Figure 10. A major problem that accompanies strip mining operations is that of restoring the land to its former productivity.

CAN PRODUCTIVITY OF MINED LAND BE RESTORED IN NORTH DAKOTA?

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Western North Dakota contains about 20 per cent of the coal reserves of the United States. With increased use of energy and decreasing supply of petroleum reserves, North Dakota coal fields will probably be developed and intensively mined before the end of this century. The Northern Great Plains Resource Program estimates that up to 300 million tons of coal may be mined and consumed in western North Dakota annually, a volume equal to 50 per cent of the coal consumed in the entire United States in 1973.

One of the major problems that will accompany development of the North Dakota coal reserve will be that of restoring strip-mined land productivity. If coal fields are developed at the estimated rate, some 10,000 to 20,000 acres will be strip-mined yearly, and potentially five to 10 per cent of the land in western North Dakota could be disturbed. Therefore, the need to develop technology to restore productivity to this land is readily apparent. The staff of the USDA Northern Great Plains Research Center at Mandan is conducting a research program for developing methods of restoring mined land productivity.

Sandoval et al. (2) outlined physical and chemical properties of spoil materials associated with mining in western North Dakota. Spoils originally from relatively shallow depths (generally less than 30 to 50 feet) usually present few major problems in reclamation. Although spoils are usually low in plant-available phosphorus, this problem is readily corrected by fertilization. Some may also be moderately saline. With good soil management, however, salinity levels are seldom high enough to pose a real hazard.

Successful revegetation has generally been achieved only on nonsodic spoils, such as those associated with relatively shallow mining operations. However, spoils originating from deeper than about 50 or 60 feet are frequently high in both adsorbed sodium and clay content. Since modern mining methods commonly remove overburden to the 80 to 120-foot depth, high sodium spoils are often left on the surface after mining. Therefore, water infiltration is extremely limited in such spoils, runoff and erosion are severe, and vegetation is difficult to maintain.

Attempts to revegetate highly sodic spoils have generally been unsuccessful. Two avenues

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of reclamation are available: (1) cover the sodic spoils with surface soil or other material suitable for plant growth; or (2) alter the physical and chemical properties of the spoils through the use of amendments, mulches, tillage or other management practices. Both of these approaches are being studied.

Treatments used to alter sodic spoils are aimed either toward preventing surface sealing and thereby enhancing infiltration and root development, or toward reducing adsorbed sodium content and promoting natural aggregation and structure development. Modest success has been achieved by both routes, as is shown by data in Table 1 on runoff from treated plots on spoils initially containing about 15 per cent exchangeable sodium. With no treatment, 90 per cent of the precipitation received ran off. With straw or a 2-inch mulch of topsoil to prevent surface sealing, runoff was somewhat reduced. Treatment with gypsum reduced adsorbed sodium content and also reduced runoff to 66 per cent. Combination of straw and topsoil mulches with gypsum reduced runoff to 35 per cent.

Table 1. Runoff From Strip Mine Spoils in May and June 1972.

Treatment	Runoff Inches	Runoff % of Precip.[1]
Check (rototilled)	4.69	90
Gypsum (rototilled)	3.43	66
Straw	4.49	86
Topsoil (2 inches)	2.74	53
Gypsum + straw	4.18	80
Gypsum + topsoil	3.10	60
Gypsum + topsoil + straw	1.84	35

[1] *Precipitation May 10 to June 17 = 5.20 inches.*

In 1970, plots on spoils with exchangeable sodium percentages of about 25 and receiving some of the same treatments used in the runoff studies discussed above were seeded to a mixture of adapted cool-season grasses. All plots receiving two inches of topsoil had good to excellent stands of grass in 1971, whereas seedings on plots receiving no treatment or only gypsum or sulfur generally failed. However, by 1973 the only perennial grass remaining on plots receiving the topsoil mulch was slender wheatgrass, a relatively unpalatable species adapted to saline areas. Maximum dry matter production in 1973 was 900 to 1,500 pounds per acre (Table 2) and the stand appeared to be thinning. These results point out the difference between revegetation and restoration of productivity. Although these plots were revegetated and erosion was controlled, the area was not restored to an economic productivity. Although treatments were somewhat effective by 1973 in reducing exchangeable sodium in the surface foot, they had not completely eliminated sodium problems (Table 2).

Table 2. Dry Matter Production and Sodium Adsorption Ratio in the Surface Foot of Spoils in Fall, 1973.[1]

Amendment	No Topsoil No Straw	No Topsoil Straw	2 Inches Topsoil No Straw	2 Inches Topsoil Straw
Dry matter production, lbs. per acre[2]				
None	0	63	605	1,283
Gypsum 10 t/a	227	316	921	746
Sulfur	47	62	930	1,587
Sodium adsorption ratio of 0 to 12-inch depth				
None	25	23	19	18
Gypsum	22	24	15	10
Sulfur	22	26	17	11

[1] *Experiment established and seeded in 1970.*
[2] *Predominately slender wheatgrass in 1973, kochia on no topsoil plots.*

Spoils moderate to low in adsorbed sodium appear to be much easier to reclaim to an acceptable level of productivity. At one such site, a series of plots, established in 1971 with various combinations of topsoil (two inches), gypsum, and nitrogen and phosphorus fertilizers, was seeded to barley. Plots were irrigated as needed in 1971 only. Data are presented in Table 3 on dry weight of barley forage at heading in 1971. Dry matter of barley was significantly increased by only phosphorus fertilization—without P, yields were about 200 pounds per acre; with P, about 2,000 pounds per acre. Responses to nitrogen were not measured because these were relatively fresh spoils so they contained exchangeable ammonium and nitrate nitrogen. Relatively high levels of plant available N are often found in fresh spoils, but not in old ones (1).

The topsoil mulch and gypsum treatments generally failed to affect plant growth in these moderately sodic spoils (exchangeable sodium percentage of about 12 per cent). Thus, these data probably represent the potential productivity of

Table 3. Dry Weights of Barley at Heading Produced on Moderately Sodic Mine Spoils.

Amendment	0-0	200-0	0-200	200-200	50-20
	Fertilizer Rate (N-P) Lb./A: Lb./Acre				
Check	175	197	2,303	2,319	1,523
Gypsum	192	137	2,787	2,449	1,915
Topsoil	260	192	2,038	1,584	1,788
Gypsum + topsoil	208	291	1,986	1,692	1,684
Average	209	204	2,279	2,011	1,728

spoils moderately low in adsorbed sodium when subjected to the best management known. Under these conditions, barley gave maximum dry matter yields of about 2,000 pounds per acre. With good management on undisturbed agricultural soils in western North Dakota, barley dry matter production would be about 8,000 pounds per acre on Class II soil, about 4,000 pounds per acre on Class IV land, and less on Class VI land. Thus, application of our present knowledge and technology indicates that moderately low sodic spoils with proper treatment and good management might be made as productive as Class VI soils, at least 50 per cent as productive as Class IV soils, but only about 25 per cent as productive as Class II soils.

Higher productivity presently cannot be achieved by merely treating spoils to change their characteristics. Thus, the alternative of burying undesirable spoils under surface soil or other suitable material must be investigated as a possibility for restoring productivity. First, we must know how deep spoils must be buried to achieve the level of productivity sought. Earlier research in western North Dakota has established that small grains exhibit significant root growth and activity into the fourth foot of soil, grasses into the fifth or even sixth foot (when water is available), and alfalfa to depths greater than eight feet. To achieve nearly full productivity we might estimate that highly sodic spoils should be buried at least to the depth of rooting of the crop to be grown. Consequently, to return mined land to a productive wheat field or high quality pasture, four to six feet of surface soil would have to be returned, and for alfalfa eight feet might be needed. If spoils were lower in sodium content, somewhat less soil material might have to be returned.

Unfortunately, research data are not presently available to define the depth of surface material that must be returned. However, field experiments are in progress to provide such information within the next few years. When these results are available, we can then estimate the degree of productivity that can be restored if spoils are buried to the prescribed depth. Other knowledge and experience in soil science suggests that at least five years may be required to restore high productivity even where the entire rooting depth of the crop has been returned. For example, several years of good fertilization and manuring practices are required to restore irrigated soil after land leveling to a high level of productivity.

If full productivity of at least Class IV land, and possibly as much as 80 per cent productivity of Class II land can be restored by burying spoils under adequate surface material and by using good soil management practices, land will still not be returned to its original condition. Some areas can be made more productive than originally, if proper reclamation procedures are followed. However, surface and groundwater hydrology will undoubtedly be altered, composition of native vegetation and wildlife habitat will be changed, and topography will be altered. Thus, restoring productivity is not necessarily the same as returning to original condition.

Before attempting reclamation we must answer several fundamental questions. One is, to what level of productivity do we wish to restore a given area? Do we want to make it into Class II land, Class IV, Class VI? The answer, of course, depends somewhat on the purpose for reclamation—if it is to be cropped, Class II land would be most desirable. Good grazing can be obtained from Class III or IV land. However, Class VI land would be mainly for wildlife with limited grazing. A second basic question is, who makes this decision? The answer to this question is beyond the scope of this report, but is basic to the reclamation procedure to be followed. These are questions that the people of North Dakota will probably resolve through legislation.

If results of research in progress continue as expected, then the question, "Can productivity of mined land be restored?", can be answered with a qualified, "Yes." Qualifications depend mainly on how well the reclamation is planned, and the care with which these plans are executed. Technology for reclamation is made available through research. Whether or not this technology is applied will depend mainly upon the will of the people concerned, because implementation will involve an expense which will probably be paid ultimately by the consumer. At today's prices, this reclamation expense can be anywhere from $100 to $3,000 per acre, or from 1 to 20 cents per ton of coal mined. As more research information becomes available and the technology for reclamation is further developed, action programs may be implemented through appropriate legislation or other effective means to incorporate this knowledge into reclamation plans. With close coordination between research and application, mined lands can be restored to a reasonable level of productivity, if that is the will of the people of North Dakota.

Literature Cited

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