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Extent and Distribution of COAL STRIP-MINED LAND IN OHIO

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Production of coal by stripping in Ohio has accelerated rapidly in recent years. Early attempts to estimate the area affected by stripping were of necessity based on visual observations supplemented by records such as Annual Coal Reports of the Ohio Department of Industrial Relations. A rapid method of obtaining a relatively accurate estimate of stripped land has become possible by the availability of complete coverage aerial photographs of Ohio. A future survey carried out in a manner similar to that described here when new aerial photos are made, should be useful in evaluating the spread of coal stripping in the state.

By 1940, an estimated 9,000 acres of Ohio coal had been removed by stripping (3). This figure was based entirely on Annual Coal Report data. No attempt was made to determine affected area, which always exceeds area of coal removed by a factor that depends on the size and nature of operation. Annual Coal Report statistics refer only to the amount of coal removed; by dividing total amount of coal removed by the estimated tons per acre, acreage of coal removed can be calculated.

The accuracy of such an estimate is dependent upon two factors: the validity of the estimate of tons of coal per acre and the completeness of Annual Coal Report production statistics. An average recovery of 5,500 tons of coal per acre was used for the 1940 estimate, which compares favorably with a theoretical calculation of coal per acre and with similar estimates used by others. The error included in production statistics of the Annual Coal Reports undoubtedly caused these figures to be low. It is unlikely that coal would be reported produced when it has not been, but it is very likely that mines were missed completely and that production figures of some reporting mines were low. This can be shown to have occurred in recent years and must have been more prevalent prior to 1940.

In 1946 a survey of the Central States Region was made, using aerial photos, coal company maps, and field examinations (1). The portion of this report concerned with Ohio furnished the most reliable figures available for the amount of Ohio land affected by stripping, an

estimated 36,213 acres. This survey included examination and classification of spoils with respect to acidity, texture, topography, stability, and ground cover.

During late 1950 and early 1951, a complete set of aerial photographs was made for the State of Ohio by the Production and Marketing Administration, U. S. Department of Agriculture. By the use of these photos, following the procedures described below, the information contained in Tables I and II, and Figures 1 to 5 was obtained.

PROCEDURE

Aerial photos were examined so as to obtain an estimate of the stripped area in each county and were used in the preparation of individual county maps showing the location of all affected areas to scale.

The area estimate was obtained by use of a dot-counting procedure similar to that developed by Moessner and Jensen (2) for use in timber cruising. A templet was selected that covered the net area of each photo (that area not duplicated on another photograph of the set) with 242 dots (about 16 dots per square inch), producing a total of 45,000

Fig. 1.—Harrison County, Ohio*

*Black areas indicate land stripped for coal. Shaded area indicates county seat.

to 80,000 counts per county, depending on county size and, to a lesser extent, on photo scale. Such dot coverage was selected to produce for as many counties as possible a maximum estimate error of 10 percent at the .05 level of significance, as indicated by a fiducial chart of number of items plotted on percent of attribute in a sample (2).

To complete the count for a given county, the templet was placed over the net area of each photo for that county. Examination of the photo showed where areas affected by stripping occurred. The number of dots falling within such areas was tallied. Total number of templet dots falling within the county were also counted. Only where the county line intersected the templet area was this total count less than the 242 total of the templet. By adding tallies from all photographs of a county, two figures were obtained—total dot-count and affected dot-count. The affected area of the county was then calculated by multiplying the ratio $\frac{\text{affected dot-count}}{\text{total dot-count}}$ by total area of the county.

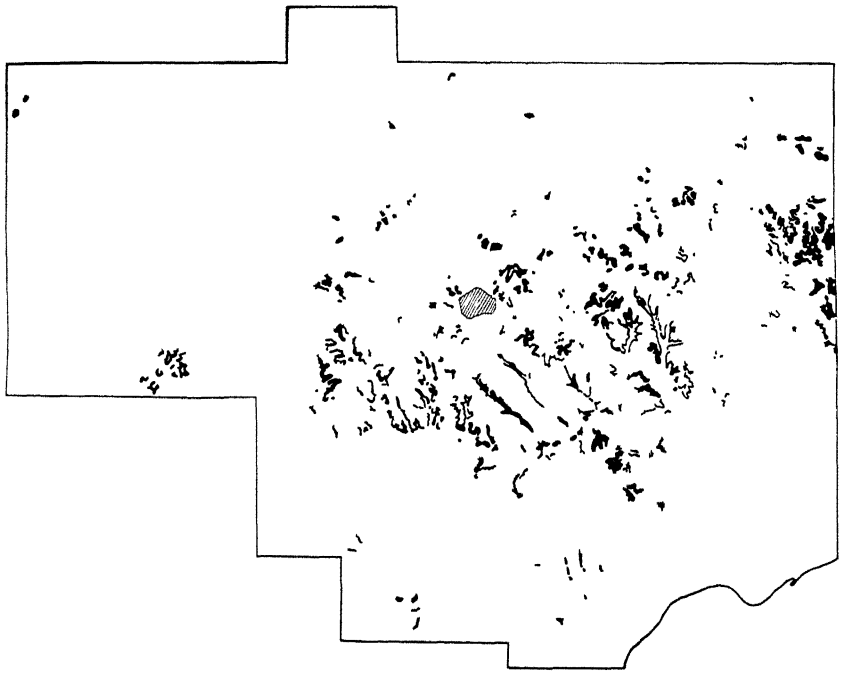

Fig. 2.—Columbiana County, Ohio

In the case of eight counties where stripping is very localized, the percent of area affected was seen to be less than 0.25 percent. In these cases, only portions of the county were counted using a templet containing 100 dots per square inch. Enough additional dots corresponding to a known area on the ground such as a section were counted to compute the scale of each photograph, thus furnishing a factor for finding the effective area for each dot. By multiplying the effective area for each dot by the affected dot-count, the affected area of the county was obtained. By this method estimate error remained about 10 percent without counting the tremendous number of dots required if the whole county were covered.

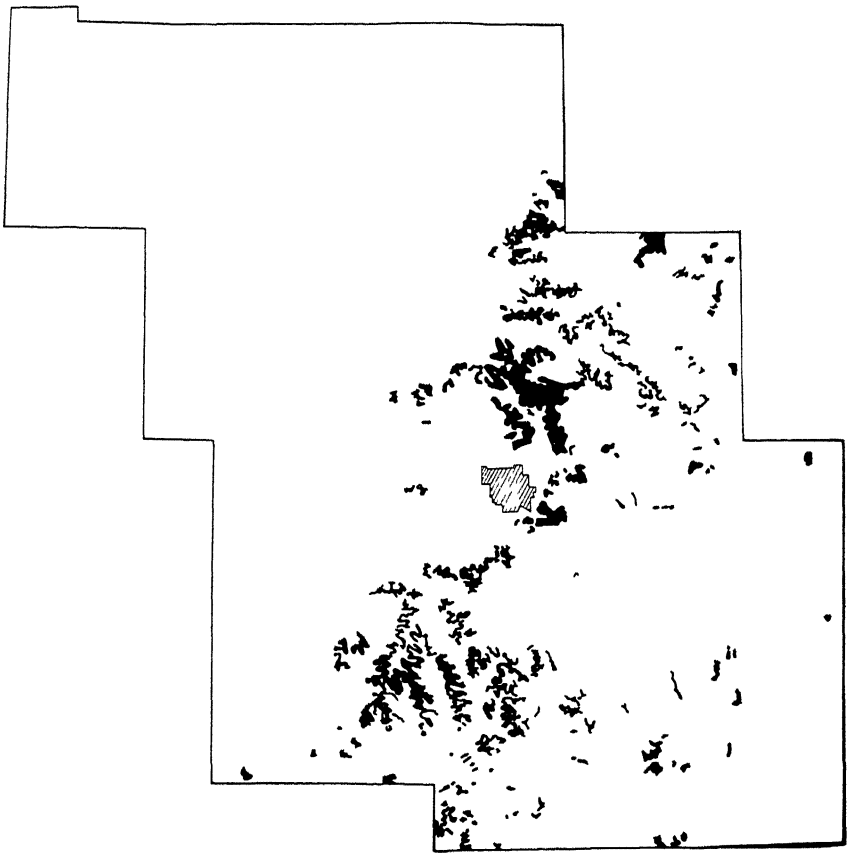

Fig. 3.—Perry County, Ohio

After the dot-counting was completed, each area affected by strip-mining was outlined on the photo with a grease pencil, avoiding duplication. Each photo containing an outlined area was projected upon a county highway map (1″ = 1 mile) by means of a Salzman reflecting

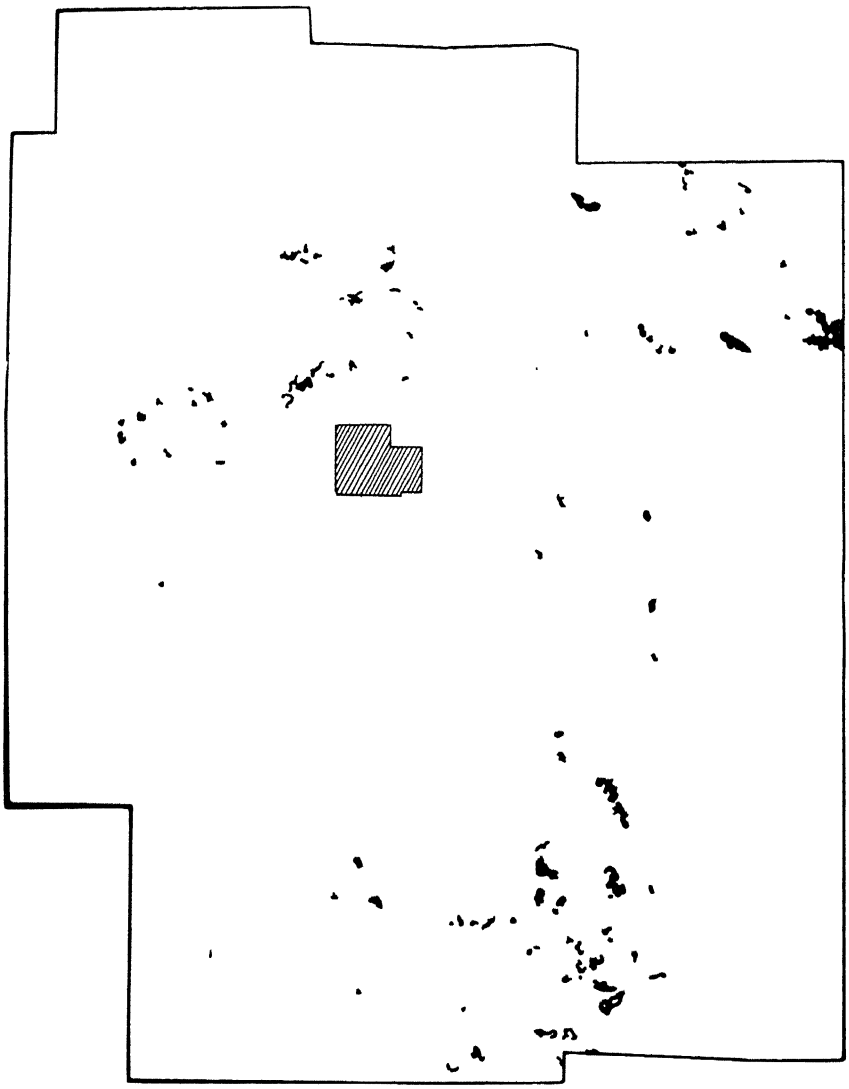

Fig. 4.—Jackson County, Ohio

projector. The photo image was reduced in size until it matched the highway map in scale and was oriented by means of road comparisons. Outlined stripped areas were then traced on the highway map as near to scale and size of the image as possible.

The county highway maps for the 27 Ohio counties containing coal stripping were traced to show only the county outlines, the areas affected by coal stripping, and the county seats for orientation. Each county tracing was photographed, and a state map was produced by assembly of the counties and rephotographing.

ERRORS

The prediction of estimate error is derived from the sampling technique using a templet for dot-counting. Errors of decision concerning whether a templet dot location falls in or out of a coal stripping affected area should be compensating. Separate from this estimate sampling error, which can be given a probable range, is an interpreting error, which cannot be estimated and is not included quantitatively in the "error of estimate" as indicated in Tables I and II.

TABLE I.—Ohio Counties Surveyed Using 16 Templet Dots per Square Inch

County	T Total Dot-count	A Affected Dot-count	County area (acres)*	A/T × 100 (% of county affected)	Estimated acres affected	Error of estimate at .05 level
Athens	57,837	267	322,560	0.462	1,490	10%
Belmont	63,481	510	344,960	0.803	2,770	8%
Carroll	45,793	328	253,440	0.716	1,815	10%
Columbiana	60,566	1,167	342,400	1.927	6,598	6%
Coshocton	67,446	335	360,320	0.497	1,791	9%
Gallia	51,633	128	301,440	0.248	748	15%
Guernsey	61,000	260	338,560	0.426	1,442	10%
Harrison	47,637	2,963	263,040	6.220	16,361	4%
Hocking	48,594	221	269,440	0.445	1,226	11%
Jackson	49,399	210	268,800	0.425	1,142	11%
Jefferson	47,928	1,703	263,040	3.553	9,346	5%
Mahoning	52,430	325	271,360	0.620	1,682	10%
Meigs	49,229	151	279,040	0.307	857	15%
Muskingum	78,699	613	428,800	0.779	3,340	8%
Noble	45,688	520	258,560	1.138	2,942	9%
Perry	47,836	1,314	262,400	2.747	7,208	7%
Stark	69,848	725	371,840	1.038	3,860	8%
Tuscarawas	67,024	1,044	365,440	1.558	5,694	7%
Vinton	46,690	314	263,040	0.673	1,770	10%

*From "Areas of the U. S., Sixteenth Census of the U. S. 1940" U. S. Government Printing Office, 1942.

Several factors can be enumerated that influence interpreting error. Defining affected area even when on the ground may be difficult; from aerial photos it becomes more difficult. Falling spoil material on the outside slope of a stripping operation may disturb or kill vegetation in such areas so that on photos it appears more disturbed than actually is the case. Interpretation of this outside dividing line was done carefully in order to approach as closely as possible the actual affected area as it would appear on the ground. An error in interpreting this outside slope line might not be completely compensating and would tend to produce an area estimate somewhat higher than the actual case.

Surface mining operations to remove clay, gravel, and limestone produce surface disturbances that appear similar to coal stripping. Many of these areas could be picked out because of observable characteristics. Some undoubtedly were called coal stripping areas by mistake and increase the estimate, especially in the heavy clay producing areas of Tuscarawas, Stark, and Columbiana Counties. Some compensation from this bias comes from the fact that some coal is taken out with other minerals and affected area was lost to the estimate.

Advanced reclamation of some small areas of stripped land has produced land difficult to identify as coal stripping even when viewed from the ground. Photo interpretation could not possibly detect all of such areas, thus reducing the area estimate by a small amount.

TABLE II.—Ohio Counties Partly Surveyed Using 100 Templet Dots per Square Inch

County	T Total Dot-count	A Affected Dot-count	C Counted area (acres)	AC/T Estimated acres affected	% of county affected	Error of estimate at .05 level
Holmes	9,617	898	6,400	598	0.220	7%
Lawrence	7,392	445	5,120	308	0.106	10%
Monroe	920	5	640	3	0.001	100%
Morgan	9,377	452	6,400	308	0.114	10%
Portage	4,805	507	3,200	338	0.104	9%
Scioto	1,766	115	1,280	83	0.021	20%
Washington	9,862	793	7,040	566	0.138	7%
Wayne	6,815	454	4,480	298	0.083	10%

An evaluation of the net effect of these interpreting errors shows that some add to the estimate and some detract from it. No attempt has been made to fix a probable range to amount of interpreting errors.

EVALUATION OF RESULTS

Figures 1 to 4 are examples of county maps showing distribution of stripped area. Harrison is the heaviest affected county in the state, both in past and current stripping. Nearly 20 percent of the land in the eastern third of the county has been disturbed by coal stripping. By 1946, Harrison County contained 8,631 acres of stripped land (1);

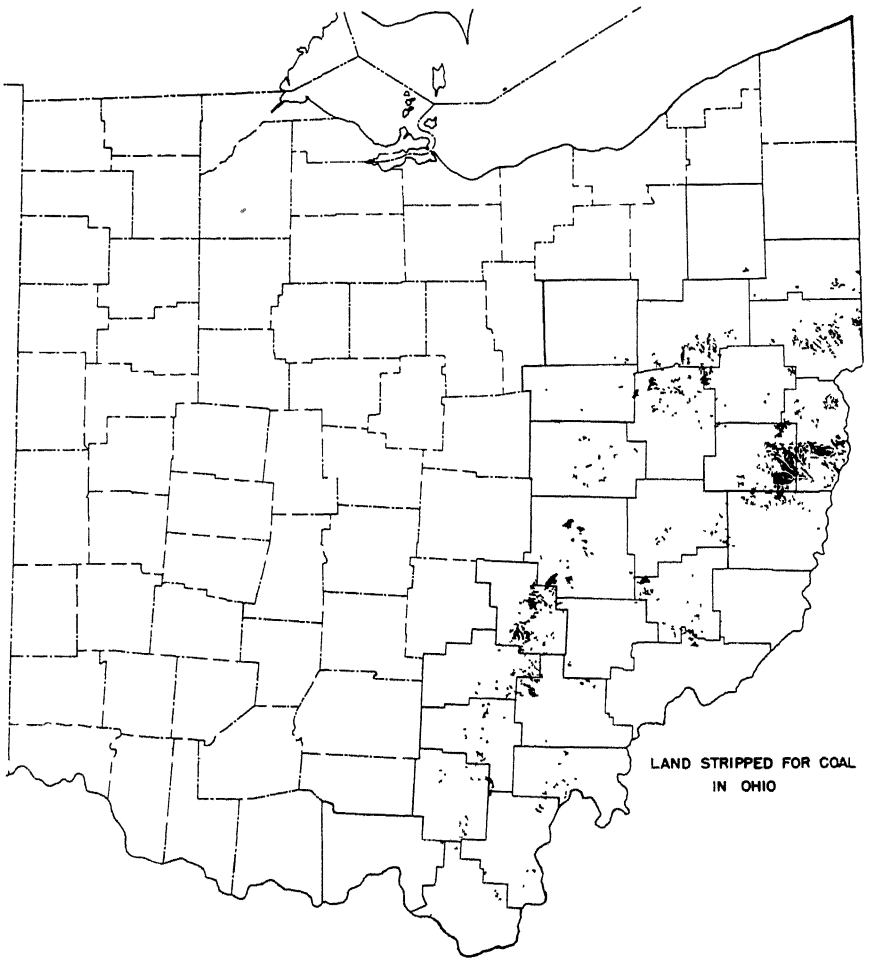

Fig. 5.—Distribution of the estimated 74,584 acres affected by stripping.

this increased to 16,361 acres by 1950 (Table I). Jefferson County's stripped area increased only from 6,252 to 9,346 acres during the same period. Columbiana County contains many mined areas scattered throughout its extent. Perry County is the center of an important coal field of southeastern Ohio.

Stripping in the extreme southern counties has been limited largely to isolated areas of small extent because of the topography. Jackson County is typical of these. It is in some of these heretofore neglected areas that the greatest increases in future stripping will probably be made due to the advent of heavy industry and the development of more efficient equipment. Scioto and Monroe Counties with 83 and 3 acres affected respectively (Table II) have apparently been disturbed since the 1946 estimate was made, as no affected area was assigned to them (1).

The relationship of the pictured individual counties to the state as a whole can be seen by comparison with Figure 5. The total area affected by coal stripping in Ohio by late 1950 was 74,584 acres with an estimate error of 6.6 percent or 5,188 acres. These figures were obtained by summation of the acreage columns of Tables I and II and a weighted error calculation. A report of the Ohio Department of Agriculture (4) indicates that during 1951 and 1952, about 7,000 acres per year were affected by stripping.

A future aerial photo survey of area affected by mining carried out in a manner similar to that described here will provide a picture of trends in the development of the coal stripping industry in Ohio.

LITERATURE CITED

(1) Limstrom, G. A. Extent, character, and forestation possibilities of land stripped for coal in the Central States. Central States Forest Experiment Station, Technical Paper No. 109, 79 pp. 1948.

(2) Moessner, K. E. and C. E. Jensen. Timber cruising on aerial photos. Central States Forest Experiment Station, Technical Paper No. 126, 27 pp. 1951.

(3) Moore, H. R. and R. C. Headington. Agriculture and land use as affected by strip-mining of coal in eastern Ohio. Ohio State University and Ohio Agricultural Experiment Station, Department of Rural Economics Mimeograph Bulletin No. 135, 40 pp. 1940.

(4) Ohio Department of Agriculture, Division of Reclamation. Official Report for the period July 1, 1950 to June 30, 1952. 22 pp.