1-1-1947

Lime supplies in West Virginia

C. E. Stockdale

Bulletin 329 June 1947

Lime Supplies in West Virginia

By C. E. Stockdale

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION, MORGANTOWN

SUMMARY AND CONCLUSIONS

1. Widespread destruction has been wrought by man and Nature on the agricultural soils of West Virginia. One fundamental phase of this situation is the marked depletion which has gradually taken place in the lime content of practically all of the state's agricultural soils.
2. Estimates indicate that at least 1,600,000 acres of cropland and 2,250,000 acres of pastureland are still worthy of lime treatment. To preserve this acreage for a successful agriculture in the future calls for an estimated initial application of 8,000,000 tons of ground limestone or its equivalent costing $33,000,000.
3. In addition, an application of the equivalent of around 800,000 tons annually is needed to maintain the lime content of the state's soils against current depletion.
4. In the seven-year period (1929-1935) a total of around 175,000 tons of ground limestone or equivalent was used. In the nine-year period (1936-1944) a total of more than 3,100,000 tons was used.
5. Increasing interest is being shown in liming pasturelands. Of the total liming materials used in the state in 1943, 14.5 percent was applied on pasturelands, as compared with 7.7 percent in 1942.
6. Chemical analyses pertaining to more than a million and a half tons of ground limestone and marl used during 1940-1944 indicate that material of a fairly good quality, with a considerable part of it excellent, is being used in West Virginia.
7. The cost of liming materials varies widely among counties in West Virginia, ranging from $1.50 to more than $5.50 per ton on a farmyard delivered basis.
8. Nearly two-thirds of the lime being used in West Virginia is shipped long distances from outside the state, mainly from Ohio.
9. The high cost of liming soils in West Virginia is largely chargeable to transportation. In 1944, materials were about $1.20 per ton. Transportation added nearly 250 percent to the cost of the materials. The high percentage of farms on unimproved roads increases trucking costs.
10. Most lime used in West Virginia is a byproduct. Very little is manufactured exclusively for agricultural purposes. A very extensive limestone industry exists within West Virginia, but little direct benefit has accrued to agriculture from this situation. There are vast quantities of high-quality limestone and marl in the 15 eastern and southeastern counties of the state with little or none in the remaining counties.
11. Trucking lime to farms in West Virginia in 1944 cost around $1.53 per ton; freight cost around $2.19 per ton. While some reduction is possible as to materials costs, the greatest opportunity for lowering prices seems to be in connection with rail and trucking costs.

Lime Supplies in West Virginia

by C. E. Stockdale

Soil fertility is a most valuable natural resource. Frequently quite easy to destroy, it is difficult, slow, and expensive to restore. Of the many problems confronting agriculture in West Virginia, those having to do with the soil are generally recognized as fundamental. During recent years much evidence has established the fact that withdrawals cannot continue to be made against the bank of agricultural fertility unless provision for adequate deposits is made therein to restore a balance.

Lime Deficiency in Croplands and Pasturelands

One fundamental phase of the general problem of soil management in West Virginia has to do with lime and lime deficiency. Practically all the cropland as well as nearly all the pastureland soils of the state, except where recent treatments have been applied, are now deficient in lime. By 1926 the West Virginia Agricultural Experiment Station had analyzed 4,000 representative soils,[1] largely cropland, from all sections of the state, and had found more than 95 percent of them in need of lime. More recently the same agency analyzed several thousand samples of soil, mostly from cropland, and found that more than 95 percent of these also needed lime. The Experiment Station survey,[2] begun in 1935 and covering 775 pastures in 20 counties of the state, found 85 percent of the total pasture area studied lacking in lime.

Such widespread lime deficiency in both crop and pasturelands is more readily understood when it is realized that 90 percent of the state's soils are of nonlimestone origin, the parent materials being largely sandstone and shale. Relatively few soil areas of the state are of limestone origin, and most of these show a lime deficiency.

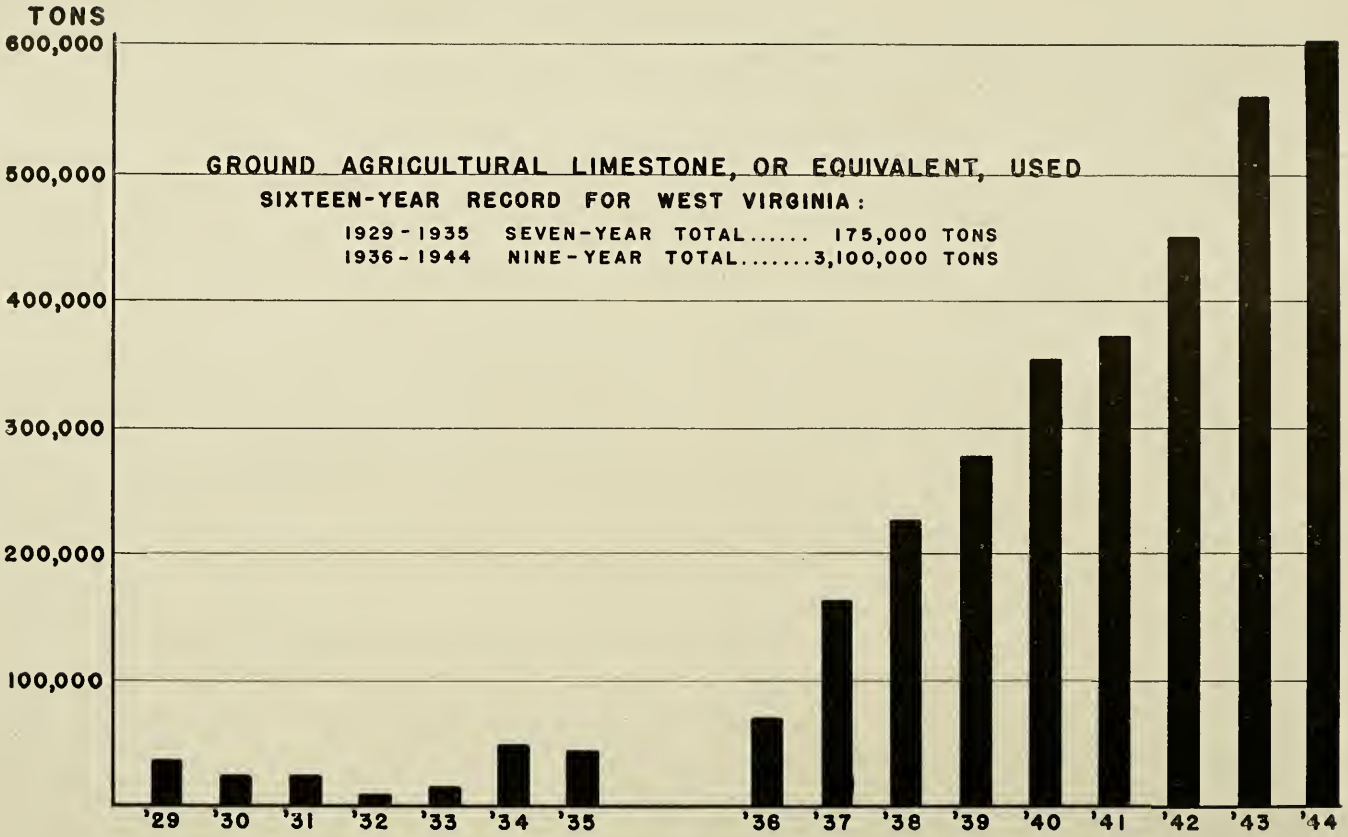
In regions of plentiful rainfall, such as West Virginia, there are fairly heavy losses of lime through leaching. Such leaching is largely responsible for the removal of calcium from the soil and for the development of soil acidity. Some loss of lime takes place through crop removal and livestock grazing. Erosion tends to wash away much of the original surface soil, with its lime content.

The writer is indebted to the state office of the Agricultural Adjustment Agency, Morgantown, W. Va., for much data contained herein pertaining to the lime-supply situation as it has developed in the state since 1935. In this development, as will be seen in the following pages, the A. A. A. has played a dominant part.

Acknowledgment is also made to Dr. G. G. Pohlman, head of the Department of Agronomy and Genetics of the West Virginia Agricultural Experiment Station, for many useful suggestions in preparation of the manuscript.

1W. Va. Agr. Exp. Sta. Bul. 215, 1926.

2W. Va. Agr. Exp. Sta. Bul. 280, 1937.


TONS
600,000
500,000
400,000
300,000
200,000
100,000
GROUND AGRICULTURAL LIMESTONE, OR EQUIVALENT, USED
SIXTEEN-YEAR RECORD FOR WEST VIRGINIA:
1929 - 1935 SEVEN-YEAR TOTAL..... 175,000 TONS
1936 - 1944 NINE-YEAR TOTAL.....3,100,000 TONS
'29
'30
'31
'32
'33
'34
'35
'36
'37
'38
'39
'40
'41
'42
'43
'44

The man in the foreground seems deeply engrossed in contemplating the scene that meets his gaze. He may be concluding that the use of lime and superphosphate, coupled with reasonably good management, would have easily prevented this agricultural atrocity and substituted therefor a beautiful, luxuriant, profitable permanent pasture.

As a general rule, in the maintenance, restoration, and improvement of West Virginia soils, liming becomes the first step.

Amount of Liming Materials Used Before 1936[3]

Lime has been used by some of the more progressive farmers of the state for a number of years. The quantity used, however, if compared with the existing need, has been exceedingly small. Particularly is this true of the years before 1936.

[3]Tonnage data as presented in the following pages, unless otherwise indicated, should be understood to refer to ground limestone or its equivalent. Ton, as used herein, refers to 2000 pounds.

CAPTION FOR CHART ON OPPOSITE PAGE

Approximate tonnage of ground limestone or equivalent used in West Virginia during the 16 years 1929-1944. The record during the last 9 years, while quite gratifying as compared to the PAST, is far from satisfactory as compared to the NEED. During 1943 and 1944, limestone use has, for the first time in the history of the state, approached substantially the equivalent of maintenance needs (to say nothing of the much larger quantity needed as a foundation application).

Practically all the lime used by farmers in West Virginia before 1936 was procured at their own expense. Although considerable educational work had been done by the Agricultural Extension Service, the Agricultural Experiment Station, farm journals, and other agencies, concerning the value of lime, only a relatively small tonnage had been used.

Only incomplete information exists as to lime used in the state before 1936. Data prepared by the National Lime Association indicate the extent. The tonnages for West Virginia as given below refer to various types of materials. Calculations indicate that the average annual tonnage may be considered equivalent to from 12,000 to 14,000 tons on a ground-limestone basis.

	Tons		Tons
1929	13,430	1933	4,544
1930	10,023	1934	16,474
1931	9,398	1935	15,260
1932	2,256	Average	10,198

Estimates by the West Virginia Agricultural Experiment Station[4] suggest that the quantity of lime produced locally by farmers during this period was somewhat larger than that procured commercially. In combining these two sources, the conclusion is that an equivalent of around 25,000 tons of ground limestone was being used annually by farmers in West Virginia before 1936. This tonnage represents less than five percent of the amount regarded as necessary for soil maintenance, to say nothing of soil improvement.

A soil-conservation demonstration begun in Roane and Wirt Counties in 1933 was carried out on approximately 440 farms, on which an estimated 40,000 tons of lime was used. Mention is made of this effort inasmuch as it constitutes the first large-scale demonstration of lime use to be undertaken in the state.

Amount of Liming Materials Used Since 1935

A second but smaller demonstration project was carried out during 1936-1940 in Marshall County by the Soil Conservation Service. About 8,000 tons of ground limestone was used on cooperating farms. This material was manufactured by small grinding plants set up locally.

Another publicly financed effort to provide lime to farmers, covering the period 1935-1942, was in conjunction with camps of the Civilian Conservation Corps. Local farmers formed lime associations which furnished management, some equipment and raw materials such as lime-

[4] W. Va. Agr. Exp. Sta. Circ. 71. 1936.

stone, brick for kilns, and coal. The Soil Conservation Service contributed labor from nearby C. C. C. camps and the use of some grinding equipment. Through this type of activity around 55,000 tons of lime was produced and used.

In 1936 the Agricultural Conservation program of the Agricultural Adjustment Agency was started. This program heavily subsized the application of lime. The resultant increased use is shown by the following tonnage data.

A. A. A. program year	Tons used under A. A. A. program
1936	59,776
1937	152,883
1938	225,842
1939	271,830
1940	345,194
1941	361,294
1942	441,690
1943	562,152
1944	600,092
	3,020,753

These figures show that during the 9-year period 3,020,753 tons of ground limestone or equivalent was used in connection with the A. A. A. farm program.

It must be recognized that some material was used outside the A.A.A. program. Of this material no adequate record exists but indications are that the amount was relatively small. This seems probable in view of the small quantity of material used by farmers before 1936. It is estimated that a total of 90,000 tons will approximate this use for the 9-year period.

From A. A. A. data, supplemented by estimates, it is concluded that during the 9-year period of 1936-1944 West Virginia farmers used more than 3,100,000 tons of ground limestone or its equivalent.

Estimate of Total Limestone Needs of the State

A more valuable comparison than that of the present with the past can be drawn between the amount of lime used and the amount that needs to be used. This latter comparison, with emphasis on needs, raises many problems.

In a study of the agricultural lime supply situation in West Virginia it is desirable to arrive at an estimate of the existing lime needs in the state. What are the total lime tonnage needs of the state, if general crops and the better pastures are to be provided with reasonably favorable growing conditions?

A small and decreasing proportion of the liming materials used in West Virginia is produced locally as burnt lime in permanent kilns (left) and in lime stacks (right). In certain sections where limestone and coal are readily procurable, provided labor is available, these methods of production often prove practicable on a small scale. Much is saved by elimination of heavy freight and trucking costs.

Much remains to be learned concerning such matters as chemical tests for soil acidity;[5] the true significance of adequate supplies of calcium in relationship to plant and animal growth, health, and nutrition; and the exact rate of loss of lime through leaching, crop removal, and erosion under widely varying conditions. Therefore only a general estimate may be expected. Nevertheless, by employing certain necessary assumptions it is possible to develop a fairly reliable estimate of the lime needs of the state.

Varying estimates have been made in the past, with variations due mainly to differences in judgment as to the state's acreages worthy of lime treatment and to the per-acre rate of application regarded as necessary. Some estimates assumed that finely ground material analyzing 100

[5]The writer calls attention to but does not attempt to deal with the two schools of thought concerning the necessity for liming: (a) that its value lies in destroying soil acidity; (b) that its value lies not in destroying soil acidity but in supplying calcium as a nutrient of great importance in plant growth and in animal health and nutrition. The latter viewpoint is well presented in a pamphlet entitled, **Mobilizing The Fertilizer Resources of Our Soils**, by Dr. William A. Albrecht of the Department of Soils, University of Missouri, and published by the Agricultural Limestone Division of the National Crushed Stone Association, Washington, D. C.

percent calcium carbonate equivalent would be uniformly spread. These conditions do not prevail in practice. Some estimates aimed at raising the soils to full neutrality (pH 7.0), while others were concerned with somewhat lower pH values.

The total lime needs of the state can perhaps best be estimated if dealt with under two heads: (a) that amount of material needed as a foundation application and (b) that amount of material needed annually thereafter to maintain the soils.

Acreages, of course, provide the starting point in the development of a total estimate. The entire state of West Virginia contains slightly more than fifteen million acres.[6] Of this area only about nine million acres[7] are now actually in farmlands, the remainder being in forests, wasteland, and various nonfarm uses. If from this total farmland figure the three million acres representing wooded areas on farms[8] be subtracted, somewhat less than six million acres remain, representing principally crop and pastureland. Cropland is known to amount to slightly less than two million acres.[9] The total pasture area plus yards, barnyards, feedlots, lanes, roads, wasteland, etc. amounts to somewhat more than four million acres.

Pastureland Acreages Worthy of Liming

Here arises a question: How much of this four million acres, largely pastureland, should be considered of sufficient quality to justify liming? The matter must be looked at from an economic standpoint in which no treatments should be proposed for worthless lands or areas far along the road to abandonment. Three answers have been proposed which may be used in arriving at an estimate as to pasturelands suitable for liming.

(A) These four million acres cannot all be regarded as suitable for liming. Much of it has passed the point where lime treatment can be considered as practicable or profitable. The West Virginia Agricultural Experiment Station, following a pasture study begun in 1935 and covering 20 counties in the state[10], concluded that "for the state as a whole it is estimated that at least one-third of the pastures are so steep or so badly eroded that fertilization and liming cannot be recommended." Such an elimination plus an additional acreage representing wasteland, fence rows, driveways, etc. leaves approximately 2,500,000 acres which can be considered as the pasture area worthy of lime treatment, if needed.

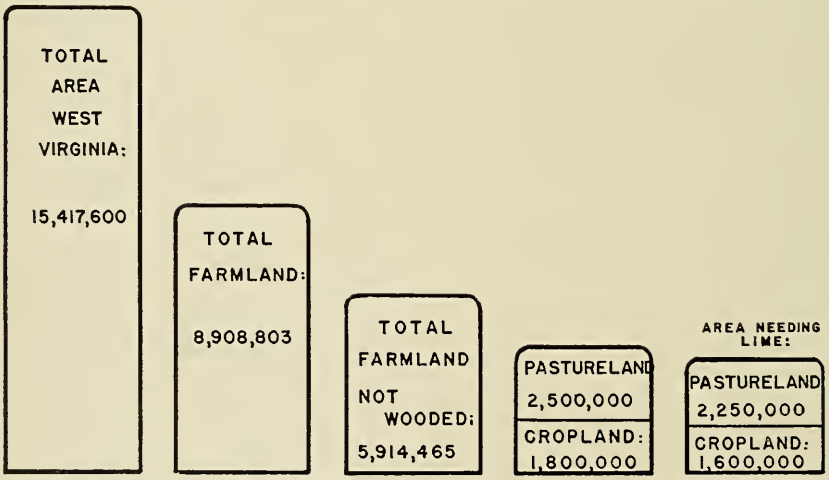
(B) The Agricultural Adjustment Agency has held individual interviews with practically all the actively engaged farmers of the state.

6U. S. Census (1940) reports 15,417,600 acres as the approximate total land area.
7U. S. Census (1940) reports 8,908,803 acres in farmlands.
8U. S. Census (1940) reports 2,994,238 acres in farm woodlands.
9U. S. Census (1940) reports 1,827,755 acres in croplands harvested, idle and failure.
10W. Va. Agr. Exp. Sta. Bul. 280. 1937.

Farmers reported their acreages of pasture of sufficient quality to carry at least one animal unit to five acres throughout a normal grazing season. Such individual estimates of "qualified" pastureland totaled 2,877,726 acres.

(C) A third estimate of the pasture acreage of the state worthy of treatment has been based on the total plowable and nonplowable pasture acreages. The plowable acreage of the state in pasture is approximately 2,000,000 acres,[11] a small percentage of which is probably unworthy of treatment. The total nonplowable pasture acreage is approximately 1,750,000 acres. While much good pasture is produced on nonplowable areas, a large proportion of such must be considered not worthy of lime treatment. If it is estimated that 25 percent of the nonplowable pasture area of the state is worthy of improvement, there are at least 2,340,000 acres of pastureland which can be considered worthy of lime treatment, if needed.

The foregoing estimates support the conclusion that approximately 2,500,000 acres of pasture constitute the present area in West Virginia worthy of liming. If to this are added the 1,800,000 acres of cropland, it seems probable that there are 4,300,000 acres of crop and pastureland in West Virginia on which lime can be applied profitably, if needed.



Much of the total area of West Virginia must now be considered as not being adapted to treatment with liming materials. However, the total needs of the state in terms of ordinary commercial ground limestone or equivalent may be conservatively estimated at (a) 8,000,000 tons as an initial or foundation application in order to bring its agricultural soils up to a suitable growing condition, and (b) the equivalent of 600,000 tons annually in order to hold or maintain its soils against current depletion.

[11] U. S. Census (1940) reports 2,033,299 acres of plowable pasture.

Percentage of Cropland and Pastureland Needing Lime

Certainly not all of this area of cropland and pastureland can be considered as needing lime. The Agricultural Experiment Station concluded from its study begun in 1935 that 85 percent of the total pasture area studied needed lime. Had the remaining 35 counties of the state been similarly studied, an even greater percentage might have been found in need of treatment. In the 10 years since the study, soils have tended to become more acid, since not enough lime was applied to meet current maintenance needs. It is concluded that between 90 and 95 percent of the worthwhile pastureland of West Virginia needs lime.

Leaching of lime on cropland is perhaps twice as rapid as on pastureland. In West Virginia also, cropland is subject to greater erosion. Croplands must also withstand the frequent removal of crops with some lime content. Even though most of the lime used in recent years has been applied on croplands, nevertheless such lands apparently need lime in no less percentage than pasturelands Some croplands, as well as some pasturelands in limited limestone areas, do not need lime, but the percentage is relatively small.

For purposes of general estimation, at least 90 percent of all cropland and a similar percentage of the pastureland worthy of treatment comprise the minimum total acreage for which lime treatments should be planned. It is difficult to see how the state's basic soil resources are to be improved or maintained without adequate lime treatment on an area of substantially this size. The pasture acreages not worthy of treatment will be currently utilized as long as their production justifies, but no direct outlay of cash or labor should be expended thereon until the better areas have been given proper treatment.

Estimate of Limestone Needed as an Initial Application

Decision concerning the rate of application of limestone per acre needed on pasture and cropland is necessary to complete an estimate of total lime needs. The West Virginia Agricultural Experiment Station[12] has stated that "ordinarily not more than 1½ tons of finely ground limestone or its equivalent is needed on pastures and in most cases one ton will be sufficient." The foregoing estimate of per-acre needs assumed a finely ground, 100 percent calcium carbonate equivalent limestone. As a matter of fact, the material being used in West Virginia averages somewhat below this standard. Also, in the recommendation, reasonably thorough dis-

[12] W. Va. Agr. Exp. Sta. Circ. 71. 1936.

tribution in spreading was assumed, whereas in actual practice the thoroughness of spreading leaves much to be desired.[13] In consideration of these circumstances a rate of 1½ tons of commercial material per acre for pastureland is considered a minimum initial application. For general cropland purposes, twice the rate for pastureland, or 3 tons per acre, is regarded as a minimum application. Of a group of 263 analyses, the 240 cropland soils needing lime showed, in fact, a requirement of 2.8 tons per acre of finely ground limestone.

On the basis of the foregoing, croplands are estimated to require an initial application of 4,800,000 tons of ordinary commercial material, and pastureland, 3,375,000 tons. Thus 8,175,000 tons, on a ground limestone equivalent basis, are needed as an initial application.

Other Estimates for Initial Application

Attention is directed to other estimates that have been made. Each estimator employed somewhat different assumptions, because of the lack of definite knowledge and because of the different purposes the estimates were designed to serve. Four estimates follow:

(A) In 1939 the West Virginia Geological Survey[14] prepared a "conservative" estimate of the state's lime needs based on the U. S. census (1935) of total cropland acreage, allowing 2 tons of ground limestone per acre, and on plowable pasture, allowing 1 ton per acre. No consideration was given to liming nonplowable pasture. The estimate totaled 5,538,635 tons.

(B) Committee workers representing the U. S. Department of Agriculture, interested primarily in post-war planning, in 1943 worked out a preliminary estimate of lime needs based largely on actual farm-planning experience with 6,000 farms in demonstration areas and in soil-conservation districts of the state. The estimate totaled 6,430,000 tons on a ground-limestone basis.

(C) More recently (1944) a more detailed estimate was prepared by workers representing the U. S. Department of Agriculture using acreages needing lime and per-acre rates of application as recommended by the Department of Agronomy and Genetics of the West Virginia Agricultural Experiment Station. A state total of 1,795,434 cropland acres was regarded as needing lime. The pasture acreage needing lime was derived by adjusting the 1940 census figure for plowable pasture. It totaled 1,920,230 acres. As an initial application, sufficient to correct acidity, 3.4 tons

[13] Several competent observers have estimated that more than 50 percent of the liming material used in West Virginia is shovel-spread. However, rapid improvement is being made in spreading practices, particularly where specially constructed spreader truck beds can be used.

[14] W. Va. Surv. vol. XII, Limestones of West Virginia. 1939.

per acre for cropland and 1½ tons per acre for pastureland were proposed. Total state needs for an initial application were thus estimated at 6,128,590 tons for croplands and 2,880,320 tons for pasturelands, or a total of 9,008,910 tons. This estimate did not allow for liming nonplowable pasture and did not consider lime applied in recent years. The per-acre rate proposed was rather high because of the intention to correct practically all known acidity.

(D) In 1944 representatives of the U. S. Department of Agriculture and of the West Virginia Agricultural Experiment Station estimated the state's total lime needs in connection with post-war adjustments. In view of the lime applications that had been made during the past 10 years it was regarded that 1,083,600 acres of cropland and 2,011,700 acres of plowable and nonplowable permanent pastureland still needed initial treatment. Considering the needs of cropland as 3 tons per acre and of pastureland as 1½ tons per acre, and correcting for the grade of material available, the estimate totaled 6,740,161 tons.

The estimate of 8,175,000 tons developed in the present study together with other estimates cited for comparison (5,538,635 tons; 6,430,000 tons; 9,008,910 tons; 6,740,161 tons) indicates the needs of West Virginia in terms of ground limestone as an initial application. To procure and deliver 8,175,000 tons of ground limestone to the farms of the state would cost $33,000,000 at average 1944 prices.

Estimate of Limestone Currently Needed as Maintenance

Even were it possible by an initial application of approximately 8,000,000 tons of ground limestone to bring the croplands and the better pasturelands of the state to a favorable lime content, it would be necessary to apply an additional tonnage every few years thereafter to maintain the soils at this level. Lime is continually being lost from soils by erosion, through the selling of crops, animals, and animal products, and through leaching. From experimental evidence, an annual estimate for such current losses in West Virginia can be set at 200 pounds of ground limestone per acre from good pasturelands and 400 pounds per acre from croplands. Such loss can be replaced by a 1-ton application every 10 years on pasturelands and 1 ton every five years on croplands. By such applications it is believed that lime depletion can be held in check.

On the basis of such assumptions, to maintain West Virginia's cropland and pastureland acreages would require an annual equivalent of 545,000 tons of ground limestone. To apply less than this tonnage annually would permit some continuation of the gradual process of lime depletion which has been in effect for many years. Other estimates follow.

A 1944 estimate prepared by representatives of the U. S. Department of Agriculture and of the West Virginia Agricultural Experiment Station indicated an annual maintenance figure of 591,633 tons.

County-by-county calculations employing census (1940) cropland data and A. A. A. "qualified" pastureland data (see Table 1) resulted in an estimated total annual maintenance requirement of 587 000 tons.

Data presented by Donald W. Aitken, representing the Division of Special Programs, A. A. A., in a talk before the National Crushed Stone Association in 1944 formed the basis of an estimate of 600,000 tons of ground limestone required annually for West Virginia croplands and pasturelands.

From the foregoing it can be concluded that the annual lime maintenance requirement for the state is in the neighborhood of 600,000 tons.

Regardless of whether it can be solved, there is advantage in realizing the magnitude of the agricultural lime supply problem in West Virginia. Evidently, matters pertaining to lime supply and price may be expected to receive serious and increasing attention of agricultural institutions, agencies, manufacturers and farm people for some time to come.

Estimate of Maintenance Requirements by Counties

Most agricultural leaders, lime manufacturers, bidders, dealers and truckers will find data at the county level of more direct interest. West Virginia counties have used unprecedented tonnages of liming materials in recent years. How far this effort has carried them toward complete handling of the lime problem is of significance. A somewhat crude though useful measure of progress from a county viewpoint is provided by comparison of the current average annual tonnage taken as a percentage of the annual lime-maintenance needs. It involves devising county-by-county estimates of maintenance needs.

Through the use of data on "qualified" pasture acreage developed by the Agricultural Adjustment Agency, county estimates have been prepared. No other data have been found which undertake to discriminate between good and poor pasturelands in the different counties. Such acreage estimates, obtained direct from farmers, carry implication of the owner's interest in their maintenance, restoration, and improvement. As before, only 90 percent of the cropland acreage (as per 1940 census) and 90 percent of the qualified pastureland acreage is being used in arriving at the county estimates, in order to provide some allowance for acreage not needing maintenance applications. The per-acre basis used has been that of an equivalent of 1 ton of ground limestone every 5 years on cropland and 1 ton every 10 years on pastureland (see Table 1).

TABLE 1—Estimate of Minimum Tonnage of Ground Limestone or Equivalent Required Annually to Maintain Cropland and Pastureland Soils

Counties	Area in cropland 1940 census	Area in qualified pasture	Amount needed for annual maintenance	Counties	Area in cropland 1940 census	Area in qualified pasture	Amount needed for annual maintenance
	acres	acres	tons		acres	acres	tons
Barbour	39,501	80,026	14,000	Mineral	24,301	43,625	8,000
Berkeley	69,148	18,688	14,000	Mingo	13,195	1,526	3,000
Boone	10,384	7,803	3,000	Monongalia	34,374	69,041	12,000
Braxton	47,723	105,784	18,000	Monroe	41,696	90,224	16,000
Brooke	12,479	11,938	3,000	Morgan	25,484	2,973	5,000
Cabell	30,765	29,410	8,000	Nicholas	33,074	30,359	9,000
Calhoun	32,548	55,877	11,000	Ohio	17,341	17,294	5,000
Clay	18,677	22,133	5,000	Pendleton	35,739	86,945	14,000
Doddridge	23,058	81,280	11,000	Pleasants	11,868	20,779	4,000
Fayette	30,014	10,296	6,000	Pocahontas	29,815	75,459	12,000
Gilmer	33,478	79,479	13,000	Preston	65,019	69,881	18,000
Grant	24,801	70,630	11,000	Putnam	38,538	41,035	11,000
Greenbrier	55,619	104,115	19,000	Raleigh	35,074	21,226	8,000
Hampshire	44,563	53,493	13,000	Randolph	41,014	69,106	14,000
Hancock	9,417	8,065	2,000	Ritchie	58,882	111,586	17,000
Hardy	29,656	63,137	11,000	Roane	49,827	116,321	19,000
Harrison	46,104	136,170	21,000	Summers	32,551	50,729	10,000
Jackson	53,331	125,314	21,000	Taylor	13,173	40,429	7,000
Jefferson	65,889	12,000	13,000	Tucker	14,917	32,374	6,000
Kanawha	36,048	22,306	8,000	Tyler	30,462	58,138	11,000
Lewis	34,573	134,050	18,000	Upshur	31,269	70,218	12,000
Lincoln	41,908	26,930	10,000	Wayne	58,368	43,875	11,000
Logan	10,202	4,064	2,000	Webster	17,929	20,167	5,000
McDowell	14,585	137	3,000	Wetzel	35,928	59,795	12,000
Marion	39,455	53,331	12,000	Wirt	20,161	46,220	8,000
Marshall	41,535	62,827	13,000	Wood	43,323	64,351	14,000
Mason	53,048	83,356	17,000	Wyoming	18,577	8,823	4,000
Mercer	42,247	52,618	12,000	TOTAL	1,827,755	2,877,726	587,000

The Agricultural Adjustment Agency Lime Program (9-year State Record)

Over the period 1936-1944 the A. A. A. lime program assumed a predominant position. Data from this program are believed to include the total tonnage used in the state to within three percent.

Some of the more significant features of the data in Table 2 are:

(a) The tonnage increase in use of lime beginning with 1936, under the stimulus and aid of a system of subsidies provided by annual federal appropriations, has been remarkable. Presumably such an "action" record would not have been possible had there not existed a live farmer interest in soil conservation and soil improvement built up by educational and research agencies over a period of years.

(b) The tonnages used since 1935 have not been sufficient to meet the current maintenance requirements of the soils of the state (Table 1).

(c) The percentages of the total tonnage furnished by the A. A. A. increased steadily. Farmers participating in the program may procure lime at their own expense and be reimbursed therefor, or they may rely upon the A. A. A. to procure and deliver the granted materials to their farms. They have preferred the latter. During 1936-1938 no lime was furnished by the A. A. A. direct to farmers. From 1939 to 1944 inclusive the percentage provided by the A. A. A. increased to 86 percent of the total.

TABLE 2—Total Tonnages Ground Limestone or Equivalent Used Under A. A. A. Farm Program, and Proportion Thereof Furnished by A. A. A.

A. A. A. program year[1]	Total lime used under program	Amount furnished direct to farmers by A. A. A.	Amount procured by farmers through their own efforts	Percentage of total furnished by A. A. A.
	tons	tons	tons	percent
1936	59,776	000	59,776	0
1937	152,883	000	152,883	0
1938	225,842	000	225,842	0
1939	271,830	48,965	222,865	18
1940	345,194	138,994	206,200	40
1941	361,294	178,633	182,661	49
1942	441,690	313,539	128,151	71
1943	562,152	478,184	83,968	85
1944	600,092	517,175	82,917	86
	3,020,753	1,675,490	1,345,263	55

[1]Program years in some instances varied somewhat from calendar years.

County Record of Limestone Used (1936-1944)

Table 3 presents a record by counties of the A. A. A. liming materials used during each year from 1936 to 1944 in terms of ground-limestone equivalent.

Some of the factors responsible for the wide variation in amounts of lime used between counties and within counties in different years were:

1. Generous farm allowances due to large crop acreages in some counties.
2. Wide variation in prices of lime delivered at the farm in different areas.
3. Unusual interest of farmers in certain localities in soil-building practices.
4. Certain counties in the state being largely nonagricultural.
5. Wide variation in the total acreage embraced within county lines.
6. Failure of contractors to fulfill their contracts in some areas during some seasons.
7. The inverse relationship existing between the use of superphosphate and lime.

County-by-county Comparisons in Meeting Lime Needs

Comparisons on a county basis may result in misleading conclusions concerning agricultural progress. County areas in West Virginia vary so widely as to make county comparisons frequently of limited value. For example, the smallest county in the state contains but 88 square miles; the largest is 12 times this size. In terms of cropland the smallest county has fewer than 10,000 acres; the largest has 7 times this acreage. In terms of plowable pasture, the smallest county has fewer than 5,000 acres; the largest has more than 2 times this acreage.

A better measure of county progress in meeting lime needs can be derived by comparing the average annual tonnages used with the estimated limestone-maintenance needs of croplands and pasturelands in the respective counties. Any county found to be meeting more than 100 percent of its maintenance needs can be considered to have held the line against current depletion and also to have made advances in whittling down its foundation needs. This presumes that any county with annually increasing applications will sooner or later reach a stage where its soils in general will no longer be suffering from lime depletion. Then, with still further tonnage increases, it will finally begin to make inroads on the larger task of restoring and building up its soils to a proper lime level consistent with successful agriculture.[15]

From the data in Table 4, representing the five years 1940 to 1944, it will be seen that approximately 79 percent of the lime-maintenance requirements of the state as a whole are being met. Many counties, however, are going well beyond maintenance and are thus beginning to restore their soils with respect to the fundamental deficiency.

[15]There are, of course, other ways of looking at the matter of limestone usage from a county standpoint. For example, Barbour County in the past five years has used somewhat more than 43,933 tons which, if applied as an initial application, would treat adequately around 15,000 acres of cropland (or 30,000 acres of pastureland). There would thus remain to be treated 24,500 acres of cropland (or 50,000 acres of pastureland) with a foundation application. Also, following any foundation application, need would soon begin to arise for a maintenance application. The writer believes the mode of looking at the matter as outlined makes for clarification.

TABLE 3—Amount of Ground Limestone or Equivalent Used Under the A. A. A. Farm Program, 9-year Record, by Counties

Counties	1936	1937	1938	1939	1940	1941	1942	1943	1944	Total
Barbour	2161	4726	5884	7878	7726	6356	4361	10868	14622	64582
Berkeley	1376	5795	10294	10017	10837	9121	9866	21768	27373	106477
Boone	3	142	198	109	2778	3664	4515	3202	1459	16070
Braxton	507	1040	885	1870	7932	7621	9278	8490	12175	49798
Brooke	671	1255	3069	3667	2996	3314	2539	3487	2893	23891
Cabell	728	1372	2544	1166	2340	2992	4506	8044	9105	32797
Calhoun	286	537	533	963	3425	2927	8943	8151	8818	34583
Clay	518	1359	412	1148	2131	2296	2913	3218	4237	18232
Doddridge	217	838	913	527	6568	6414	6179	11700	12472	45828
Fayette	668	2308	2053	4246	5437	7847	8139	8645	6312	45660
Gilmer	54	402	522	964	2837	2845	8454	9782	8401	34261
Grant	1518	2175	4803	5217	6104	5761	5884	5608	5521	42591
Greenbrier	2892	10642	16095	16776	16441	19324	12887	15633	27894	138584
Hampshire	2109	4628	6923	5841	6898	6840	10217	11260	13425	68141
Hancock	979	1082	1894	2290	1239	1880	3549	4711	1986	19610
Hardy	1257	3420	4999	5062	5269	5710	6154	14832	13450	60153
Harrison	1418	5048	5984	6661	16047	9942	13080	12896	19200	90276
Jackson	727	1652	3088	4132	7962	9330	12170	25202	21599	85863
Jefferson	2895	4984	10119	10617	11760	12651	19044	32613	35081	139764
Kanawha	330	566	1341	778	1181	4982	5693	10650	9069	34690
Lewis	1190	2102	3587	4237	9975	3328	9607	15676	17353	67055
Lincoln	311	511	942	575	4080	3011	3838	3575	3026	19869
Logan	4	104	186	44	2272	3427	2415	2633	1359	12442
McDowell	0	0	0	0	0	32	5	0	172	209
Marion	602	2251	3368	4037	4368	7546	11164	11041	14962	59339
Marshall	2739	3404	4683	4107	6687	6827	9219	13809	13956	65431
Mason	2190	3799	6116	5847	8487	11506	14618	16255	21286	90104
Mercer	1077	5439	6387	6238	7027	6683	5862	4994	8569	52276

TABLE 3 (concluded)

Counties	1936	1937	1938	1939	1940	1941	1942	1943	1944	Total
Mineral	1457	2964	4414	5284	4325	4167	3766	6421	7072	39870
Mingo	16	0	28	36	191	3583	3733	2094	403	10084
Monongalia	1179	3607	5604	8935	7633	5843	11238	14323	9893	68255
Monroe	1326	3004	4728	5416	6633	9248	7801	15145	16843	70444
Morgan	1409	2737	2577	2689	2697	3560	6631	8479	8676	38455
Nicholas	1205	4634	6716	9044	9731	7997	8107	9963	9032	66529
Ohio	1594	2416	4667	5012	2871	3640	3236	4426	3945	31907
Pendleton	1602	4248	6889	8307	8622	6390	4051	3177	9098	52384
Pleasants	180	378	52	646	2476	1799	2754	4243	4115	16643
Pocahontas	2025	7446	16059	15772	17817	16682	13774	9655	16680	115924
Preston	3863	14297	18329	22299	17742	20252	16543	27420	17664	158400
Putnam	617	1010	1083	2360	4150	4993	8590	10117	14282	47202
Raleigh	56	757	1879	6421	13731	18411	13240	15961	6748	77304
Randolph	2654	8215	13063	14596	13010	11520	20752	14973	16362	115145
Ritchie	452	1294	1859	5384	5483	8056	13214	19566	16871	72179
Roane	1423	2666	3770	5075	9172	7964	14855	17928	19063	81916
Summers	684	2680	3051	2914	5636	6318	5856	11070	9070	47279
Taylor	1468	1884	2123	3304	3511	5741	6427	6485	5555	36498
Tucker	695	3476	5457	7219	6084	5946	5889	6585	6546	47897
Tyler	185	406	460	1917	2897	2212	6048	5633	8642	28400
Upshur	1075	3392	6227	10552	9965	7187	9280	10296	11169	69143
Wayne	2097	4781	3782	5499	2364	6211	8682	4522	6812	44750
Webster	242	1040	1356	1779	2983	3461	2333	2934	4067	20195
Wetzel	1594	1542	1325	1326	4916	3708	9076	10050	11760	45297
Wirt	396	910	442	361	1570	2209	4827	5978	6525	23818
Wood	817	1390	1800	3271	5067	4818	10498	10964	13092	51717
Wyoming	38	134	284	798	3113	5201	5292	4700	4329	23889
	59,776	152,883	225,842	271,830	345,194	361,294	441,690	562,152	600,092	3,020,753

TABLE 4—Percentage of Maintenance Needs Being Met by Counties Over the Five Years 1940-1944

	Annual limestone maintenance	Average annual application 1940-44	Percentage of maintenance being met
	tons	tons	percent
Barbour	14,000	8,787	63
Berkeley	14,000	15,793	113
Boone	3,000	3,124	104
Braxton	18,000	9,099	51
Brooke	3,000	3,046	102
Cabell	8,000	5,397	67
Calhoun	11,000	6,453	59
Clay	5,000	2,959	59
Doddridge	11,000	8,667	79
Fayette	6,000	7,276	121
Gilmer	13,000	6,464	50
Grant	11,000	5,776	53
Greenbrier	19,000	18,436	97
Hampshire	13,000	9,728	75
Hancock	2,000	2,675	134
Hardy	11,000	9,082	85
Harrison	21,000	14,233	68
Jackson	21,000	15,253	73
Jefferson	13,000	22,230	171
Kanawha	8,000	6,315	79
Lewis	18,000	11,188	62
Lincoln	10,000	3,506	35
Logan	2,000	2,421	121
McDowell	5,000	42	1
Marion	12,000	9,816	82
Marshall	13,000	10,100	78
Mason	17,000	14,430	85
Mercer	12,000	6,627	55
Mineral	8,000	5,150	64
Mingo	3,000	2,001	67
Monongalia	12,000	9,786	82
Monroe	16,000	11,194	70
Morgan	5,000	6,009	120
Nicholas	9,000	8,966	100
Ohio	5,000	3,644	73
Pendleton	14,000	6,268	45
Pleasants	4,000	3,077	77
Pocahontas	12,000	14,922	124
Preston	18,000	19,924	111
Putnam	11,000	8,426	77
Raleigh	8,000	13,618	170
Randolph	14,000	15,323	109
Ritchie	17,000	12,638	74
Roane	19,000	13,796	73
Summers	10,000	7,590	76
Taylor	7,000	5,544	79
Tucker	6,000	6,210	104
Tyler	11,000	5,086	46
Upshur	12,000	9,579	80
Wayne	11,000	5,718	52
Webster	5,000	3,156	63
Wetzel	12,000	7,902	66
Wirt	8,000	4,222	53
Wood	14,000	8,888	63
Wyoming	4,000	4,527	113
	587,000	462,084	79

Proportion of Limestone Applied to Pasturelands

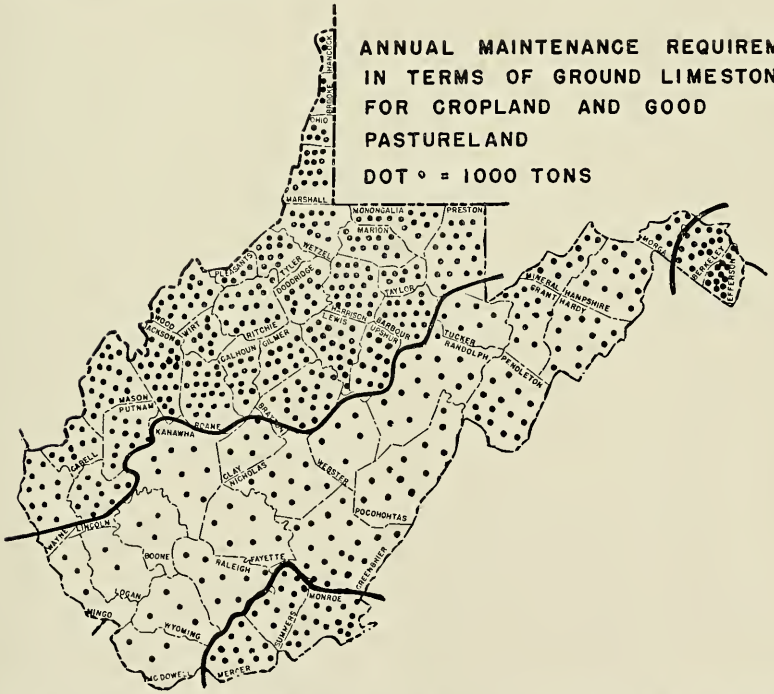
West Virginia farmers have been strongly inclined to make their first applications of lime on their croplands, leaving the treatment of their pastures to some future date. The following data as to crop and pasture applications made in connection with the A. A. A. program in 1942 and 1943 indicate increasing interest in pasture treatment. (Table 5.)

TABLE 5—Proportion of Limestone Being Applied to Pasturelands, 2-year Record

	1942 A. A. A. program year	1943 A. A. A. program year	Total two-year record
Tonnage used on croplands and pasturelands	441,690	562,152	1,003,842
Number of farms treating pastures	4,334	8,136	12,470
Tons ground limestone equivalent applied to pasturelands	34,187	81,592	115,779
Acres of pastureland treated	22,508	41,820	64,328
Average application per acre (tons)	1.5	1.9	1.8
Percentage of total tonnage on pasturelands	7.7	14.5	11.5

Quality of Liming Materials Used

While the quantity of liming materials used is a matter of fundamental importance agriculturally, the quality of the materials cannot be disregarded in any careful examination of the supply situation. Data as to the quality of limestone supplied in connection with the A. A. A. program furnish indication as to quality of the total supply.



The limestone needs of West Virginia are concentrated in three separate areas: (1) two counties of the Eastern Panhandle; (2) three or four counties along the southern border, and (3) about 28 counties in the northwest part of the state. The first two areas are served fairly adequately by local sources. The northwestern area is lime-poor as to local sources and is served mainly from northwestern Ohio. The territory with few dots, for the most part, has a relatively small acreage needing lime.

TABLE 6—Coverage of Limestone and Marl Samples Over 5-year Period

A. A. A. program year	Amount purchased by A. A. A.	Number of producers	Number of samples analyzed		
			Limestone	Marl	Total
	tons	number	number	number	number
1940	138,994	11	214	00	214
1941	178,633	16	226	21	247
1942	313,539	23	205	12	217
1943	478,184	26	229	28	257
1944	517,175	31	177	86	263
	1,626,525	52	1051	147	1198

Chemical and mechanical analyses made in the laboratory of the West Virginia Agricultural Experiment Station involve samples from 1,626,525 tons of liming material supplied by the A. A. A. during 1940 through 1944. These samples were procured from carload quantities and from trucks, stockpiles, and bins. Sufficient samples were taken to provide information necessary for control regarding specifications of materials contracted for by the A. A. A. (Tables 6 and 7.) Simple arithmetic averages calculated from the aforementioned samples provide information as given in Table 7.

During 1940-1944, in addition to the 1,626,525 tons of which analyses were made, 683,897 tons of lime were used in connection with the A. A. A. This lime was procured by farmers at their own expense. Much of this latter material originated from the same sources as did the A. A. A. lime and was of similar quality.

Although ground limestone contracts of the A. A. A. for West Virginia specify a minimum requirement of no less than 85 percent calcium carbonate equivalent, with at least 90 percent of the material passing through a 10-mesh screen, it is obvious from the analyses described that manufacturers delivered material well above minimum requirements both chemically and mechanically. Contracts pertaining to marl specify no less than 85 percent calcium carbonate equivalent and material of sufficient fineness to permit spreading by the equipment normally used. The marl supplied has analyzed as high as the ground limestone from the

TABLE 7—Average Mechanical and Chemical Analyses, 1198 Samples

	Number of samples	Percentage through 10-mesh screen	Percentage through 20-mesh screen	Percentage through 60-mesh screen	Percentage through 100-mesh screen	$CaCO_3$ equivalent
	number	percent	percent	percent	percent	percent
Limestone	1051	96.8	76.1	45.3	32.8	92.3
Marl	147	85.4	68.2	43.0	29.2	92.4
Both materials	1198	95.4	75.2	45.0	32.4	92.3

chemical standpoint and but slightly lower mechanically. Each material has provided a fair amount of the finer portions (through 100-mesh screen) desirable to provide immediate availability along with the coarser portions to insure lasting effects. The material used has been of good quality. Suppliers of inferior material have been eliminated.

TABLE 8—Analyses of Materials Furnished by 52 Producers over a 5-year Period, 1940-1944

Type of material and origin	Number of samples	Percentage of calcium carbonate equivalent	Percentage through 10-mesh screen	Percentage through 100-mesh screen
	number	percent	percent	percent
Limestone (W. Va.)	111	91	99	29
Limestone (Ohio)	141	106	99	51
Limestone (N. J.)	24	95	99	53
Limestone (Va.)	43	86	98	39
Limestone (W. Va.)	77	89	97	21
Limestone (W. Va.)	20	75	97	29
Limestone (Va.)	18	106	100	70
Limestone (Va.)	17	102	100	44
Limestone (Ohio)	137	97	96	25
Limestone (Va.)	10	96	100	57
Limestone (Va.)	5	94	100	39
Marl (Va.)	21	97	95	57
Limestone (Ohio)	21	100	93	26
Limestone (W. Va.)	33	93	97	19
Limestone (W. Va.)	20	86	93	16
Limestone (W. Va.)	17	78	87	23
Limestone (W. Va.)	12	73	90	21
Limestone (Ohio)	5	91	99	46
Limestone (W. Va.)	48	85	93	25
Limestone (Va.)	7	96	100	25
Limestone (W. Va.)	16	83	100	17
Marl (W. Va.)	31	91	81	16
Limestone (W. Va.)	6	86	92	26
Limestone (Ohio)	3	95	98	31
Limestone (W. Va.)	31	92	98	31
Limestone (W. Va.)	57	85	100	27
Limestone (Va.)	10	95	93	29
Marl (Va.)	4	95	70	34
Limestone (Ohio)	33	87	91	22
Limestone (W. Va.)	11	77	96	32
Marl (W. Va.)	16	93	90	29
Marl (Va.)	17	95	82	33
Limestone (W. Va.)	15	94	100	23
Limestone (Va.)	8	100	100	30
Limestone (Pa.)	10	89	99	29
Limestone (Ohio)	4	104	99	41
Limestone (W. Va.)	5	95	95	28
Limestone (Ohio)	17	91	96	31
Limestone (W. Va.)	26	90	99	26
Marl (W. Va.)	7	91	77	18
Marl (W. Va.)	7	90	79	22
Marl (W. Va.)	8	92	75	13
Marl (W. Va.)	7	90	93	36
Marl (W. Va.)	8	90	80	20
Marl (W. Va.)	6	92	94	29
Marl (W. Va.)	7	90	90	33
Marl (W. Va.)	7	91	88	31
Marl (W. Va.)	7	94	88	21
Limestone (W. Va.)	10	87	98	25
Limestone (W. Va.)	2	81	94	20
Limestone (W. Va.)	8	99	96	33
Marl (W. Va.)	7	92	80	20

TABLE 9—Sources by States of Liming Materials Purchased by A. A. A. During 1943-1944 Program Years

Program year	From West Virginia	From Ohio	From Virginia	From Pennsylvania	Totals
	tons	tons	tons	tons	tons
1943	166,139	241,720	49,571	19,730	477,160
1944	183,718	297,097	36,361	000	517,175
1943-44	349,857	538,817	85,932	19,730	994,335
Percent	35.2	54.1	8.7	2.0	100.0

Quality of Liming Materials by Companies and Sources

Illustrative of the extent and nature of the variations in quality of materials supplied by 52 companies which have served West Virginia under A. A. A. contracts, data are presented in Table 8.

In the rather small percentage of commercial material used in West Virginia which is manufactured exclusively for the agricultural trade, the chemical quality is governed by the character of the open quarry stone, the mine, or the marl bed as it exists in the natural deposit. No process of grading up or adjusting to minimum specifications seems practicable with a product of such low per-ton value. The mechanical quality of fineness, however, is controllable by the type of grinding equipment in use.

Sources and Types of Liming Materials Being Used

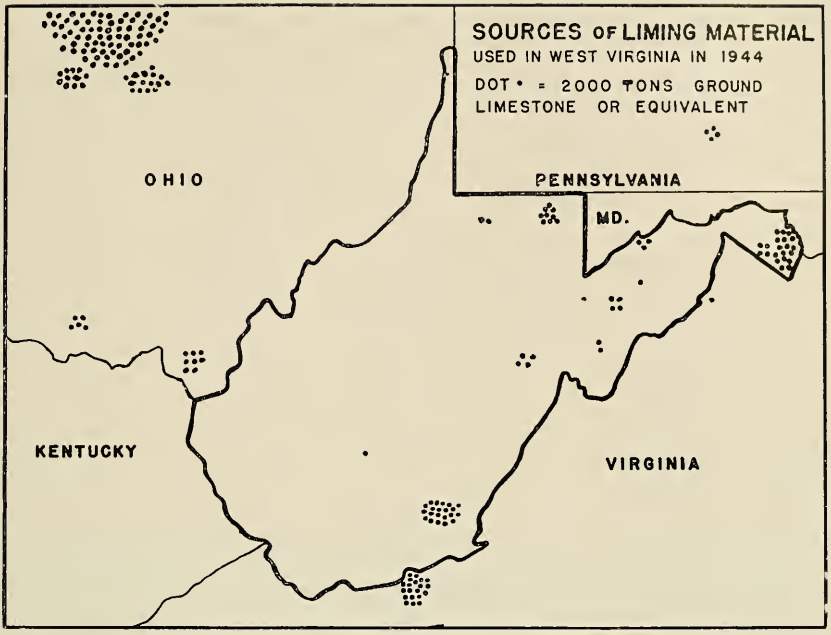
An idea of the sources of lime used in West Virginia may be obtained from purchases made by the A. A. A. during 1943 and 1944. Slightly under 1,000,000 tons was purchased and supplied to West Virginia farmers during this period. This constituted nearly 90 percent of the state's total usage for the two years. For sources by states see Table 9.

Two-thirds of the liming materials used in West Virginia in 1943-1944 came from out of state, and of this more than 83 percent came from Ohio.

Concerning 517,175 tons of liming material purchased by the A. A. A. for West Virginia farmers in 1944, the types of material are shown in Table 10.

TABLE 10—Types of Material and Proportion of Each Purchased by A. A. A. in 1944

Types of material	Amount	Percentage
	tons	percent
Amount of byproduct material	394,227	76.2
Amount of nonprocessed marl	101,728	19.7
Amount of stone (from plants grinding for agricultural use only)	21,220	4.1



Only about one-third of the liming material being used in West Virginia originates within the state. More than one-half is shipped considerable distances from Ohio into 25 or 30 of the state's western and northwestern counties. Freight charges on most of this material are about $2.50 per ton.

Attention is called to the relatively insignificant amount of material (21,220 tons) supplied by the five sources devoted to grinding limestone for agricultural use only. The small amount of this material proved inadequate to meet the needs of the five counties (Grant Pendleton, Tucker, Mineral, Marion) in which these local grinders operated; consequently an additional quantity of 13,127 tons was purchased elsewhere. The chemical quality of these local grindings averaged 3.5 percent below the state average, but the material was about equal in mechanical fineness.

Plants Grinding for Agricutural Use Exclusively

Data have been procured covering 1942-1945 with respect to 19 plants located in West Virginia which have been devoted to grinding limestone for agricultural use. These plants all are or have been small producers serving in each case a limited nearby area. Of the 19, seven have gone out of business; 5 have been producing for some time. The financial picture with respect to these small-scale lime industries is none too bright. Some of the more important facts concerning operation of these enterprises are:

(A) The production per plant has been relatively small, varying from 1,000 to 10,000 tons per year.

(B) Nearly all of the plants have had difficulty in turning out material of good quality, mainly because of the low quality of the original limestone supply. Usually, adequate fineness has been obtained.

(C) The material produced has generally been put on the local market at a high price, usually around $2.50 to $3.00 per ton f. o b. truck at plant. Frequently, high prices were necessary to cover high costs.

(D) In a few cases high prices have obviously been due to the isolated location of the plants which, being thus protected from outside competition, were able to set a higher price.

(E) Most of the plants have been set up in rather inaccessible locations because of the necessity of operating from limestone outcrops located along the Allegheny Mountains.

An inexpensive method of unloading high-sided, hopper-bottom cars. Where no underpass can be arranged, a belt conveyor (with one end in a shallow pit dug out underneath the railroad, the other end elevated over the truck bed) proves a big labor saver where a sufficient quantity is to be unloaded.

Lime Use in Adjoining States

The use of lime in adjoining states since 1938 has increased at a rate comparable with that in West Virginia. Since much of the lime used in West Virginia comes from outside the state, the growth in use in these neighboring states may affect the supply available for use in West Virginia.

Cost of Liming Material Used in West Virginia

The per-ton cost of liming materials delivered to farmyards in West Virginia is in a state of frequent change within counties as new sources are developed, old sources disappear, and competition exerts its influence. The following data relating to A. A. A. contracts in 1944, under which materials were purchased in excess of 500,000 tons, present the best picture obtainable of county costs. The per-ton figures given in Table 11 represent costs rounded out slightly for convenience in administration. Rates quoted refer to ground limestone or its equivalent, and not to burned or hydrated lime. Very little slag (around 9,200 tons) was purchased, but considerably more marl (around 100,000 tons). Except in Preston and McDowell Counties, the rates given refer to materials delivered to farmyards. The per-ton costs in 1944 were slightly higher than in previous years, but around 20 cents lower than in 1945.

Costs of ground limestone or equivalent varied widely, ranging from $1.45 to $5.55 per ton.

The per-ton cost of supplying lime on a farm-delivery basis in most counties of the state is high. In 10 counties the cost delivered to farms was $5 per ton or more and in 31 counties, $4.50 per ton or more. The weighted average cost for all counties was $4.08 per ton. After delivery of materials, they must be applied. It thus becomes clear that, except in a few favorably situated counties, the liming of West Virginia soils is rather expensive.

Three items enter into the farm-delivered cost of lime: (a) cost of material, (b) cost of freight, and (c) cost of trucking. In most cases, cost of material is not excessive. In 1944, large tonnages were procured at the plant at prices ranging from $1.00 to $1.45 per ton.

From data available on 488,133 tons of the 517,175 tons purchased by the A. A. A. in 1933, the materials were procured from the companies at a weighted average cost of $1.11 per ton. It is believed that, had the remaining 29,043 tons been included in the calculations, the total materials purchased in 1944 could have been procured f. o. b. the source, at a cost of $1.20 per ton.

Costs of Liming Materials Used, by Counties

TABLE 11—County-by-county Costs of AAA Liming Materials on a Farmyard-Delivery Basis for the Program Year of 1944

Counties, types of material, and sources (1944)		Per-ton cost delivered to farmyards
Barbour	(limestone, by rail and truck, from Ohio)	$5.05
Berkeley	(local marl, by truck)	1.50
Boone	(limestone, by rail and truck, from Ohio)	4.95
Braxton	(limestone, by rail and truck, from Ohio)	5.55
Brooke	(nearby slag, by truck, W. Va. source)	2.50
Brooke	(limestone, by rail and truck, from Ohio)	4.40
Cabell	(limestone, by truck, from Ohio)	3.40
Calhoun	(limestone, by rail and truck, from Ohio)	5.50
Clay	(limestone, by rail and truck, from Ohio)	5.15
Doddridge	(limestone, by rail and truck, from Ohio)	4.90
Fayette	(limestone, by rail and truck, W. Va. sources; also marl, by rail and truck, Va.)	3.85
Gilmer	(limestone, by rail and truck, from Ohio)	5.25
Grant	(local limestone, by truck)	4.00
Grant	(limestone, by rail and truck, W. Va. source)	4.25
Greenbrier	(local limestone, by truck)	3.65
Hampshire	(marl, by truck, W. Va. source)	4.25
Hampshire	(limestone, by truck, W. Va. source)	4.70
Hancock	(local slag, by truck)	2.75
Hancock	(limestone, by rail and truck, from Ohio)	4.40
Hardy	(local marl, by truck)	4.00
Harrison	(limestone, by truck and rail, from Ohio)	4.60
Jackson	(limestone, by rail and truck, from Ohio)	4.80
Jefferson	(local marl, by truck)	1.45
Kanawha	(limestone, by rail and truck, from Ohio)	4.55
Lewis	(limestone, by rail and truck, from Ohio)	5.00
Lincoln	(limestone, by truck, from Ohio)	4.50
Logan	(limestone, by rail and truck, from Ohio)	4.95
McDowell	(marl, at R. R. stations in the county, from Va.)	2.70
Marion	(local limestone, by truck; also, limestone by rail and truck, from Ohio)	4.50
Marshall	(local slag, by truck)	3.00
Marshall	(limestone, by rail and truck, from Ohio)	4.60
Mason	(limestone, by rail and truck, from Ohio)	4.15
Mercer	(marl, by truck, from Va.)	3.00
Mineral	(local limestone, by truck)	3.20
Mingo	(limestone, by rail and truck, from Ohio; also, marl, by rail and truck, from Va.)	4.85
Monongalia	(local limestone, by truck)	3.80
Monroe	(marl, by truck, from Va.)	3.00
Morgan	(local marl, by truck)	2.90
Morgan	(limestone, by truck, W. Va. source)	3.05
Nicholas	(nearby slag, by truck, W. Va. source)	5.20
Ohio	(nearby slag, by truck, W. Va. source)	3.00
Ohio	(limestone, by rail and truck, from Ohio)	4.35
Pendleton	(local limestone, by truck)	4.80
Pleasants	(limestone, by rail and truck, from Ohio)	4.45
Pocahontas	(limestone, by rail and truck, W. Va. source)	4.50
Preston	(limestone, at nearby plant only, W. Va. source)	1.55
Putnam	(limestone, by rail and truck, from Ohio)	4.20
Raleigh	(limestone, by rail and truck, W. Va. source; also, marl by rail and truck, from Va.)	4.05
Randolph	(local limestone, by truck)	4.20
Randolph	(limestone, by rail and truck, W. Va. source)	5.05
Ritchie	(limestone, by rail and truck, from Ohio)	4.75
Roane	(limestone, by rail and truck, from Ohio)	4.95
Summers	(limestone, by truck, W. Va. source; also marl by truck from Va.)	4.15
Taylor	(limestone, by rail and truck, from Ohio)	4.70
Tucker	(local limestone, by truck; also, nearby limestone, by truck, W. Va. source)	4.55
Tyler	(limestone, by rail and truck, from Ohio)	4.65
Upshur	(limestone, by rail and truck, from Ohio)	4.90
Wayne	(limestone, by truck from Ohio)	3.95
Webster	(limestone, by rail and truck, W. Va. sources)	5.55
Wetzel	(limestone, by rail and truck, from Ohio)	4.75
Wirt	(limestone, by rail and truck, from Ohio)	5.10
Wood	(limestone, by rail and truck, from Ohio)	4.55
Wyoming	(marl, by rail and truck, from Va.)	4.30

The lime-cost situation in West Virginia as represented by A. A. A. purchases in 1944 was as follows:

Materials Delivered to Farms: Weighted average per-ton cost of materials in the amount of 517,175 tons on a farmyard delivery basis.... $4.08.

1. *Materials Only*: Amount of above figure representing the per-ton cost of materials f. o. b. car or truck at source $1.20
2. *Transportation*: Remaining cost associated with transportation (railroad where used, plus all trucking to farms) including all miscellaneous costs such as the 3 percent transportation tax, demurrage, car unloading, truck loading at railroad destination, truck unloading at farm, trucker supervision, etc. $2.88

The cost data as to liming materials for 1944, a fairly representative year, reveal that 70.6 percent of the total farm-delivered cost is charged against transportation. Any appreciable reduction in the cost of liming soils in West Virginia thus apparently will have to be made in transportation costs, although some slight reduction is possible in cost of materials.

The weighted average freight cost incurred on the shipment of 319,826 tons of lime in 1944 in 39 counties was $2.19 per ton. Trucking costs on 517,175 tons furnished by the A. A. A. were $1.53 per ton.

Many factors influence the cost of truck transportation, the most important of which is the fact that 66 percent of the farms of the state are located on dirt roads.[15]

Financing a Limestone Program in West Virginia

It is not within the province of a discussion of the lime-supply situation to attempt to solve the many and perplexing problems associated with financing an adequate lime program for West Virginia. Obviously many of these problems must be met before the use of lime on farms will reach the ultimate desirable proportions. Neither is it within the scope of the present discussion to develop the returns one might expect in terms of monetary value from the application of lime in varying amounts, on different types of soils, and on land devoted to widely different uses. Both of these problems are worthy of more careful study and attention than they have received. Such study should contribute much toward solution of the over-all lime problem of the state.

West Virginia's Limestone Resources

West Virginia has within its borders vast, practically inexhaustible, limestone resources. The quantity possible to produce, should occasion re-

[15] U. S. census, 1940.

quire, is so enormous as to render superfluous any attempt at estimation. As to quality, much of this material is excellent for agricultural purposes, analyzing well above 90 percent calcium carbonate equivalent. The dolomites analyze around 106 percent calcium carbonate equivalent in some cases. The marls frequently analyze 90 to 95 percent or above.

Industrial Development of Limestone Resources

In connection with this natural resource, quite an extensive development has already taken place having a relationship, however, almost exclusively to industry and not to agriculture. For example, data for 1937 from the U. S. Bureau of Mines show a production by 37 active plants within West Virginia of 2,564,220 tons of crushed or broken limestone products (mainly fluxing stone, crushed stone for concrete and road building, railroad ballast, etc.). This figure is to be increased by that considerable additional tonnage of limestone made use of in the manufacture of burned lime and cement.

West Virginia ranked fourteenth among the states in 1937 in the manufacture of crushed-stone products. West Virginia plus the five states which border thereon produced in 1937 more than 32,000,000 tons, this tonnage being 33.3 percent of the entire production of the Nation. The following data for 1937 show West Virginia at the center of a vast limestone-production area.

	Tons		Tons
West Virginia	2,564,220	Pennsylvania	12,713,830
Kentucky	3,408,240	Maryland	424,830
Ohio	9,891,860	Virginia	3,353,090

That the above-mentioned development in West Virginia has taken place without reference to agriculture becomes readily apparent when the small tonnages of commercial liming materials purchased by farmers in the years prior to 1936 (about 12,000 tons annually) are considered.

Ordinarily, liming materials can be offered at a lower cost if produced as a byproduct or joint product of important industrial processes West Virginia agriculture has in recent years benefited from this circumstance. In 1944, 97,130 tons of byproduct material was supplied West Virginia farmers by seven in-state industrial plants and much more by out-of-state plants. If the use of agricultural liming materials continues to increase rapidly, there might well be a marked expansion of byproduct use to the mutual advantage of both agriculture and industry. In 1944, of the total tonnage of byproduct materials used by West Virginia farmers (394,227 tons), only about 24.6 percent originated in West Virginia. The situation suggests that an effort at expansion on the

part of manufacturers and farmers of the more economic utilization of available limestone byproducts materials would offer worth-while possibilities for all concerned.

Although West Virginia possesses vast limestone resources of high quality, they are located primarily in 15 eastern counties of the state.. Few limestone outcrops exist in the remaining 40 counties of central and western West Virginia and these are usually thin, of low grade, or so inaccessible as to have little value except locally.

Small local operations may prove practicable in certain carefully selected situations because of the considerable advantage to be gained over in-shipments through elimination of heavy transportation costs. With cheaper and more abundant farm labor the burning of lime stacks and the operation of small permanent kilns may again prove practicable in the more favorable locations. However, it is likely that this 40-county area will, as in the past, rely largely on importing liming materials from outside sources.

Development of Marl-bed Resources: Quantity and Quality

In addition to the raw-limestone resources mentioned, there are in West Virginia valuable deposits of calcareous marl (or bog lime) presumed to have been formed in ages past through the slow disintegration of limestone deposits. These marl beds are frequently located along the streams or in narrow valleys near the foot of mountains. Such deposits are found in great abundance in Jefferson and Berkeley Counties and to a very much lesser extent in the counties of Morgan, Hampshire, Mineral, Hardy, Grant, Pendleton, and possibly others.

In Jefferson and Berkeley Counties 10 marl beds are being or have been operated almost exclusively for agriculture. In addition to these commercial beds there are 12 well-known deposits and possibly others not so widely known. Doubtless some deposits in this area remain to be discovered. According to a crude method of estimating the quantity of material in a marl bed (counting 2000 tons per acre for each foot in average depth), a bed covering 1 acre and having a 7-foot depth would contain approximately 14,000 tons. The workable marl-bed resources of Jefferson and Berkeley Counties by conservative estimate contain several million tons of good material, perhaps no less than 15,000,000 tons.

The production of natural marl for agricultural purposes reached a peak in 1944. In this two-county region a total of 52,754 tons was furnished to the A. A. A. in that year. The material was furnished and delivered to farms at a cost of $1.45 per ton in Jefferson County and $1.50 per ton

in Berkeley County. In 1945 the cost was $1.39 in Jefferson County and $1.50 per ton in Berkeley County. Some material trucked from Berkeley County to farms in Hampshire County cost $4.25 per ton delivered. This latter figure serves to illustrate the effect of transportation on costs.

While much marl in the Jefferson-Berkeley area is of good quality for agriculture, this is not the case with all local deposits. Some operations have had to be abandoned mainly because of low chemical analyses, excess moisture, or presence of hard chunks necessitating grinding.

Marl is usually soft and crumbly in nature, bluish-gray to slightly yellowish in color, and noncaustic. It is found in extensive beds much as would be the case with sand and usually requires no grinding, screening, drying, or processing. It can be loaded from the bed directly into trucks and hauled to farms for immediate application. Usually some overburden must be removed, but frequently this is only a matter of 8 to 10 inches of topsoil. The top few inches of marl in a bed may be changed slightly in color by organic matter which darkens the product slightly and lowers its analysis somewhat.

Simple equipment of some sort is devised to facilitate rapid loading. A wide cylindrical scraper drawn by a tractor which circles around the bed, then drives up a constructed incline, dropping its load through an opening into a delivery truck stationed beneath, proves to be a good loading method. About a dozen trips or fewer will scrape up a load for a 5-ton truck. With larger scrapers six trips will provide a load. The material is so plentiful that weighing becomes unnecessary. A heavy rain interferes with loading and necessitates a day or two of delay for drying. Material with a moisture content of around 10 percent proves to be in good workable condition.

With respect to marl in the counties of Morgan, Hampshire, Mineral, Hardy, Grant and Pendleton, a different situation exists. Morgan County has developed a small bed or two of only fair quality, but other possibilities exist. Mineral County has no marl bed in operation, but there are some deposits. Hampshire County has a few beds of promise, and some years ago worked a deposit which required quarrying and drying as well as grinding. Several thousand tons have been worked from a bed in Hardy County at the base of a mountain. The material requires grinding. Grant County has several small beds which have possibilities but from which as yet there has been little production. At Williamsport in Grant County there is a large, undeveloped deposit of fair quality. Pendleton County has several marl beds which have not been developed, although limestone is being ground locally and delivered to farmyards at $4.80 per

ton. Outside of Jefferson and Berkeley Counties, however, marl resources represent possibilities rather than certainties, but each deposit deserves investigation because of the low cost of production associated therewith and of the small investment usually required.

A brief review of the lime resources of West Virginia would be incomplete without reference to marl deposits near Narrows, Virginia. Narrows is situated within five or six miles of the Mercer and Monroe County lines. A marl development of some consequence began here in about 1941 and has increased rapidly since. In 1944 more than 36,000 tons was purchased from this area by the A. A. A. for use by West Virginia farmers. Some grinding of a small part of the material was necessary. The plant price of the material in that year was around $1.25 per ton. Production is for agricultural use only and under normal conditions might be estimated at a maximum of around 200,000 tons per year. It is difficult to determine the extent of these deposits. The southern territory of West Virginia should in time derive its share of benefit from these resources.

* * *

The foregoing description of liming materials resources in West Virginia has necessarily been general in nature and brief. It seems desirable, therefore, to include an extended reference to a valuable work by McCue, Lucke, and Woodward, published in 1939 by the West Virginia Geological Survey under the title, **Limestones of West Virginia.** This 560-page volume contains all the significant information available to that date as to the limestone resources of the state. The volume is based on three years of intensive field and laboratory study along with data assembled in preparation of previous County Geological Reports. Chemical analyses are included with respect to 1473 limestone samples collected in 35 counties of the state along with a brief description of each sample. A large map is included showing the limestone areas of the state together with location of quarries and of each of the samples. Along with much other useful information, descriptions are given concerning outcrops in a large number of localities regarded by the authors as being worthy of consideration for local development.

THE BACK COVER

The Louderback marl bed illustrated on the back cover is typical of the natural marl deposits in Berkeley and Jefferson Counties. In operation, the surface of the bed is loosened up with a double-disk harrow; then the material is scraped up with the cylindrical scraper attached to the tractor and is dragged up to the top of the loading pit. Material is then dropped through an opening into the spreader truck, which has been backed into loading position. About a dozen rounds will load a 5-ton truck. This bed has yielded about 25,000 tons of marl to date, analyzing around 90 percent or better of calcium carbonate equivalent.

June 1947

Bulletin 329

October 1947

Agricultural Experiment Station
College of Agriculture, Forestry, and Home Economics
West Virginia University
C. R. Orton, Director
Morgantown