reiterating the intent of the study program as that of producing an acceptable stand of vegetation with a minimum amount of amending treatment, the results of this program must be viewed as most encouraging. However, it should also be stressed that this program was developed and conducted for a site-specific set of circumstances; and accordingly, these results should be viewed within that context.

Eastern fly ash, because of its physical and chemical characteristics, appears well-suited for the reclamation techniques described in this paper. Accordingly, through the results achieved during the study, few problems exist in reclaiming eastern fly ash with minimal amending techniques. From a cost and efficiency standpoint it appears to be most desirable to consider reclamation programs using the principles illustrated in this paper.

The results from the western ash plots are not as straightforward as those from the eastern ash test plots. From a positive standpoint, acceptable herbaceous vegetation can be established utilizing minimal amending techniques. The two inches to six inches of add mixtures adequately established growing mediums capable of producing stands of vegetation equivalent to those produced on the eastern ash. However, because of the extreme hardening associated with the western ash, the survival of woody species is questionable.

Without contradicting an earlier remark about generalizing from site-specific situations, it does seem reasonable, in light of these results, that utilities and other coal users might consider breaking away from the traditional amounts of cover applications to explore the benefits and applicability of more "minimal" reclamation efforts. It also seems appropriate that regulatory agencies, particularly at the state level, re-examine reclamation requirements to ensure that the stated quantities of cover material are reasonable and not unnecessarily burdensome. Hopefully, the lessons learned and information gained from this study will enable the state-of-the-art in fly ash reclamation to consider one more possibility--that of minimal revegetation techniques.

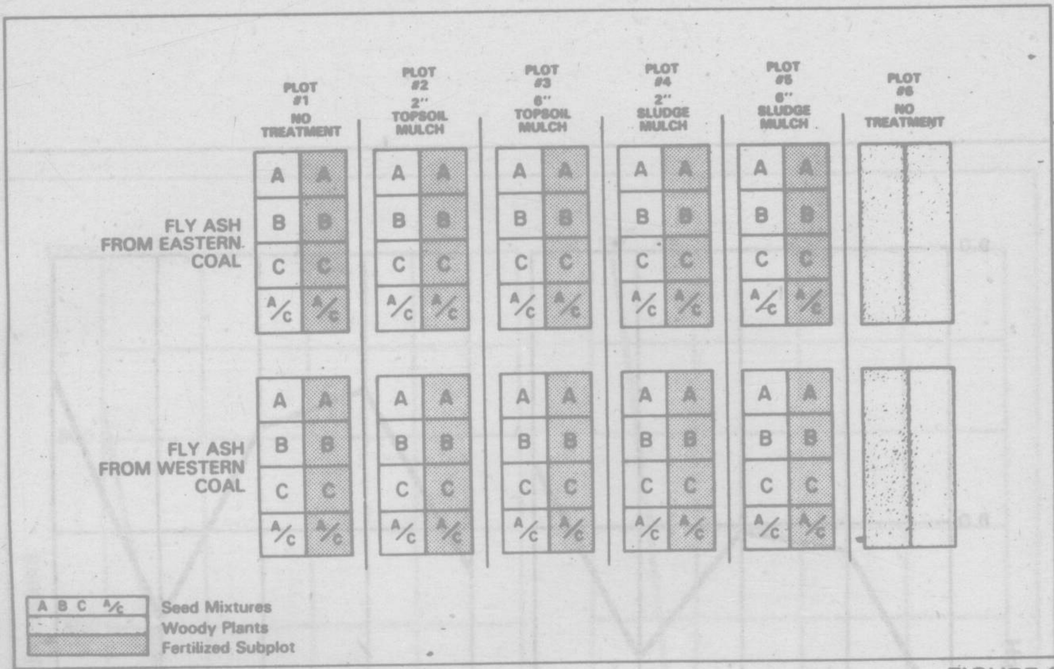

FIGURE 1
PLOT ORGANIZATION

MIX	SPECIES		APPLICATION RATE (Pounds/Acre)
A	Kentucky 31 Fescue	Festuca arundinacea	32
	Perennial Rye	Lolium perenne	80
	Kentucky Bluegrass	Poa pratensis	32
	Alsike Clover	Trifolium hybridum	15
B	White Sweet Clover	Melilotus alba	5
	Orchard Grass	Dactylis glomerata	23
	Sericea Lespedeza	Lespedeza cuneata	7
C	Crownvetch	Coronilla varia	23
	Birdsfoot Trefoil	Lotus corniculatus	3
A/C	Kentucky 31 Fescue	Festuca arundinacea	20
	Crownvetch	Coronilla varia	10
	Birdsfoot Trefoil	Lotus corniculatus	2
	Perennial Rye	Lolium perenne	48
	Kentucky Bluegrass	Poa pratensis	20
	Alsike Clover	Trifolium hybridum	10

TABLE 1
SEEDING MIXTURE AND APPLICATION RATES

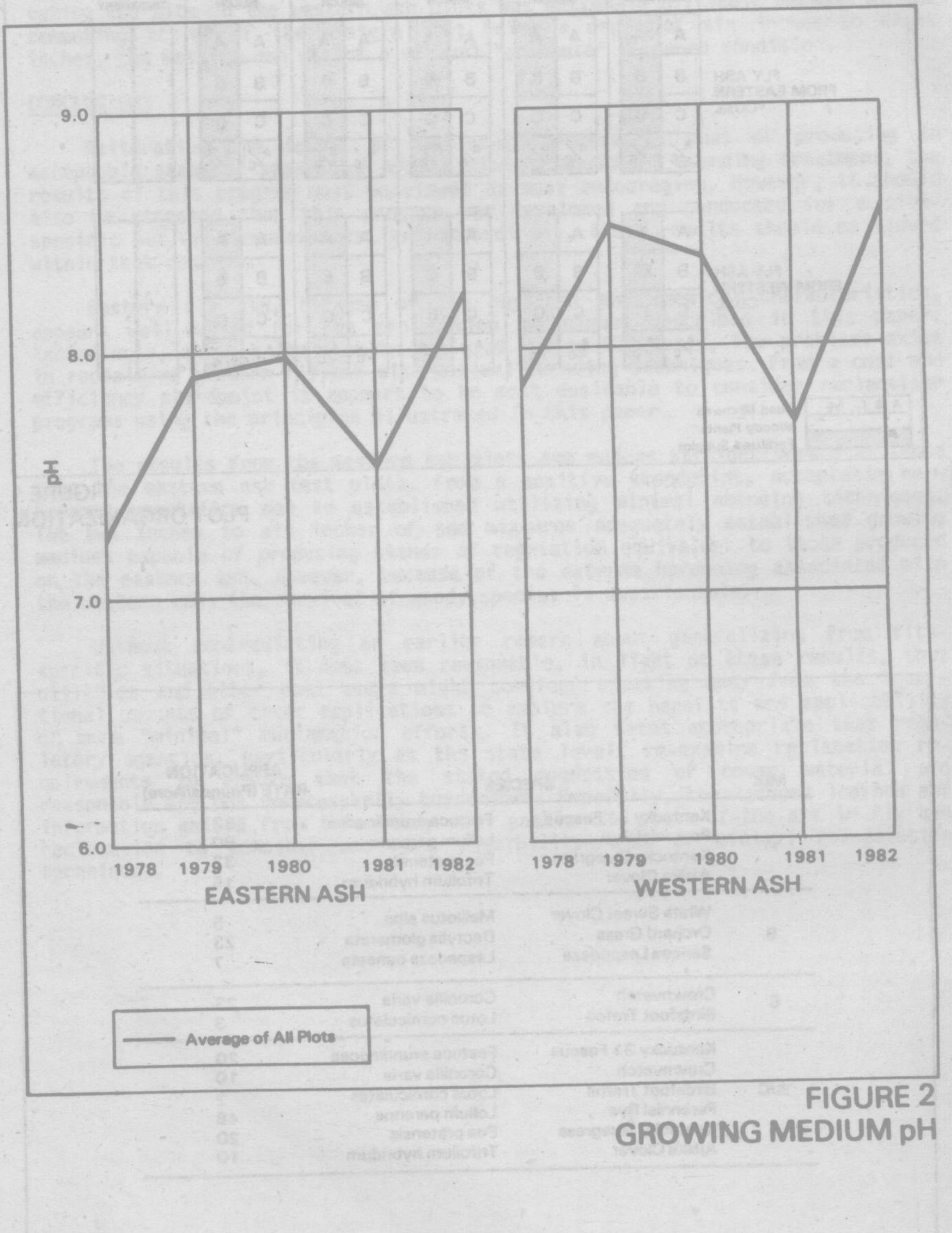

FIGURE 2
GROWING MEDIUM pH

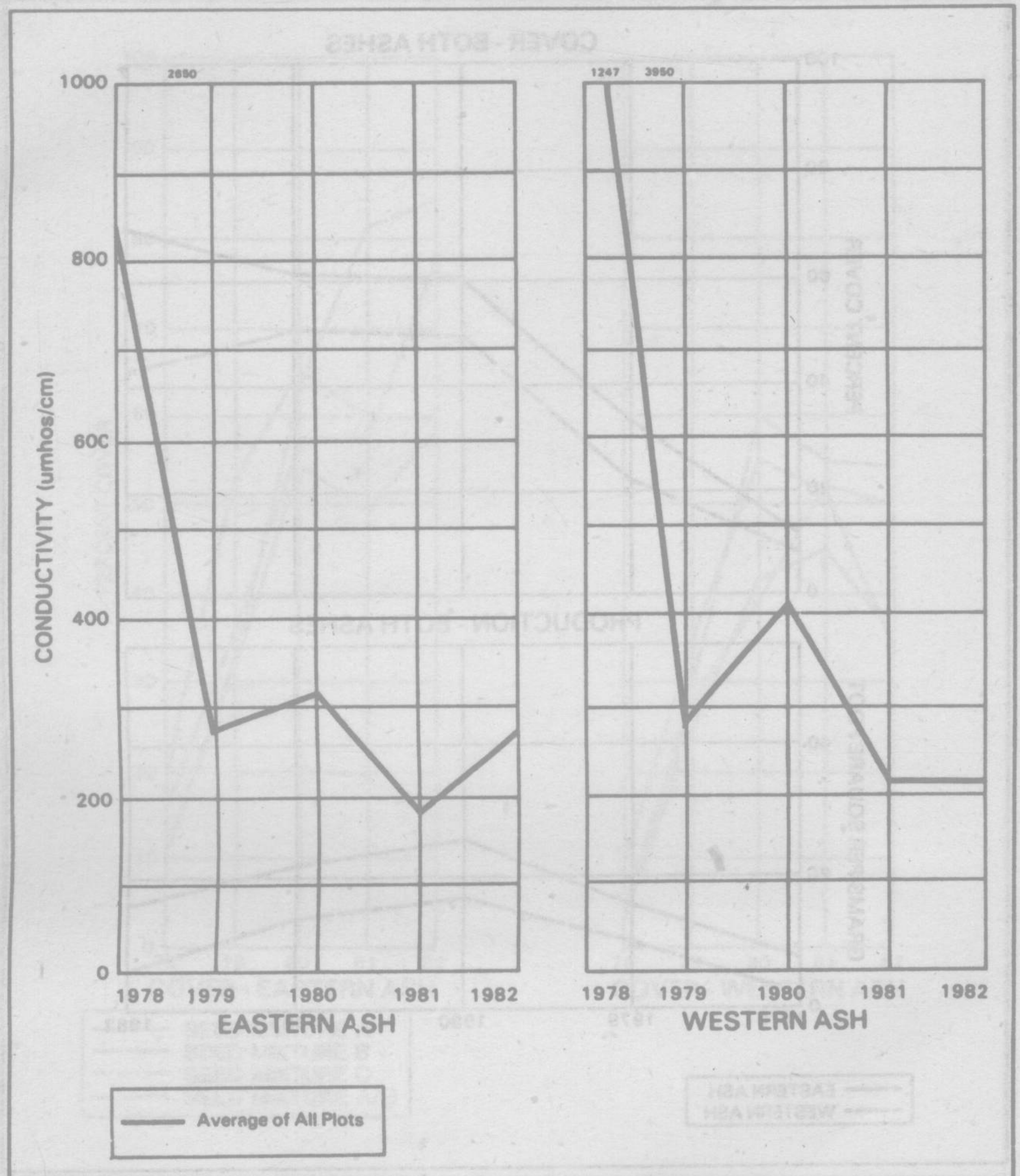

FIGURE 3
GROWING MEDIUM SALINITY
AS MEASURED BY CONDUCTIVITY

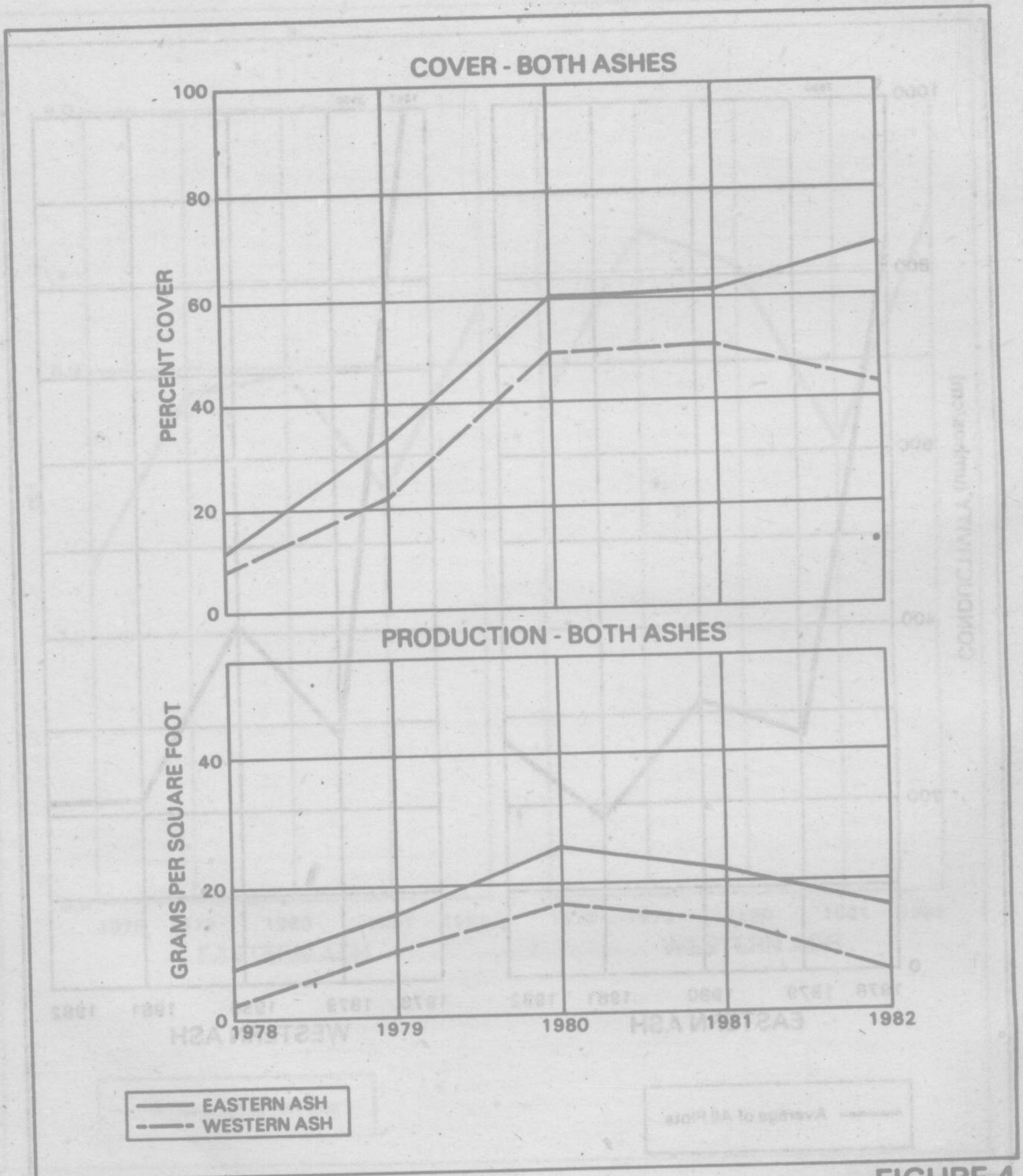

FIGURE 4
AVERAGE OF ALL COVER AND PRODUCTION