THE NATURAL INVASION OF NATIVE PLANTS ON RETORTED OIL SHALE

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ABSTRACT

Various plants, native to the Western Colorado oil shale region, were observed growing on retorted shale disposed at several locations at Anvil Points. These observations were documented in studies made over several years. These preliminary studies consisted of taking numerous photographs of plants growing in retorted shale, making lists of species found growing in the retorted shale and surrounding areas, documenting the vigor of the plant communities by taking measurements of density, cover, and size, and sampling specimens of selected plants for analysis of trace elements. The results of these preliminary studies, presented in this paper, show that the natural invasion of native plants on exposed surfaces of retorted shale dispsal sites is not significantly different from the natural revegetation of disturbed soils.

INTRODUCTION

The retorted shale sites invoved in this study are located at Anvil Points, near Rifle CO. One site is the canyon disposal used by Paraho Development Corporation and other developers since the early Bureau of Mines activities, more than forty years ago. This site lies along the eastern edge of the DOE Anvil Points facility.

The other location is the retorted shale compaction area used by Paraho in field research performed in 1974-1976. This site is located just south of the DOE Anvil Points facility. This site consists of retorted shale, compacted to a depth of about nine feet thick and covering an area of 180 feet by 400 feet (Heistand and Holtz 1980). The southern half of this site has been used for revegetation research involving water harvesting (McKell and Van Epps 1984). Most of the observations and measurements in this paper were made on the northern half of the compacted retorted shale disposal area.

Neither of these retorted shale disposal sites is available for continued studies at this time. The canyon site is part of the DOE facility, decomissioned and reclaimed during 1985-1986 (Virgona 1986). The compacted retorted shale site has been used by Paraho for retorted shale disposal during 1984 operations. The native plants, observed in this study, have been covered with that retorted shale.

As part of proposed reclamation/abandonment plans, there have been numerous research studies involving revegetation of retorted shale disposal areas. Some of these studies involved the following: specially designed lysimeters to study effects of soil cover and leached zones (Harbert 1978, Garland et al 1979); effects of seeding practices, seed mixtures, along with mulching, fertilization, and irrigation (Redende and Cook 1981); capillary barriers (Redente and Ruzzo 1979); and water harvesting (McKell and Van Epps 1984). Many of these aspects of revegetation have been incorporated in permit applications and Environmental Impact Statements for oil shale facilities.

Most of these revegetation designs are costly, and more important, require large quantities of irrigation and/or leach water. The observations made in this preliminary study indicate that elaborate revegetation plans may not be necessary. The natural invasion of native plants may provide sufficient cover to mitigate adverse effects of leaching and erosion.

OBSERVATIONS AND MEASUREMENTS

Since the observations and measurements were made over a several year period, the data presented in this paper are somewhat qualitative. For example, chemical analyses were carried out in 1982, a year after the field measurements for plant density and cover were made. Observations and photographs covered a three-year period and include species noted throughout that period. The natural invasion of native plants appears to be an evolutionary process -- changing from season to season as the pioneer communities give way to more diverse mixture of plants.

Observed Species. Most of the species listed in Table 1 were observed growing in the retorted shale and disturbed soil at the field compaction site. Some were observed growing in retorted shale over soil at the edges of the canyon disposal site. These observations at the compaction site were made 3-6 years after the major field construction had ceased. Observed species fall into six families of plants: Chenopodiaceae, chenopods; Compositae, sunflowers; Loasaceae, evening stars; Verbenaceae, verbena; Malvaceae, mallow family; Graminae, grasses. These species are typical of pioneer plants that invade disturbed areas. These species are adapted to a xeric, alkaline environment. The list of observed plants in Table 1 is quite remarkable when one considers that they represent a natural invasion within a few years after construction activity.

Cover and Density. Cover and density measurements were made at the compaction

Table 1

Identified Species

	Disturbed Soil	Retorted Shale
Chenopod Family		
Shadscale *Atriplex sp.*	X	X
Saltbush *Atriplex canescens*	X	X
Halogeton *Halgeton glomeratus*		X
Fireweed *Kochia scorpia*	X	X
Fireweed *Kochia americana*	X	X
Russian Thistle *Salsola kali*	X	X
Sunflower Family		
Rabbit Brush *Chrysothamus sp.*	X	X
Daisy *Erigeron canus*	X	X
Goldenrod *Solidago sp.*		X
Gum Weed *Grindella squarrosa*	X	
Snake Weed *Gutierrezia sarothrae*	X	
Rag Weed *Ambrosia artemisiifolia*		X
Sun Flower *Helianthus annuus*	X	
Mallows		
Copper Mallow *Sphaeralcea coccinea*	X	X
Verbenas		
Verbena *Verbena bracteata*		X
Evening Stars		
Evening Star *Mentzelia sp.*		X
Grasses		
Indian Rice Grass *Oryzopsis hymenoides*	X	X
Cheat Grass *Bromus tectorum*	X	

test site and surrounding area. In order to obtain unbiased data, the locations of the transects and density measurements for both the retorted shale and disturbed soils were selected using a random number table. The plant density and percent cover measurements are summarized in Tables 2 and 3.

Table 2

Plant Density

	Disturbed Soil	Retorted Shale
No. of Measurements	5	6
Mean Density (plants/m^2)	68	43
Std. Dev. of Mean	21.2	10.2
Per Cent of Soil	100.0	63.2

Table 3

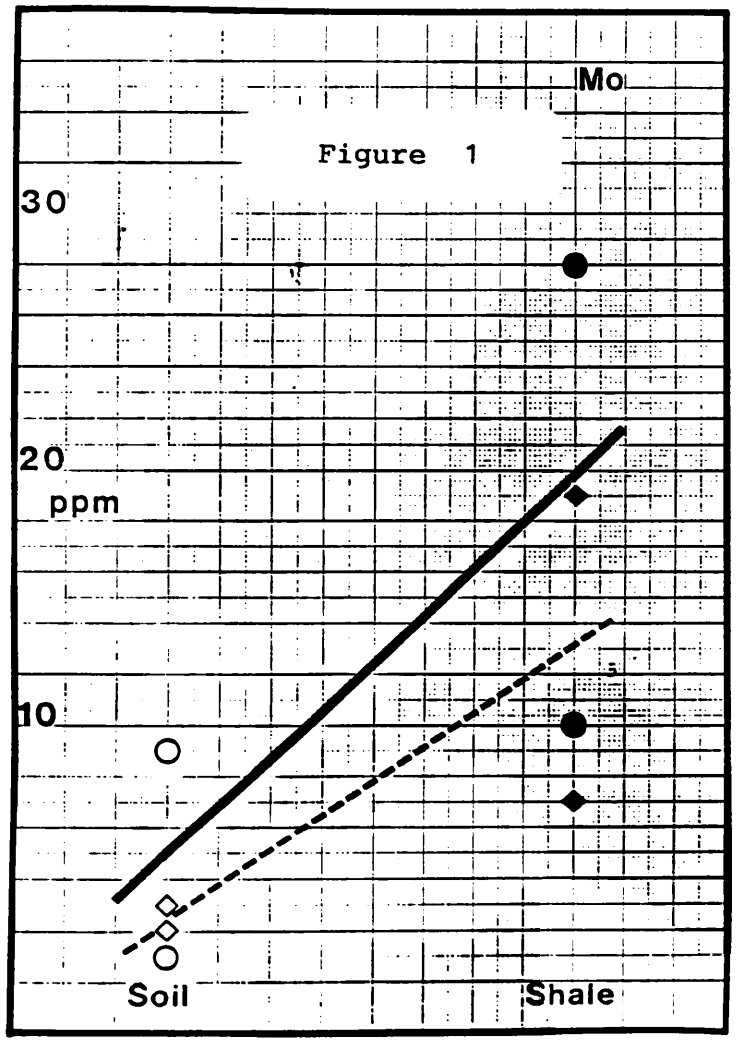
Per Cent Cover

	Disturbed Soil	Retorted Shale
No. of Measurements	5	6
Mean Per Cent Cover	19	29
Std. Dev. of Mean	4.0	3.8
Per Cent of Soil	100.0	152.6

As expected, the individual measurements varied considerably. Density measurements for disturbed soils varied from 39 to 151 plants per square meter; for retorted shale, the data varied from 30 to 93 plants per square meter. Although the widely varying data creates some uncertainity, it would appear that the plant density on retorted shale was about 63% of that found for surrounding disturbed soil.

As noted for density measurements, the uncontrolled natural growth presented some variability for the per cent cover measurements as well; however, since the cover measurements are restricted from 0% to 100%, the variability wasn't as great. Individual per cent cover for disturbed soils ranged from 5 to 26%; for retorted shale, the data ranged from 17 to 41 per cent. These data, along with the summarized data in Table 2, would suggest that retorted shale exhibited better cover than the disturbed soils -- about 153% of the soil cover.

Chemical Analyses. A limited amount of chemical analyses is included in this preliminary study. Analyses were limited to trace elements (molybdenum, fluorine, copper, and boron) in new growth from saltbush and fireweed plants growing in native soil and retorted shale. Data are summarized in Figures 1-4. Concentrations in fireweed are shown as circles; concentrations in saltbush are shown as diamonds. For the most part, there are no significant differences between the



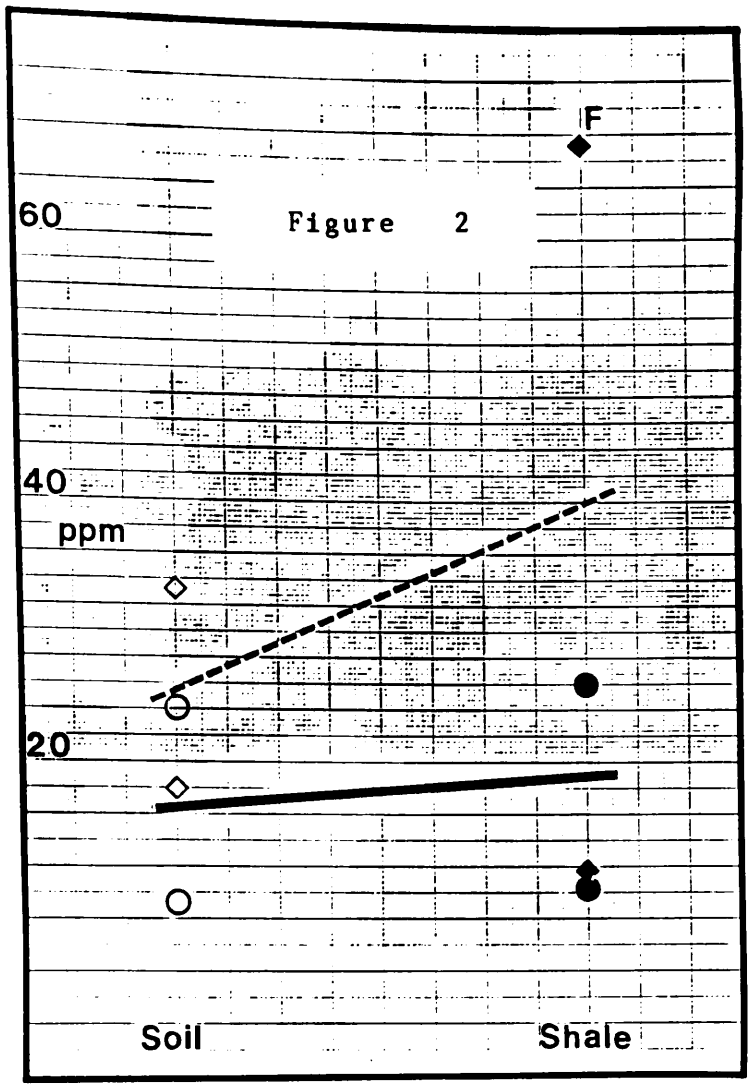


Figure 2

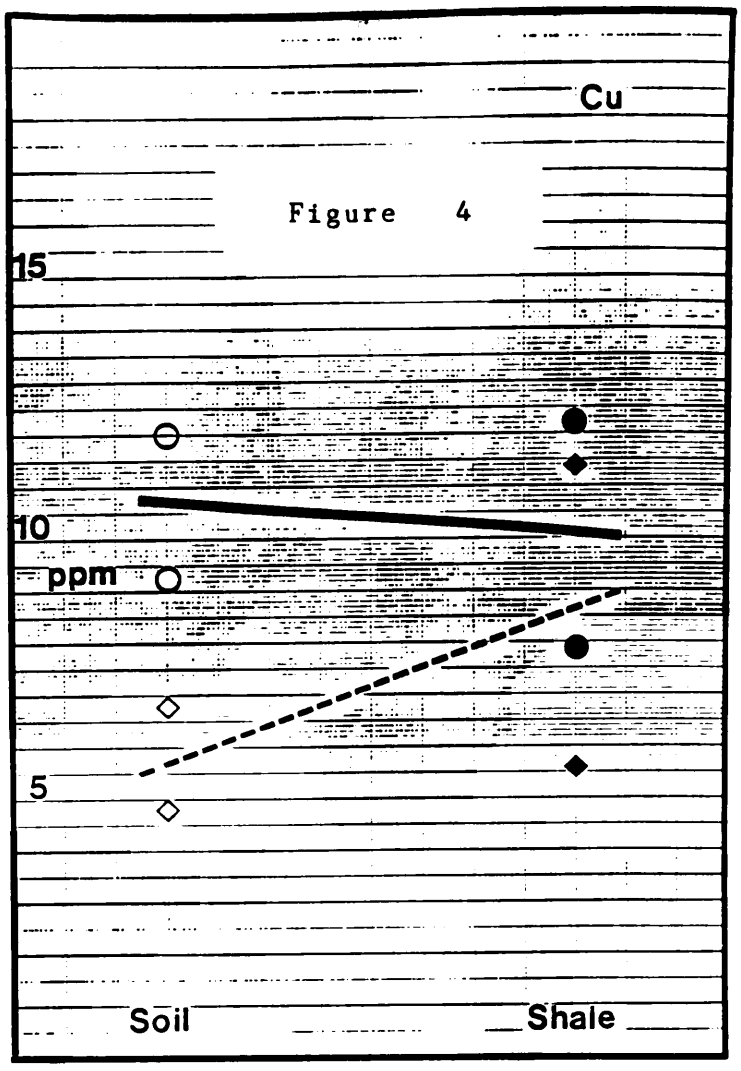


Figure 4

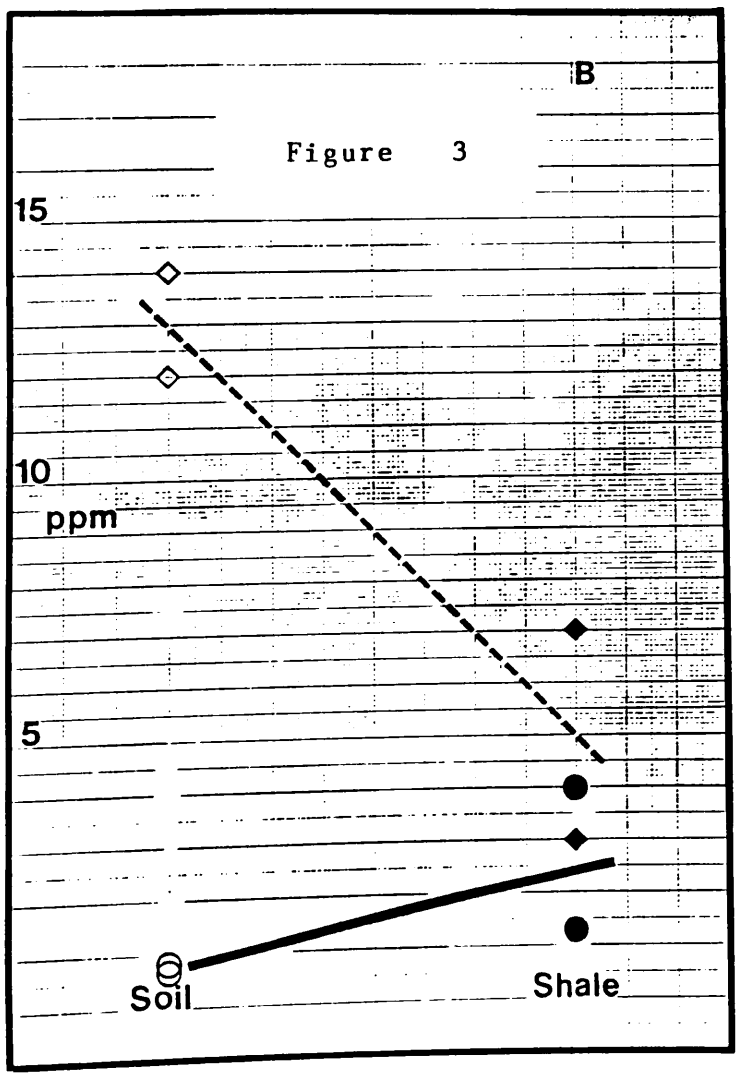


Figure 3

trace element concentration in plants growing in retorted shale or native soil.

Molybdenum concentrations are definitely higher for both species growing in retorted shale (see Figure 1). In the case of fluorine (see Figure 2), the results are not as clear. The salt bush, presented as diamonds and a dashed line, show increases in retorted shale, although the high (70 ppm) point may be an outlier. No increased fluorine concentration was detected for fireweed growing in retorted shale. Boron shows a small increase for fireweed in retorted shale (see Figure 3), while salt bush shows a signigicant boron decrease in retorted shale. There are no differences in copper concentrations in plants growing in disturbed soils and retorted shale (see Figure 4); the soil data range from 4.7 to 12.0 ppm Cu and the retorted shale data range from 5.3 to 12.2 ppm Cu.

Results of this preliminary study should be viewed with care. Only two species were included. Various parts of plants

(roots, stems, flowers, and seeds) were not included in these chemical analyses. Only four trace elements were included in this preliminary study. A more thorough study is needed. Nevertheless, results from this study indicate no adverse impacts from native plants growing naturally in retorted shale.

CONCLUSIONS

There are several important conclusions that can be drawn which include:

(1) Native plants can invade retorted shale disposal areas and thrive under extremely adverse conditions. This natural invasion was not limited to a few plants, but consisted of numerous species and families of native plants. The establishment of these plant communities took place under extremely adverse conditions -- no mulching or fertilization, no seeding or transplanting, no irrigation, and no protection of this south-facing area from solar radiation and dehydration.

(2) The invasion of native plants and the establishment of pioneer communities took place in a short period of time. Plants were well established in less than three years.

(3) These plant communities appear to thrive in retorted shale. Plant density is 63% of that established in adjacent disturbed soils; plant cover exceeds that found in adjacent soil. The native plants growing in retorted shale are robust.

(4) The concentrations of trace elements (Mo, F, Cu, and B) do not show any large increases in new plant growth when plants growing in retorted shale are compared with similar plants growing in adjacent soils.

The observations and findings from this preliminary study suggest a low-cost, useful alternative to some of the more elegant revegetation/reclamation programs that have been considered. Additional studies should be made to confirm the observations and measurements of this preliminary study.

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