World Supplies of Phosphorus Fertilizers.

WORLD SUPPLIES OF PHOSPHORUS FERTILIZERS

John R. Douglas, Jr., and E. A. Harre

Introduction

In any study of the fertilizer industry the phosphate portion must take a predominant place. It was from the phosphate industry that the fertilizer industry as we know it today developed. The industry began with the use of sulfuric acid to acidulate bones to make phosphorus more available and has evolved into an industry vital to the world's welfare.

Elemental phosphorus was discovered in 1669 by Hennig Brandt of Hamburg, Germany. As was the case with most chemists of his day, he tried to keep this discovery a secret, but other chemists soon found out how to make phosphorus and discovered it in many chemical combinations. They also found that phosphorus is an essential element for every living cell of both plants and animals.[1]

Over a hundred years later, Sir Thomas Malthus brought forth his theory that overpopulation and mass starvation were inevitable. Since that time we have continued to hear this concept. Dire forebodings, at times, have bordered on complete defeatism. Yet today, more than a century and a half later, the world is feeding its people--in many cases, much better than before.

The Malthusian theory has been proven wrong for several reasons. New productive lands have been brought into agricultural production, new varieties of crops have been discovered, new methods of cultivation have been developed, vast acreages have been irrigated, and the use of fertilizers has prevented our soils from becoming depleted and nonproductive as envisioned by Malthus.

All of these factors, with fertilizer in the forefront, have combined to keep food production in developed nations in step with population increases. In fact, world food production per capita has increased over 1953-57 levels. In the developing regions, however, per capita food production is decreasing.[2] The increased population pressures on the food supplies in these areas challenge the world fertilizer industry to continue its technological achievements and further expand its production in order to maintain per capita food production throughout the world.

This paper deals with phosphate fertilizers--an essential part of any plan to increase world food production. It will delve into the short-range supply and demand situation for phosphates and into some of the probable short-range trends in the product mix of the phosphate industry. Phosphate rock, the basis of all phosphate fertilizers, also is discussed.

World Trends in Phosphate Fertilizers

To explore the future demand for phosphatic fertilizer on a world-wide basis, a look should be taken at past and present trends in the use of phosphates in the various regions of the world.

In 1955 more than 7.5 million tons of P_2O_5 was consumed as fertilizer. Over 5 million tons of this was used in Western Europe and North America and over 7 million tons was used in the more developed areas. Only 400,000 tons was used in the countries which we designate as developing countries.

Use of P_2O_5 has increased in every area of the world. On an absolute basis, the big increase has been in the developed areas. In 1965 these areas used over 12 million tons of P_2O_5--an increase of almost 5 million tons. It is significant that almost 1-1/2 million tons of this increase was accomplished in the countries of Western Europe where agriculture is most intensive. In North America the total increase during this period was 1.1 million tons of P_2O_5. In Eastern Europe the increase amounted to 1.6 million tons.

The developing countries showed an increase of 1.5 million tons in this 10-year period.[3] Table 1 shows the increases that have occurred in P_2O_5 consumption between 1955 and 1965 and the estimated 1970 consumption. Much has been made of the percentage increases in P_2O_5 consumption in the developing countries--an increase of well over 100 percent. These increases must be viewed, however, in terms of absolute figures if a supply-demand balance for future years is to be obtained through proper planning.

Many have pointed out that in the period 1960 through 1965 the rate of increase has been considerably higher than the rate during the previous 5 years. Some have suggested that this recent increased rate of consumption can be extrapolated indefinitely, or for at least 10 or 15 years. Very few market analysts, however, are truly expecting such an occurrence. It is possible; it is to be hoped for; it is even quite probable in the short-run. But can we expect such increases to occur consistently over a long period? Have we reached a "millennium" in which worldwide political and economic stability is sufficient for a rapid and uninterrupted growth?

Some researchers have contended that most of the recent increase in fertilizer use in developing nations has been more a function of foreign aid programs than of a truly effective demand. If this is the case, then further expansion of the fertilizer market in these developing nations might well depend upon further expansion of foreign aid programs. Will the developed nations be able, and willing, to continue increasing these programs involving fertilizers? This may well be the most important question in making forecasts of future demand for fertilizers.

Demand for Phosphatic Fertilizers

Within the past 2 or 3 years we have seen various and sundry estimates of "requirements for," "need for," and "demand for" fertilizers of all types. Estimates have varied widely--some apparently based upon straight-line projections of past trends, others based upon other types of projections. Tremendous increases in "requirements for" and "need for" fertilizers have been indicated. These estimates as they were made generally have been bounded by such parameters and under such assumptions as to make each of them accurate if taken strictly within context.

Several estimates have been made of fertilizer "requirements." These estimates have assumed that world population will continue to expand at a consistent rate. They are also limited by the assumption that world population will "need" so much food to maintain a minimum diet. One projection of this type, by Mr. L. J. Carpentier, predicts that by 1970 plant nutrient requirements in developing countries alone will be about 4.0 million tons of P_2O_5.[4] Mr. Anthony E. Cascino of IMC has set a 1980 goal for total world "requirements" of over 113 million tons including N, P_2O_5, and K_2O.[5] FAO has quoted a suggested "need" of 53 million metric tons by 1970 and 80 million metric tons by 1980.[6] Extrapolations of 1948-1963 growth rate of world fertilizer consumption, made by Ewell, indicate that 100 million tons of plant nutrients will be used by 1980, with 25 million metric tons being P_2O_5.[7]

Many other estimates of "requirements" or "needs" have been made. Among the latter are those made by TVA in a study entitled "Estimated World Fertilizer Production Capacity as Related to Future Needs."[8] In this estimate the world "requirements" by 1970 will exceed 67 million metric tons of plant nutrients. No breakdown was made on how much of this would be phosphates.

In contrast to this large number of studies of "needs" and "requirements" few projections have been made of actual consumption of fertilizers by 1970. Dr. Russell Coleman of The Sulphur Institute has made what is considered to be the best approach to answering this question. Of course, Dr. Coleman also had to make certain assumptions as to the stability of the overall political and economic picture. His estimates also include the thinking of many of the worldwide leaders of the fertilizer industry. His projections of probable actual consumption of fertilizer, as indicated in Table 1, fall well below the estimates based on "requirements" and "needs." They are far above anything the world has seen in the past. For example, phosphorus will increase almost 50 percent by 1970. These projections indicate consumption of approximately 57 million metric tons of plant nutrients by 1970 as contrasted with the 1964 use of 37 million metric tons. Projected use of phosphate as fertilizer exceeds 18 million metric tons as contrasted with 12.6 million metric tons in 1964. Also to be noted is the fact that these figures exclude Albania, Mainland China, and the other Communist countries of Asia for which statistics are not available.[9]

Regardless of the type of estimate used, one thing becomes clear in any study of the phosphatic fertilizer market--this market is expanding. It is growing more rapidly than is the total rate of industrial expansion and it can be expected to do so for many years. As will be pointed out later, tremendous expansions in productive capacity for phosphates are already under way. Most analysts expect that probable expansions in the demand for phosphatic fertilizer, along with that for the other plant nutrients, will be of such magnitude as to prevent a major oversupply situation for any extended period of time. At the same time, the total phosphate industry of the world may operate at less than full capacity for short periods as the rapid buildup of productive facilities continues.

For the United States, projections of fertilizer use have seen many different approaches. Each has been based upon different evaluations of our national policy toward crop production and our economic stability and well-being. Some have even been based upon predicted weather conditions.

Last fall 10 leading figures in the fertilizer industry were asked to make their individual projections of the total U. S. consumption of N, P_2O_5, and K_2O through 1980.[10] Figure 1 is the result of this survey and shows actual 1964 consumption by regions and the expected increases for 1970 and 1980. Some of these "experts" included the results of a complicated statistical analysis; others admittedly took a "horseback approach." Without exception, however, it was the opinion of this panel that P_2O_5 consumption would continue to increase in all areas of the U. S., with the largest increases in the East North Central and West North Central states. The 1970 projections shown on the chart are straight-line interpolations; however, several members of the panel expected larger increases in the period 1965 through 1970 than between 1970 and 1980. They did not indicate how much larger or what percent of the total increase would occur between now and 1970.

The worldwide demand for phosphate fertilizer can be expected to increase rapidly between now and 1970. Barring a major catastrophe, there should be about a 40 percent increase in the total phosphate fertilizer market between 1965 and 1970. A majority of this increased use will occur in the developed countries where actual consumption will be about equal to needs and capacity will exist to produce the necessary fertilizers. "Needs" will not be met in the developing countries.

The capability should exist by 1970 in the developing countries as a whole to produce in the range of Dr. Coleman's projected use. This, however, does not tell the true story. Future capacity in the developing countries is planned for very few of these countries, while others have no plans for production of any kind. It may be possible to build P_2O_5 plants more economically in some undeveloped countries. However, in others the P_2O_5 may be imported more economically. It is certain that many of the developing countries will need to continue importing finished fertilizer products to keep abreast of their expanding populations if no additional facilities are provided.

What remains is to make rapid adjustments in the developing countries through an education program that will encourage the use of fertilizers up to a level approaching needs and thus exceeding the 1970 projected use. The world fertilizer industry is ready, willing, and able to assist the developing nations in meeting their fertilizer requirements. The supply of fertilizers can be made available--effective demand must be created.

Supply of Phosphatic Fertilizers

From the overall viewpoint, the supply side of phosphatic fertilizers appears to be progressing rapidly. True, many of the countries--especially among the developing nations--do not have the capacity nor planned capacity for supplying the required amounts of phosphatic materials. For some of these, it may be economically unwise to plan for production facilities. Offsetting these nations where supply is expected to be short, there are other areas of the world which have the capacity and firm plans for additional capacity which should be able to supply the demand for phosphate fertilizers in the deficit areas.

Before we look at the product mix of finished phosphatic fertilizers, a brief review of the supply picture for phosphate rock is necessary, because this raw material is the basis of the entire industry.

During the past 10 years world production of phosphate rock has increased at phenomenal rates. The 1955-59 average world production was estimated at only 34 million metric tons. By 1964 this had grown to approximately 59 million metric tons.[11] The United States during this period supplied approximately 40 percent of the total market; Africa, 25 percent; and Russia, between 16 and 22 percent. In 1964 these three areas supplied 89 percent of the world production of phosphate rock. Other areas, such as the Pacific Islands, the Near East, and the Communist Far East, have supplied the remainder. Table 2 indicates regional production of phosphate rock for the past 5 years and estimated production for 1970.

Various estimates have been made of the probable demand for phosphate rock by 1970. These estimates have ranged all the way from 70 to 90 million metric tons.[12] Even if the higher figure of 90 million metric tons is required, it appears, from our limited survey of the phosphate rock industry, that the world producers have firm plans to supply this amount of material.

U. S. producers of phosphate rock in 1965 had productive capacity approximating 27 million metric tons. Additional capacity exceeding 10 million metric tons is under development. This 10 million metric ton figure does not include at least one project which has been announced without giving a capacity figure. Thus, by 1970 the United States alone will have capacity to produce almost as much phosphate rock as was used by the entire world in 1960. Table A is a listing of the U. S. phosphate rock producers, their capacities, and announced future plans.

The nations of North Africa which have ample reserves of phosphate rock have continually increased productive capacity of these mines for the past 10 years. Reported plans indicate further expansion, perhaps at an increasing rate. Morocco expects to increase capacity by at least 1 million tons per year each year through 1970. Israel, Jordan, Tunisia, and Senegal have each announced increases in future production and shipment of phosphate rock to the world markets. Africa almost certainly will provide a minimum of 20 million tons of rock per year by 1970, with a clear possibility of reaching 25 million tons.

Russia is estimated to have produced 13 million metric tons of phosphate rock in 1964. Many reports indicate that a larger proportion of Russia's total resources is to be devoted to agriculture and it has been reported that annual production of their Kola rock will reach 14-1/2 million metric tons. Additional production is planned at Kingissepp and Dzhanatass; thus, Russian production by 1970 could well reach 25 million metric tons.

In addition to these three major sources of phosphate rock there may well be other expansions by 1970. Frequently we hear rumors of special study groups investigating the possibilities of opening mines in completely new areas or expanding mines in areas where small amounts of rock are already being produced. Among these possibilities for new or increased production are projects in Australia, Peru, Colombia, Brazil, Spanish Sahara, France, Turkey, India, and China. Most certainly we have overlooked some in this list, and it is just as certain that there are others going on which have not been reported. It is known that there are phosphate deposits over much of the earth's surface. Finding phosphate is not a difficult job. Finding phosphate in sufficient quantity and of a quality that can be used--and in a feasible location--is a different story. With the advance of technology in the phosphatic fertilizer industry, however, it becomes increasingly clear that the world need not fear a shortage of total phosphate reserves in our lifetime nor in the lifetime of our grandchildren. Table 3 gives an indication of the known phosphate rock reserves.

In a recent study of estimated world fertilizer productive capacity and its relationship to future needs, it was found that at the end of 1965 the world phosphate fertilizer industry had a capacity to produce almost 18 million metric tons of P_2O_5.[8] Planned additions which will probably be in operation well before 1970 are indicated to be in the range of 9 million metric tons, excluding targets set by Russia and Mainland China. If we include these targets, productive capacity could reach well over 31 million metric tons of P_2O_5 by 1970.[13] Table 4 shows the actual world production of P_2O_5 in 1965, estimated capacity in 1965, and total announced capacity by 1970. Of course, a portion of this P_2O_5 capacity will be required for industrial uses. Currently an estimated 18-20 percent of all phosphorus produced is being used for industrial purposes. This indicates a probable world industrial use approaching 3 million metric tons of P_2O_5. By 1970 industrial uses will probably increase to something in the range of 4 to 5 million metric tons of P_2O_5. There should be in the range of 26 to 27 million metric tons of P_2O_5 productive capacity available for fertilizer use by or before 1970.[14]

Much of this capacity will be located far from the area in which it probably will be used. In many nations--especially among the developing nations--there will still be shortages. As long as these shortages exist within many different countries, the world phosphate industry can expect to see additional planning being done to determine if additional facilities should be installed.

Product Mix of Finished Fertilizer Products

Review of the demand situation has shown the need for large increases in production of finished phosphate fertilizers by 1970. It is also clear that sufficient phosphate rock can be made available to supply any foreseeable increase in demand during this period of time. The next logical step is to determine what types of products will be demanded and what type of plant complex can be expected. The answers now are not quite as clear. Specific trends have developed and are developing. Few of these trends, however, indicate quantitatively the exact place of each component of the world's product mix for phosphatic fertilizers.

Trends in production facilities for the United States are clearer than they are for the world in general. However, these trends cannot be taken as guidelines for the rest of the world because they are brought about by economic pressures of different raw materials, production facilities, and distribution channels. Since the picture on product mix of finished phosphatic fertilizers for the world is not as clear as that for North America, the major portion of what we shall cover will be of necessity related to the United States and Canada.

During the past 15 years there has been a consistent shift in the U. S. to use of phosphate in multinutrient and mixed fertilizer materials instead of straight materials for direct application. This trend has been accentuated by the recent development of the diammonium phosphate industry and its relationship to bulk blending. We fully expect this trend to continue during the next 5 years. Figure 2 shows the amount of P_2O_5 being consumed in mixtures and in straight materials in the United States.

Everyone would like to know how much material has been sold in bulk versus materials sold as bagged mixed fertilizer. In short, what is the growth rate for bulk blending? While we do not know precisely how much material is being handled by bulk blenders, the amount of material that is shipped to retail dealers in bulk form indicates that this growth has been exceptionally rapid, as shown in Table 5. This trend can be expected to continue through 1970, at least in the United States. There is little evidence, however, that this type of production and distribution pattern has any great value in most other countries of the world--at least, not under present conditions.

Liquid fertilizers are expected to continue to increase in importance as a method of fertilizer distribution in North America. Liquid materials and the numbers of liquid plants, as shown in Table 5, have grown steadily even with the much more rapid growth in bulk blending. Liquids lend themselves well to the large farm units that are prevalent in the U. S. and they can be easily integrated into farming systems that are already based around the application of nitrogen solutions as side dressing. The past problems of low analysis may have slowed the overall growth of liquids, but it appears that technology is now overcoming these problems satisfactorily and we can expect the distribution of fertilizer in liquid form to grow in importance in the United States. We see less growth in the use of liquids on a worldwide basis than in North America because of the relatively small farm units and the prevalence of well established distribution systems built around solid mixed fertilizers.

With the advent of triple superphosphate in the 1940's and diammonium phosphate in the late 1950's and early 1960's, phosphoric acid has become the major intermediate product in the U. S. phosphatic fertilizer industry. Before the advent of these two products, the fertilizer industry depended upon sulfuric acid for rock acidulation. However, in order to obtain the higher analysis fertilizer materials phosphoric acid must be used. Figure 3 shows the growth of total phosphoric acid production in the United States and the growth of both furnace acid and wet-process acid. Furnace acid shows a relatively slow but steady increase, mostly because of industrial uses. Wet-process phosphoric acid has been a much more spectacular growth item and can be expected to grow even more in the future, as indicated by our estimations of planned production capability by 1967. Wet-process phosphoric acid producers and plant capacities are shown in Table B.

The production of normal superphosphate, concentrated superphosphate, and ammonium phosphates is shown in Figure 4. For many years normal superphosphate has been the basic carrier of P_2O_5 in the phosphate industry. The introduction of concentrated superphosphate and, later, the introduction of ammonium phosphates has brought a drastic change in the product mix of phosphatic fertilizers. Normal superphosphate is declining rapidly in relative importance. Production of concentrated superphosphate in 1964, on a total P_2O_5 basis, exceeded the production of normal superphosphate. By 1965 the production of ammonium phosphates, in terms of P_2O_5, also exceeded the production of normal superphosphate. These trends will continue, with concentrated superphosphate perhaps peaking off and ammonium phosphates increasing rapidly in relative importance.

The trend toward greater production of ammonium phosphates can be seen in Table C which lists the present U. S. ammonium phosphate plants and announced plants due by 1967. As of July 1, 1965, the U. S. had a P_2O_5 capacity, as ammonium phosphate, of 1,757,000 tons per year. By the end of 1965 or early in 1966, this had increased over 1 million tons--to 2,761,000 tons. By 1967 capacity will reach 3,384,000 tons per year, an increase of 1,627,000 tons of P_2O_5 in less than 3 years. This is almost a 100 percent increase in capacity.

The increase in productive capacity for concentrated superphosphate is not keeping pace with the ammonium phosphates. On July 1, 1965, capacity was 1,907,000 tons and by 1967 an increase of 527,000 tons is expected, bringing total U. S. concentrated superphosphate capacity to 2,434,000 tons of P_2O_5 per year. Table D is a listing of concentrated superphosphate producers.

It is interesting to note the magnitude of these projected increases in productive capacity. By 1967 ammonium phosphate and concentrated superphosphate production could account for almost 6 million tons of P_2O_5. This exceeds our present P_2O_5 production and is above the projected U. S. demand for phosphates by 1967. Thus, we could meet our domestic requirements with these two products alone and not produce any other types of phosphatic fertilizer materials.

Canadian producers, as shown in Table E, are planning a product mix similar to that in the United States. Phosphoric acid capacity and ammonium phosphate capacity will more than double by 1967, while concentrated superphosphate capacity will increase only 15 to 20 percent.

Today we hear of the possible construction of nitric phosphate plants in the United States. European fertilizer firms have long used this production process, while in the United States we generally have not considered it the most economical or efficient process. We now have six plants in the United States which use some modified process to produce nitric phosphates. Three are owned by Chevron Chemical Company. Others are, the Tennessee Farmers Cooperative plant at Sheffield, Alabama; a modified nitric phosphate plant at Escambia Chemical Company in Florida; and a new combination demonstration fertilizer unit at TVA which will produce a modified nitric phosphate fertilizer and other granular fertilizer materials. If the apparent world shortage of sulfur persists and becomes more acute, more attention will be given to the modified processes which use nitric acid or acids other than sulfuric to produce a finished fertilizer product. It should be noted that almost all of the so-called modified processes other than the Odda process still use appreciable quantities of sulfur to help increase water solubility of the phosphate. Thus, nitric phosphates per se are not a full answer to the apparent sulfur shortage.

The World Phosphate Fertilizer Industry

Expectations in the product mix for the world by 1970 are not easy to delineate. It is clear that the product mix for the United States will be primarily high-analysis diammonium phosphates, concentrated superphosphates, and other forms of high-analysis and/or multinutrient fertilizer materials, including phosphoric acid, liquid mixed fertilizers, and perhaps ammonium polyphosphates. In our recent study of the anticipated world production facilities it became evident that phosphoric acid as a prime product is receiving a great deal of attention. The producers of nitric phosphates are thinking in terms of producing wet-process phosphoric acid. The producers of thermal electric furnace acid are also moving toward wet-process acid to supply the fertilizer portion of their phosphorus requirements. It is true, of course, that some normal superphosphate plants are still being constructed or planned for areas where demand is small and surplus sulfuric acid is available. In those countries which have built up a demand for large quantities of phosphate fertilizer, however, plans for construction almost invariably call for the higher analysis materials.

The shift toward high-analysis materials is shown in Table 6. Normal superphosphate accounted for 54 percent of world P_2O_5 production in 1958, but it has been declining and is now 47 percent of the total product mix. Concentrated superphosphate and basic slag have maintained their positions, but complex fertilizers have grown in importance from 17 percent in 1958 to 25 percent of world P_2O_5 production in 1963.

It is interesting to compare the product mix in the United States (Figure 4) with the world as a whole. Normal superphosphate accounted for 38 percent of U. S. P_2O_5 production in 1963, while concentrated superphosphate amounted to 35 percent and ammonium phosphates, 28 percent. Of the 9.3 million tons of P_2O_5 produced worldwide as these three products, the relative contribution of each is 55 percent for normal superphosphate, 15 percent for concentrated superphosphate, and 29 percent for complex fertilizers.

Table 7 is a summary, by regions, of the world capacity to produce wet-process phosphoric acid. Including the United States and Canada, the world capacity for phosphoric acid production is now approximately 5,442,000 metric tons of P_2O_5 per year. By 1970 this should approach 11.3 million metric tons, a 108 percent increase. Capacity will continue to be centered in the developed regions; however, the developing countries will increase their share of the total P_2O_5 produced as wet-process phosphoric acid. We were unable to estimate the capacities for ammonium phosphates and concentrated superphosphates. A look at the numbers of plants, however, indicates that ammonium phosphate will take a larger share of the market in the years to come.

It is difficult to generalize on the route to be followed in fertilizer production, since world economic conditions vary widely from one nation to another. In some areas, where raw materials are available for making anhydrous ammonia and nitric acid but none are available to enable sulfuric acid production, some portion of the fertilizer industry certainly will use a modified nitric phosphate process of some form. Only a detailed study of the individual country and its particular requirements and resources can possibly give the correct answer as to which is the best route to follow.

World Trade in Phosphate Fertilizers

As previously pointed out, the production of phosphates will continue to be in those world regions where markets are already established. Production in these areas will adequately meet requirements, and it appears that surplus materials will be available. This brings us to the question of world trade in phosphate fertilizer.

The United States is a major exporter of phosphate rock, ranking second to Morocco. Table 9 indicates the growth of U. S. phosphate rock exports, which totaled 6,300,000 short tons in 1964. The United States does not import appreciable amounts of rock for fertilizer use.

Adequate supplies of fertilizer materials have been made available for domestic consumption by U. S. producers; consequently, phosphate imports into the United States have not been of major importance except in the case of the ammonium phosphates. Imports of these materials reached a peak in the period 1955-59 when an average of 190,000 tons of material came into this country. Since that time, imports have steadily declined until in 1964 only 95,000 tons of material was imported.

The United States, as indicated in Table 8, has become an exporter of phosphate fertilizers. Normal superphosphate exports in the 1950's averaged 250,000 tons of material per year, but have been declining until recently an average of only 100,000 tons of material per year is exported. Ammonium phosphate exports were under 100,000 tons of material per year until the past 3 years when large amounts have been moving into world trade. In 1964 almost 400,000 tons of material went into the world markets.

Exports of concentrated superphosphate have presented a different picture. Continuing increases in exports of this product have been seen since 1949. Now, over 600,000 tons of material, or approximately 15 percent of our total production, is exported.

In the export market we can also see the trend toward high-analysis materials. Concentrated superphosphates and more recently the ammonium phosphates are moving in larger and larger quantities, as shown in Table 8. Normal superphosphate exports are declining in importance. We feel that this will continue and that we may see ammonium phosphates take a larger share of the market, replacing concentrated superphosphate to some extent. This will depend in part, of course, on our domestic demand situation.

The emphasis on foreign aid by the U. S. government has had a profound effect on phosphate exports. In 1964 concentrated superphosphate and ammonium phosphate shipments to countries receiving AID loans accounted for over 60 percent of the total value of the material that was exported.

World phosphate rock trade is shown in Table 9. Morocco, the United States, and Tunisia are the leading exporters. Europe and Asia are the leading importing regions. In 1963 a total of 21 million metric tons of rock moved into world trade, with over 13 million metric tons going into Europe. Over 3 million metric tons went to Asia and 2.5 million tons moved into Australia and New Zealand. U. S. rock exports to Canada were over 1,100,000 tons of material. We foresee little change in this pattern except in Oceania where their sources of rock are rapidly being depleted. If the reported reserves found recently in Australia are not developed, then this region will be importing rock from other exporting areas.

Examination of regional world trade data shows that Europe is the major exporter of finished phosphate fertilizers, moving 847,000 tons of P_2O_5 in 1963. North America is second, but total P_2O_5 exports are only a third of the European trade. None of the other regions of the world exported more than 68,000 tons of P_2O_5 in 1963.[3]

A regional analysis, however, does not present an accurate picture of the world trade. For example, we estimate that over 55 percent of all P_2O_5 listed as exports by the European countries is imported by countries on the continent. Contrast this to U. S. data which indicates that only 15 percent moves within the North American continent. Based on "overseas shipments," the United States exports almost as much P_2O_5 as the total for all countries in Western Europe.

Table 10 indicates the relative importance of the various phosphate products in world trade. Normal superphosphate and basic slag have declined in importance. This decline would be even more pronounced if these data were based on "overseas shipments." The higher analysis materials, concentrated superphosphate and complex fertilizers which include the ammonium phosphates, are becoming more important. The United States, for example, exports almost 100 percent of its P_2O_5 as high-analysis materials. This trend is also developing in Europe and Japan, the other major producers of these materials. Africa, our major rock exporter, has recently shown indications that at least some small portion of the total P_2O_5 exported will be in the form of the high-analysis material produced at the mine site, rather than phosphate rock.

The world markets for phosphates will be expanding rapidly in the next few years. Many of the developing nations are planning to build nitrogen plants, but do not have plans at present for phosphates. Nitrogen plants can be built economically anywhere in the world where there is a source of hydrogen, water, and fuel. Phosphate plants are more economical when located near a source of rock or sulfuric acid. As more and more nitrogen is used, phosphate will become a limiting factor in crop production. To obtain higher yields, phosphate will be demanded. This demand must be met by imports until such time as economically sized phosphate production units can be built.

Economics and the Trends

Some of the changes in the product mix have been discussed--the trend toward wet-process acid, the trend toward triple superphosphate and diammonium phosphate, and the trend toward liquid fertilizers. The reasons for the changes can be explained in part by simple economics.

With more fertilizers being produced at a central location and distributed over large geographic areas, the "economic distance" of distribution has been expanded. With this expansion, it has become necessary that every advantage of high-analysis fertilizers be exploited. As a result of the long "economic distances" involved within the United States, the trend in use of phosphates has been rapidly toward the concentrated product.

Prior to the advent of low-cost methods of producing ammonia and diammonium phosphate, concentrated superphosphate held a clear-cut advantage over other solid phosphatic fertilizer products. With the introduction of diammonium phosphate, together with improved technology for ammonia production, it rapidly became clear that large economies exist for diammonium phosphate versus the production of concentrated superphosphate and some form of solid nitrogen. This is shown in Table 11. Conversion factors were furnished by The Sulphur Institute.[15] The major point is that under today's pricing systems it is more profitable for a producer to base his phosphatic fertilizer capacity around diammonium phosphate rather than around concentrated superphosphate. Under many situations existing today he can well expect double the margin per ton of P_2O_5 from diammonium phosphate as contrasted to the margin available on concentrated superphosphate. As long as economics favor diammonium phosphate so decidedly over concentrated superphosphate, it can only be expected that the product mix will continue a rapid shift toward multinutrient products at the expense of straight phosphatic fertilizers.

The same advantage exists at the buyer level. Table 12 shows a cost comparison of buying concentrated superphosphate and some form of solid nitrogen versus buying the equivalent amount of diammonium phosphate. As indicated, it is better from the purchaser's side to buy the diammonium phosphate rather than an equivalent amount of solid nitrogen and concentrated superphosphate. From the above analysis it can be concluded that both production economics and distribution economics are balanced in favor of diammonium phosphate as opposed to equivalent amounts of plant nutrients contained in solid single nutrient fertilizer products.

With the worldwide emphasis on expansion of phosphoric acid facilities, there is the continual comparison of producing electric furnace acid versus wet-process acid. It is conservatively estimated that wet-process phosphoric acid, under present economic conditions, is being produced in Florida at a cost not exceeding 60 cents per unit of P_2O_5. Under the same conditions, it is estimated that electric furnace acid costs a minimum of \$1 per unit of P_2O_5. These estimations are based upon the bare production costs and do not include cost of overhead, administration, sales, storage, shipment, etc.

Questions are raised continually regarding changing prices of sulfur and electric power and the resultant change in basic economies of electric furnace acid versus wet-process acid. Production of wet-process acid requires between 0.84 and 0.90 ton of sulfur per ton of P_2O_5. Thus, an increase in the price of sulfur of $20 per ton would increase the cost of P_2O_5 in wet-process acid only about 18 cents per unit. Since it requires approximately 6,000 kwh per ton of P_2O_5 to produce electric furnace acid, a decrease in cost of electricity by 3 mills per kwh would decrease the cost of electric furnace acid only 18 cents per unit of P_2O_5. With this type of economics facing the two processes, it may be expected that most of the new capacity for production of phosphoric acid for fertilizers will be in the form of wet-process material. Statistics on new productive facilities bear out this point with reference to both regular phosphoric acid and superphosphoric acid.

Specific requirements and other reasons may bring electric furnace acid into the product mix at isolated locations. Some firms may have requirements for portions of high-quality acid which cannot be supplied via the wet-process route, or they may have available phosphate rock which is not of the quality necessary for use in wet-process acid production. Under these conditions it is possible that additional electric furnace acid may be more available for industrial uses and, incrementally at least, for fertilizer uses.

We know that liquid phosphoric acid costs the buyer at a retail location appreciably more than solid straight phosphatic material, but this has not deterred the growth of liquid fertilizers. While phosphoric acid may cost more than equivalent solid phosphates, the nitrogen used in the liquid mixed fertilizer costs less than nitrogen in solid fertilizers. Thus, the end product as a liquid mixed fertilizer may be equal in total cost to a like amount of plant nutrients contained in solid materials. In short, they are using phosphoric acid at $1.60 per unit of P_2O_5 and nitrogen at $1.40 per unit of N to compete with solid phosphate at $1.35 per unit of P_2O_5 and solid nitrogen at $2.00 per unit. This, however, may not get to the heart of the true economics of liquid mixed fertilizers. To the best of our knowledge, no complete study has been made of the cost of application of the fertilizer on the farmer's field at the time when it is needed. Liquid mixtures are said to be used primarily as starter fertilizers and are being incorporated into the total farm production system in a way that eliminates an extra trip over the acreage planted. If this is the case, economies to the farmer may make him willing to pay more money for the liquid mixed materials.

New Products and Processes

As you can see by our previous discussion, we have come a long way in the phosphate industry in a very short time. The search continues, however, for new and better methods of production and distribution and there is the constant search for new products that carry more and more plant food per ton of material. Several new products have been found that appear to have the requirements to become mainstays in the phosphate industry.

Superphosphoric acid is the foremost of these new materials. It is made either by concentrating wet-process acid or producing furnace phosphoric acid to a P_2O_5 level of 68 to 72 percent or 75 to 79 percent, depending on the type of acid used. Because of sequestered impurities, the final concentration of wet-process acid is generally lower than furnace acid. The obvious advantage of the superacids is the lower freight costs per unit of P_2O_5.

Superphosphoric acid could lead to a host of new materials. Sequestering properties allow it to carry micronutrients in solution. Higher analysis liquid fertilizers can be made. A 54 percent P_2O_5 granular superphoshate has been produced by TVA, using superacid, and finally a 16-58-0 ammonium polyphosphate has been developed. This material is highly water-soluble either in liquid or granular form. Its adaptability to the formulation of clear liquid fertilizers should make it an important base material in this phase of the industry.

Urea - ammonium phosphate is another multinutrient fertilizer material that may contribute to the trend toward high analysis. In the production of this product, the urea-synthesis unit is simplified, all effluents are treated in one operation, and the need for a urea prilling tower and vacuum evaporator may be eliminated. Indications are that urea - ammonium phosphates are excellent fertilizer materials, especially for the fertilization of rice paddies. The dependence on rice of large segments of the world population, especially in Asia, could make this product one of the world's leading phosphate-carrying materials.

Major emphasis so far has been placed on N-P compounds. Potassium metaphosphate, which at the present time is being investigated by TVA, Scottish Agricultural Industries, and the Israel Mining Institute, is a high-analysis material containing, in the pure form, up to 60 units of P_2O_5 and 40 units of K_2O. The production economics of the material do not appear to be favorable. There may be cases however where phosphate and potash are located close together and where there is a requirement for large amounts of hydrochloric acid, a major byproduct of the process, that would make its production feasible.

There will be other new products. For example, research workers have found long chain, slowly soluble pentammonium tripolyphosphate containing 90 percent plant food. The list goes on; and with it goes the phosphate industry--ever changing and ever growing.

FOOTNOTES

1. Vincent Sauchelli, Phosphates in Agriculture, New York, Reinhold Publishing Corporation, 1965.

2. FAO, Production Yearbook, Rome, United Nations, 1964, Vol. 18, p. 30.

3. FAO, Fertilizers: An Annual Review of World Production, Consumption, and Trade, Italy, United Nations, 1964, and preliminary estimates for 1965.

4. L. J. Carpentier, "Fertilizer Production in the Developing Countries," Phosphate Notes, Paris, The International Superphosphate Manufacturing Association Ltd., May 1965.

5. A. E. Cascino, Fertilizer: A New Era of Growth, 1965.

6. F. W. Parker, D. D. Steward, and P. Peperzak, "The Expanding World Fertilizer Market," Fertilizer News, March 1964.

7. Raymond Ewell, "Agriculture's Crucial Role in the Next Decade," Agricultural Chemicals, July 1965, p. 32.

8. D. L. McCune, T. P. Hignett, and J. R. Douglas, Jr., Estimated World Fertilizer Production Capacity as Related to Future Needs, Muscle Shoals, Alabama, Tennessee Valley Authority, February 1966.

9. Russell Coleman, "Projected Use of Plant Nutrients," Changes in Fertilizer Distribution and Marketing, Tennessee Valley Authority, 1965.

10. John R. Douglas, Jr., "Changes in U. S. Plant Nutrient Use," Changes in Fertilizer Distribution and Marketing, Tennessee Valley Authority, 1965.

11. Richard W. Lewis, "Phosphate Rock," Minerals Yearbook, U. S. Department of the Interior, Bureau of Mines, Washington, D. C., 1964.

12. K. L. C. Windridge, "Phosphate Rock: Trends in Supply and Demand in Relation to World Requirements in 1970." Paper presented at Inter-regional Seminar on the Production of Fertilizers, Kiev, August 1965.

13. In computing "productive capacity" the actual production statistics for 1963 were used as capacity data for normal superphosphate, basic slag, and organic materials. No capacity estimates for plants not reporting were made and planned production targets were not included.

14. Including estimate of 0.5 to 1.0 million tons of P_2O_5 for Mainland China.

15. D. W. Bixby, D. L. Rucker, and S. L. Tisdale, Phosphatic Fertilizers Properties and Processes, Washington, D. C., The Sulphur Institute, February 1964, Technical Bulletin No. 8.

Table 1

WORLD P_2O_5 CONSUMPTION AND ESTIMATE OF USE IN 1970

Region	P_2O_5 Consumption (Fiscal Year)				Percentage Change		
	1955	1960	1965	1970	1955-1960	1960-1965	1965-1970
	(Metric Tons of P_2O_5)						
Western Europe	2,884	3,548	4,257	5,185	23	20	22
Eastern Europe	1,063	1,592	2,672	4,325	50	68	62
North America	2,283	2,560	3,425	4,492	12	34	31
Oceania	649	733	1,136	1,528	13	55	24
Africa	210	260	373	672	24	43	80
Asia	411	681	1,082	1,498	66	59	38
Latin America	162	224	537	682	38	40	27
World Total	7,662	9,598	13,474	18,382	25	40	36

Source:

FAO, Fertilizers: An Annual Review of World Production, Consumption and Trade, 1963, Italy, 1964, and preliminary estimate for 1965.

Coleman, Russell, "Projected Use of Plant Nutrients," Changes in Fertilizer Distribution and Marketing, Tennessee Valley Authority, 1965.

Table 2

WORLD PRODUCTION OF PHOSPHATE ROCK

Region	Rock Production					
	1960	1961	1962	1963	1964	1970 (range)
	(Thousand Metric Tons)					
North America	17,938	19,038	19,854	20,331	23,465	35-40
South America	1,073	852	800	509	511	-[b]
Russia	7,000	8,799	10,008	11,003	12,995	20-25
Africa	11,216	11,967	12,395	14,045	15,694	20-25
Near East	586	643	668	711	618	-[b]
Pacific Islands[a]	2,624	2,737	2,652	2,935	3,344	-[b]
Other Areas	1,392	1,460	1,700	1,865	2,210	5-10
Total	41,829	45,496	48,077	51,399	58,837	80-100

a. Includes Christmas Island.
b. Included in Other Areas.

Source:
Lewis, Richard W., "Phosphate Rock," Minerals Yearbook, U. S. Department of the Interior, Bureau of Mines, Washington, D. C., 1964.

1970 estimates by the authors.

Table 3

WORLD RESERVES OF PHOSPHATE ROCK[1]

Region	Reported Reserves (Million Metric Tons)
North America	13,742
South America	1,531
Russia	7,689
Africa	47,004
Near East	919
Pacific Islands[2]	185
Other Areas	681
Total	71,566

1. Includes apatite and all grades of rock.
2. Includes Christmas Island.

Source:

FAO, Fertilizers: An Annual Review of World Production, Consumption and Trade, 1963, Italy, 1964, United Nations.

British Sulphur Corporation, A World Survey of Phosphate Deposits, 2nd edition, London, 1964.

Table 4

WORLD P_2O_5 CAPACITY AND FERTILIZER PRODUCTION AND CONSUMPTION
1965 AND 1970

Region	Fertilizer P_2O_5 Production 1965[a]	P_2O_5 Capacity (Fertilizer and Industrial) 1965	Planned Additions By 1970	Total Announced By 1970	Plants Not Reporting[b]	Fertilizer P_2O_5 Consumption 1965[a]
		(Thousand Metric Tons)				
Europe						
Northern Europe	3,535	4,413	1,068	5,481	2	3,372
Southern Europe	930	1,120	606	1,726	1	885
Eastern Europe	1,209	1,292	635	1,927	3	1,309
Russia	1,407	915	110	1,025	14	1,360
Asia						
Western Subcontinent	49	81	305	386	-	71
India	146	245	487	732	-	150
Middle Subcontinent	3	2	27	29	-	23
Eastern Subcontinent	1	29	100	129	2	179
Japan	593	1,017	18	1,035	-	519
Mainland China	N.A.	124	-	124	-	N.A.
Pacific Island Countries	43	64	222	286	1	137
Africa						
Egypt	35	46	142	188	-	55
South Africa	175	142	122	264	-	195
Mediterranean Africa	162	433	409	842	-	70
West North Central	-	5	77	82	-	14
West South Central	-	.	-	-	-	2
East North Central	-	-	-	-	-	1
East South Central	16	42	90	132	-	31
North America						
United States	3,665	5,796	2,924	8,720	5	3,175
Canada	350	536	499	1,035	2	250
Latin America						
Mexico	60	114	388	502	1	80
Central America	-	42	-	42	-	44
Caribbean	-	8	-	8	1	85
Brazil	70	74	212	286	-	120
South America-North	79	145	208	353	2	113
South America-South	13	56	78	134	-	94
Oceania						
Oceania & Pacific Islands	1,128	1,058	443	1,501	1	1,138
Total	13,669	17,799	9,170	26,969[c]	35	13,472

a. Preliminary data. Fiscal Year.
b. Plants for which no capacity data is available.
c. Targets set by Russia and Mainland China would raise 1970 capacity to 31,341,000 metric tons of P_2O_5.

Sources:

FAO, Preliminary estimates of 1965 production and consumption.

McCune, D. L., Hignett, T. P., and Douglas, J. R., Jr., "Estimated World Fertilizer Production Capacity as Related to Future Needs," Tennessee Valley Authority, Muscle Shoals, Alabama, February 1966.

Table 5

DISTRIBUTION OF BULK AND LIQUID FERTILIZERS TO RETAIL DEALERS

Fiscal Year[a]	Bulk Fertilizers Mixtures and Materials	Number of Bulk Blend Plants	Liquid Fertilizer Mixtures	Number of Liquid Mix Plants
	(Thousand Tons)		(Thousand Tons)	
1954	1,830	N.A.	28	N.A.
1955	N.A.	N.A.	N.A.	N.A.
1956	N.A.	N.A.	N.A.	111
1957	N.A.	N.A.	245	196
1958	N.A.	N.A.	N.A.	260
1959	2,742	201	464	335
1960	3,309	441	N.A.	390
1961	3,847	736	587	538
1962	N.A.	908	N.A.	556
1963	5,563	1,326	796	617
1964	N.A.	1,536	872	717
1965	N.A.	2,551	N.A.	N.A.

a. Plant numbers on calendar year basis.

Source:

Scholl, W., U. S. Department of Agriculture, personal communication.

Commercial Fertilizer Year Book, annual, 1956-1964, Brown Publishing Company, Atlanta, Georgia.

Tennessee Valley Authority. Field engineering reports.

Keim, Myron M., "Basic Economics of Bulk Blending," Changes in Fertilizer Distribution and Marketing, Tennessee Valley Authority, 1965.

Table 6

RELATIVE CONTRIBUTION OF PHOSPHATE PRODUCTS TO WORLD PRODUCTION

Fiscal Year	Normal Superphosphate	Concentrated Superphosphate	Basic Slag	Complex Fertilizers[1]
	(Percent of Total)			
1958	54	13	16	17
1959	53	14	15	18
1960	52	13	16	19
1961	50	14	15	21
1962	49	14	14	23
1963	48	13	14	25
1964	47	14	13	26

1. Includes complex fertilizers, ammonium phosphates, other phosphatic fertilizers, and organics.

Sources:

FAO, Fertilizers: An Annual Review of World Production, Consumption and Trade, 1964, Italy, 1965.

Table 7

ESTIMATED WORLD WET-PROCESS PHOSPHORIC ACID CAPACITY AND ANNOUNCED FUTURE CAPACITY BY 1970

Region	Wet-Process Phosphoric Acid					Phosphate Products			
	Capacity 1965	Announced Future Capacity By 1970	Total Planned Capacity By 1970	Plants Not Reported[1]		Concentrated Superphosphate Plants		Ammonium Phosphate Plants	
				Present	Future[2]	Present	Future[2]	Present	Future[2]
	(Metric Tons P_2O_5)								
Western Europe	1,443,000	1,412,000	2,855,000	4	11	30	2	27	7
Eastern Europe[3]	N. A.	380,000	380,000	2	5	2	2	-	2
Africa	270,000	531,000	801,000	-	3	4	7	1	2
Near East	17,000	114,000	131,000	-	1	1	2	-	-
Far East[4]	359,000	479,000	838,000	-	2	4	1	26	8
Oceania	96,000	57,000	153,000	-	-	2	2	-	1
Latin America	77,000	433,000	510,000	-	2	2	6	-	1
North America[5]	3,180,000	2,518,000	5,698,000	-	5	19	10	38	33
Total	5,442,000	5,924,000	11,366,000	6	29	64	32	92	54

1. Not reported to avoid disclosing confidential information, or capacity unannounced. Total may not agree with plants not reported in Table 4. Data in Table 4 includes only plants for which no data is available.
2. Includes expansions.
3. Does not include Russia.
4. Does not include Mainland China.
5. From Tables B, C, D, and E.

Table 8

U. S. EXPORTS OF PHOSPHATE FERTILIZERS

Cal. Year	Normal Superphosphate	Concentrated Superphosphate	Ammonium Phosphates
		(Tons of Material)	
1950	237,940	33,729	169,545
1955	285,333	129,512	84,907
1960	153,200	313,763	107,371
1961	147,758	377,743	77,503
1962	129,839	495,331	120,537
1963	87,513	586,600	185,282
1964	192,881	600,015	361,116
1965 [a]	97,284	506,432	319,652

a. Preliminary data.

Source:
U. S. Bureau of the Census, U. S. Exports of Domestic and Foreign Merchandise, Report No. FT 410, U. S. Department of Commerce, Washington, D. C.

Table 9

PHOSPHATE ROCK EXPORTS FOR SELECTED COUNTRIES[a]

Country	1961	1962	1963	1964[b]
		(Thousand Metric Tons)		
Algeria	381	407	339	N.A.
Morocco	7,622	8,015	8,516	10,116
Tunisia	1,718	1,793	1,961	2,216
United Arab Republic	421	168	442	N.A.
Senegal	341	342	455	829
Togo	57	199	476	778
Jordan	392	373	368	627
Israel	123	82	157	180
Ocean Islands	2,953	2,725	3,023	N.A.
United States	4,189	4,310	4,683	5,719

a. Calendar year.
b. Preliminary data.

Source:
International Superphosphate Manufacturers' Association, "Phosphate Rock Statistics," London, 1961-1964.

British Sulphur Corporation, "Phosphorus and Potassium," bimonthly issues, 1965.

Lewis, Richard D., "Phosphate Rock," Minerals Yearbook, U. S. Department of the Interior, Bureau of Mines, Washington, D. C., 1964.

Table 10

RELATIVE IMPORTANCE OF PHOSPHATE FERTILIZERS IN WORLD TRADE

Fiscal Year	Normal Superphosphate	Concentrated Superphosphate	Basic Slag	Complex Fertilizers[1]
		(Percent of Total)		
1958	20	26	38	16
1959	19	25	36	20
1960	20	22	37	21
1961	20	26	29	25
1962	18	29	28	25
1963	16	27	30	27
1964	14	30	28	28

1. Includes ammonium phosphates, other complex fertilizers, organics, and other phosphatic materials.

Source:
FAO, Fertilizers: An Annual Review of World Production, Consumption and Trade, 1964, Italy, 1965.

Table 11

ECONOMICS OF PRODUCTION
CONCENTRATED SUPERPHOSPHATE VS. DIAMMONIUM PHOSPHATE

Raw Materials		Price	Concentrated Superphosphate		Diammonium Phosphate	
			Units	Cost	Units	Cost
Phosphoric Acid (54% P_2O_5)	(ton)	$33.70[a]	.648	$21.80	.87	$29.30
Phosphate Rock	(ton)	8.33	.393	3.28	-	-
Anhydrous Ammonia	(ton)	35.00	-	-	.23	8.05
Power	(kwh)	.007	7.0	.05	20.00	.14
Fuel Oil	(gal.)	.06	3.0	.18	3.00	.18
Total Raw Material				$25.31		$37.67
Other Direct Cost				1.10		1.28
Indirect Cost				1.65		2.01
Total Manufacturing Cost				$28.06		$40.96
Estimated Sales Value[b]				$56.00		$81.00
Estimated Markup for Sales, Overhead, Other Cost, and Profits				$27.94		$40.04

a. Estimated cost of 62 cents per unit P_2O_5.

b. Published prices, spring 1966.

Table 12

COST COMPARISON AT THE RETAIL LEVEL
CONCENTRATED SUPERPHOSPHATE VS. DIAMMONIUM PHOSPHATE

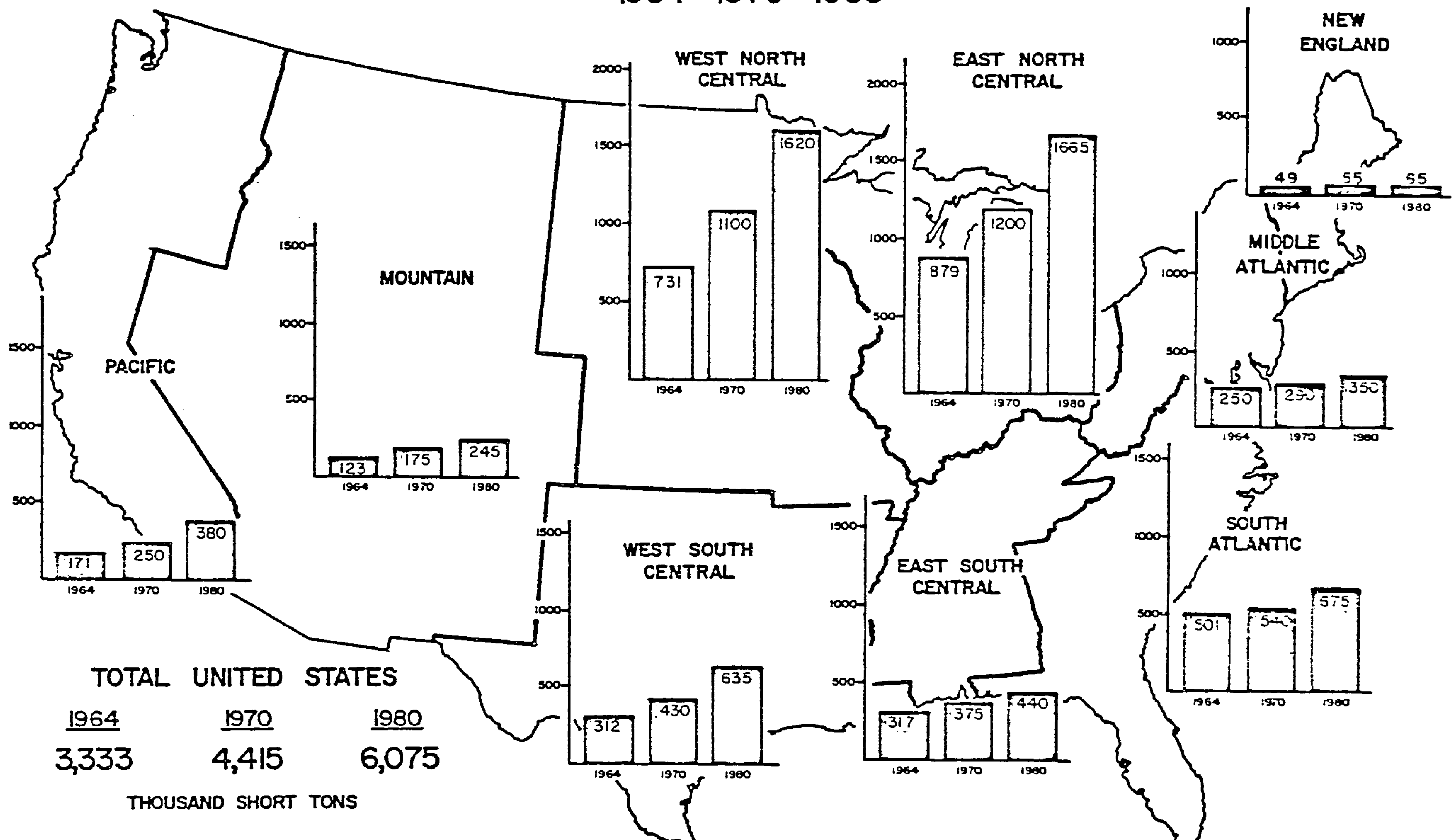
	Tons	Price[1]	Total Cost
Diammonium Phosphate (18-46-0) Equivalent			
Concentrated Superphosphate (0-46-0)	1.00	$56.00	$56.00
Urea (46-0-0)	.39	92.00	36.00
Total			$92.00
Diammonium Phosphate (18-46-0)	1.00	$81.00	$81.00
Cost Advantage			$11.00

1. Spring 1966 prices.

FIGURE—1

P_2O_5 CONSUMPTION IN THE UNITED STATES

1964—1970—1980

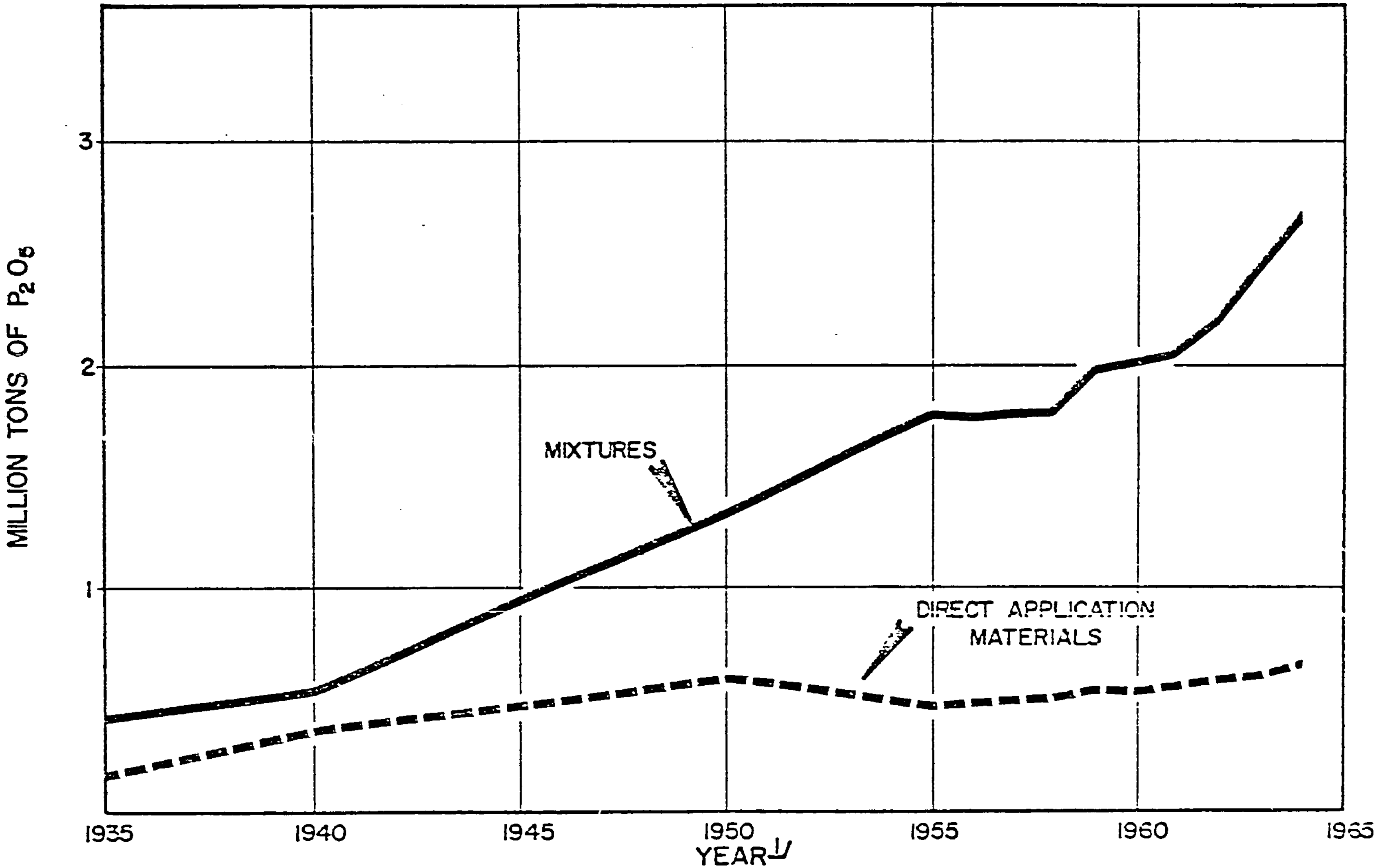


SOURCE: DOUGLAS, J.R., Jr., "CHANGES IN U.S. PLANT NUTRIENT USE," CHANGES IN FERTILIZER DISTRIBUTION AND MARKETING, TENNESSEE VALLEY AUTHORITY, MUSCLE SHOALS, 1965.

FIGURE—2

P_2O_5 CONSUMPTION

DIRECT APPLICATION MATERIALS AND MIXTURES



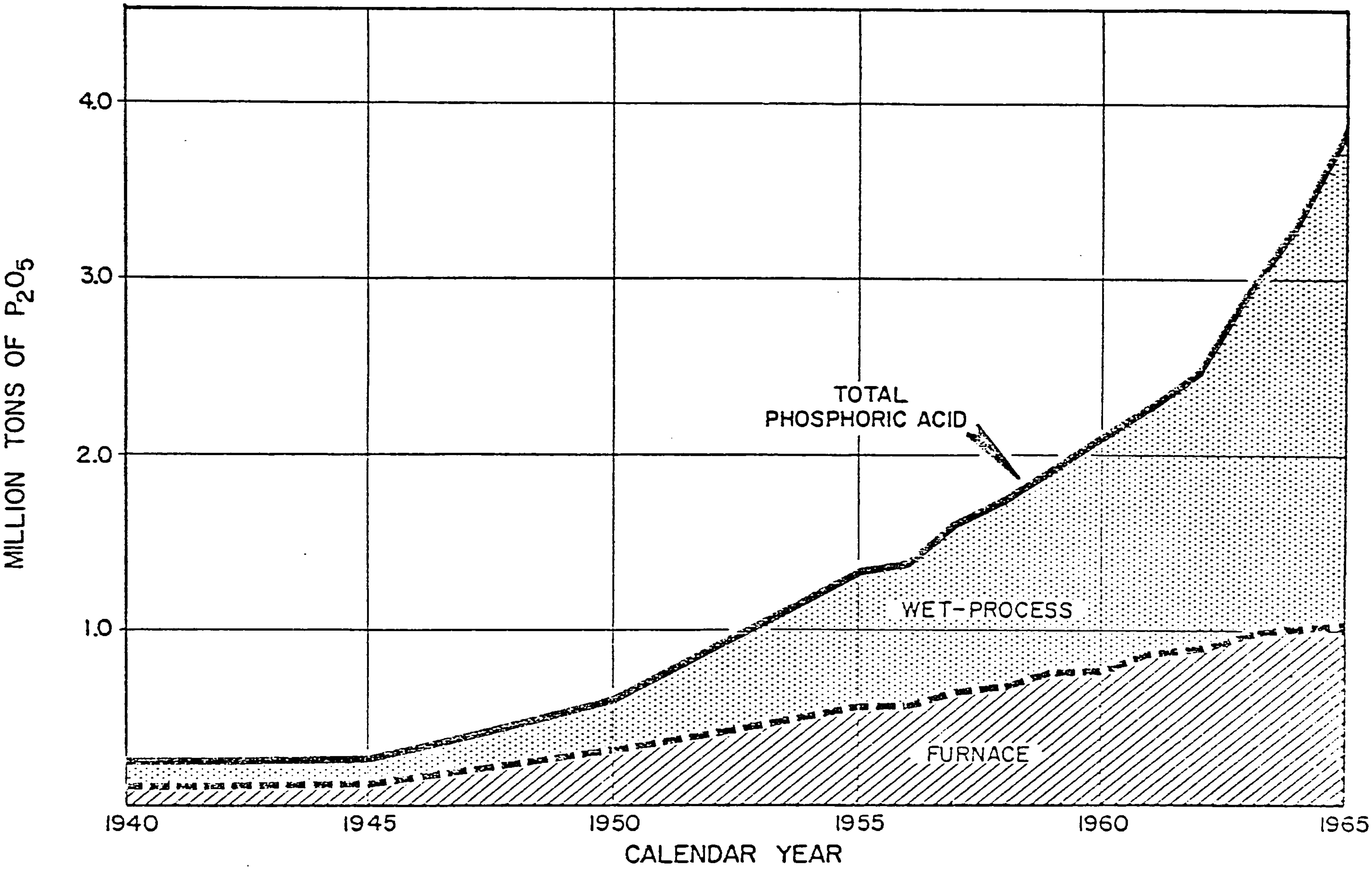
1/ 1935—1945 CALENDAR YEARS. 1946—1964 FISCAL YEARS.

SOURCE: MEHRING, A.L., et al., "STATISTICS ON FERTILIZER AND LIMING MATERIALS IN THE U.S." STATISTICAL BULLETIN NO. 191, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C., APRIL, 1957.

SCHOLL, W., et al., "CONSUMPTION OF COMMERCIAL FERTILIZERS AND PRIMARY PLANT NUTRIENTS IN THE U.S." 1940—1964, U.S. DEPARTMENT OF AGRICULTURE, BELTSVILLE, MD.

FIGURE—3

PHOSPHORIC ACID PRODUCTION

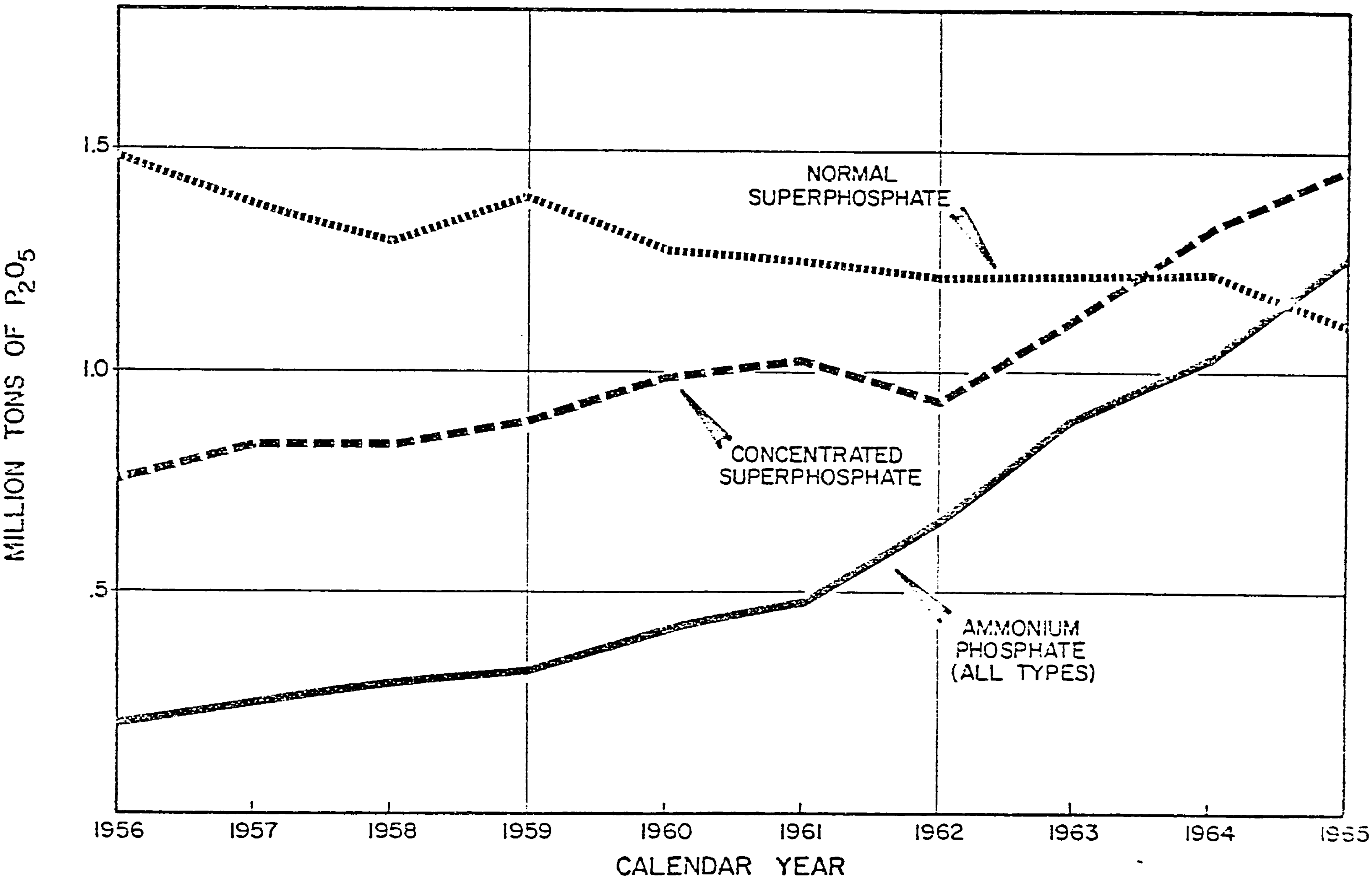


SOURCE: BUREAU OF THE CENSUS, "CURRENT INDUSTRIAL REPORTS SERIES M28A, INORGANIC CHEMICALS AND GASES", 1940—1964, U.S. DEPARTMENT OF COMMERCE, WASHINGTON, D.C.

35

FIGURE— 4

PRODUCTION OF PHOSPHATE PRODUCTS



SOURCE: BUREAU OF THE CENSUS, CURRENT INDUSTRIAL REPORTS SERIES M28D, "SUPERPHOSPHATE AND OTHER PHOSPHATIC FERTILIZER MATERIALS," 1956—1964, U.S. DEPARTMENT OF COMMERCE, WASHINGTON, D.C.

Table A

PHOSPHATE ROCK MINES IN THE UNITED STATES, PLANNED EXPANSIONS, AND NEW MINES UNDER DEVELOPMENT[a]

(January 1, 1966)

Company	Location	Present Capacity	Planned Additional Capacity
		(Short Tons of Material/Yr.)	
Florida			
American Cyanamid Company	Orange Park, Fla. Sidney, Fla.	1,900,000	-
	Bradley, Fla.	-	N.A.
Armour Agricultural Chemical Company	Armour, Fla. Lake Hancock, Fla.	1,500,000	-
Borden Chemical Company (Smith-Douglass Company)	Teneroc, Fla.	850,000	-
Continental Oil Company (American Agricultural Chemical Co.)	Palmetto, Fla. Boyette, Fla.	3,000,000	-
W. R. Grace & Company	Bonny Lake, Fla.	1,550,000	-
International Minerals & Chemical Co.	Achan, Fla. Noralyn, Fla.	6,000,000	-
	Bartow, Fla.	-	2,000,000
Kerr-McGee, Incorporated	Brewster, Fla.	-	1,500,000
Occidental Agricultural Corporation	White Springs, Fla.	1,500,000	1,500,000
Socony Mobil Oil Company (V-C Chemical Company)	Clear Springs, Fla. Homeland, Fla. Peace River, Fla.	2,850,000	2,850,000
Swift & Company	Watson, Fla. Silver City, Fla.	1,550,000	-
Total		20,700,000	28,550,000
North Carolina			
Texas Gulf Sulphur Corporation	Lee Creek, N. C.	90,000	3,000,000
Tennessee			
Armour Agricultural Chemical Co.	Columbia, Tenn.	90,000	-
Hooker Chemical Company	Columbia, Tenn.	750,000	-
Monsanto Company	Columbia, Tenn.	1,000,000	-
Presnell Phosphate	Columbia, Tenn.	700,000	-
Socony Mobil Oil Company (V-C Chemical Company)	Mt. Pleasant, Tenn.	200,000	-
Stauffer Chemical Company (Victor Chemical Company)	Mt. Pleasant, Tenn.	600,000	-
Tennessee Valley Authority	Knob Creek, Tenn. Franklin, Tenn.	200,000	-
Total		3,540,000	3,540,000
Western States			
Consolidated Mining & Smelting Co. (Montana Phosphate Products Co.)	Garrison, Mont. Phillipsburg, Mont.	1,050,000	-
El Paso Natural Gas Company	Georgetown, Idaho	400,000	-
Monsanto, Company	Ballard, Idaho	500,000	-
George Relyea	Garrison, Mont.	100,000	-
J. R. Simplot Company	Fort Hall, Idaho Soda Springs, Idaho	1,600,000	-
Stauffer Chemical Company (San Francisco Chemical Co.)	Hot Springs, Idaho Montpelier, Idaho	200,000	-
	Cherokee, Utah Vernal, Utah	600,000	-
	Leefe, Wyoming	300,000	-
(Victor Chemical Company)	Melrose, Mont.	600,000	-
Total		5,350,000	5,350,000
Total Announced Capacity		29,680,000	40,530,000

a. Based on published announcements and correspondence with industry. Corrections or additions would be appreciated by the authors.

Table 8

WET-PROCESS PHOSPHORIC ACID PLANTS IN THE UNITED STATES, PLANNED EXPANSIONS, AND NEW PLANTS UNDER CONSTRUCTION OR PLANNED BY 1967[a]
(January 1, 1966)

Company	Location	Capacity July 1, 1965[b]	Planned Additional Capacity 1965	1966	1967
		(Thousand Short Tons of P_2O_5/Yr.)			
Allied Chemical Company	East St. Louis, Ill.	50	-	-	-
	Geismar, Louisiana	-	-	-	100
	North Claymont, Del.	35	-	-	-
American Cyanamid Company	Brewster, Fla.	200	-	-	-
American Potash and Chemical Co.	Trona, California	5	-	-	-
Arkla Chemical Company	Helena, Arkansas	-	N.A.	-	-
Armour Agricultural Chemical Co.	Bartow, Florida	85	-	-	-
	Ft. Meade, Florida	190	-	-	-
Borden Chemical Company (Smith-Douglass Company)	Port Manatee, Fla.	-	-	76	-
	Streator, Illinois	33	-	-	-
	Texas City, Texas	40	-	-	-
Bunker Hill Company	Kellogg, Idaho	33	N.A.	-	-
Central Phosphates, Inc.	Plant City, Fla.	-	200	-	-
Cities Service Oil Company (Tennessee Corporation)	Tampa, Florida	340	N.A.	-	-
Coastal Chemical Company	Pascagoula, Miss.	45	90	-	-
Consumers Cooperative Association (Farmers Chemical Co.)	Lakeland, Florida	-	200	-	-
	Joplin, Missouri	53	-	-	-
Continental Oil Company (American Agricultural Chemical Co.)	Pierce, Florida	-	200	-	-
Des Plaines Chemical Company	Morris, Illinois	50	-	-	-
El Paso Natural Gas Co.	Soda Springs, Idaho	-	110	-	-
W. R. Grace and Company	Joplin, Missouri	33	-	-	-
	Ridgewood, Fla.	165	-	100	-
Hooker Chemical Co. (National Phosphate Corp.)	Marseilles, Ill.	110	-	-	-
	Taft, Louisiana	200	-	-	-
International Minerals & Chemical Co.	Bonnie, Florida	490	-	-	-
National Distillers and Chemical Co.	Tuscola, Ill.	30	-	-	-
New Jersey Zinc Corporation	Depue, Ill.	-	-	125	-
Nipak, Inc.	Tulsa, Oklahoma	30	-	-	-
Northwest Coop. Mills, Inc.	Pine Bend, Minn.	40	-	-	-
Occidental Agricultural Corp. (Best Fertilizer Co.)	White Springs, Fla.	-	-	175	-
	Lathrop, Cal.	20	-	-	-
Olin Mathieson Chemical Co.	Joliet, Illinois	125	-	-	-
	Pasadena, Texas	123	210[c]	-	-
Phillips Chemical Company	Pasadena, Texas	60	-	-	-
Phosphate Chemicals, Inc.	Houston, Texas	-	100	-	-
F. S. Royster Guano Co.	Mulberry, Fla.	30	-	-	-
J. R. Simplot Company	Pocatello, Idaho	120	120	-	-
Socony Mobil Oil Company (V-C Chemical Company)	Nichols, Florida	150	N.A.	-	-
Stauffer Chemical Company (Western Phosphates, Inc.)	Garfield, Utah	50	50	-	100
Swift & Company	Agricola, Florida	90	-	-	-
Texas Gulf Sulfur Corp.	Lee Creek, N. C.	-	-	350	-
Valley Nitrogen Producers, Inc.	Helm, California	60	-	-	-
Western States Chemical Company	Dominguez, Cal.	12	-	-	-
Total Announced Capacity		3,097	4,254	5,080	5,280

a. Based on published announcements and correspondence with industry. Corrections or additions would be appreciated by the authors.
b. Based on 54% P_2O_5 content of phosphoric acid. Capacity may include minor quantities of superphosphoric acid produ ed using same facilities.
c. Will replace existing facilities.

Table C

DIAMMONIUM PHOSPHATE PLANTS IN THE UNITED STATES, PLANNED EXPANSIONS, AND NEW PLANTS UNDER CONSTRUCTION OR PLANNED BY 1967[a]
(January 1, 1966)

Company	Location	Capacity July 1, 1965	Planned Additional Capacity 1965	1966	1967
		(Thousand Short Tons of P_2O_5/Yr.)			
AFC, Inc.	Edison, California	N.A.	-	-	-
Allied Chemical Company	Geismar, Louisiana	-	-	-	48
American Cyanamid Company	Brewster, Florida	60	92	-	-
Arizona Agrochemical Company	Chandler, Arizona	18	-	-	-
Arkla Chemical Company	Helena, Arkansas	-	N.A.	-	-
Armour Agricultural Chemical Co.	Bartow, Florida	15	-	-	-
	Cherokee, Alabama	75	-	-	-
Borden Chemical Company	Port Manatee, Fla.	-	-	85	-
	Streator, Illinois	6	-	-	-
	Texas City, Texas	25	-	-	-
Bunker Hill Company	Kellogg, Idaho	-	23	-	-
Central Phosphates, Inc.	Plant City, Florida	-	N.A.	-	-
Chevron Chemical Company	Ft. Madison, Iowa	-[c]	-	-	-
	Kennewick, Washington	-[c]	-	-	-
	Richmond, California	-[c]	-	-	-
Cities Service Oil Company (Tennessee Corporation)	Tampa, Florida	100	60	-	-
Coastal Chemical Company	Pascagoula, Miss.	220	-	-	-
Colorado Fuel & Iron Company	Pueblo, Colorado	7[b]	-	-	-
Consumers Cooperative Assn.	Lakeland, Florida	-	100	-	-
(Farmers Chemical Co.)	Joplin, Missouri	50	-	-	-
Continental Oil Company (American Agricultural Chemical Co.)	Pierce, Florida	-	92	-	-
Dominguez Fertilizer Company	Long Beach, Cal.	15	-	-	-
El Paso Natural Gas Company	Soda Springs, Idaho	-	98	-	-
Ford Motor Company	Dearborn, Michigan	10[b]	-	-	-
W. R. Grace & Company	Henry, Illinois	-	-	-	N.A.
	Joplin, Missouri	20	-	-	-
	Ridgewood, Fla.	40	-	92	-
Hooker Chemical Company (National Phosphate Corp.)	Marseilles, Ill.	76	-	-	-
	Taft, Louisiana	154	-	-	-
International Minerals & Chemical Co.	Bonnie, Fla.	230	-	-	-
Kaiser Steel Corporation	Fontana, Cal.	15	-	-	-
Monsanto Company	Luling, Louisiana	-	120	-	-
National Distillers & Chemical Co.	Danville, Illinois	15	-	-	-
New Jersey Zinc Corp.	Depue, Illinois	-	-	124	-
Nipak, Inc.	Kerens, Texas	50	-	-	-
	Tulsa, Oklahoma	35	-	-	-
Northwest Coop. Mills, Inc.	Pine Bend, Minn.	40	-	-	-
Occidental Agricultural Corp.	White Springs, Fla.	-	-	115	-
(Best Fertilizer Company)	Lathrop, Cal.	10	-	-	-
	Plainview, Texas	-	9	-	-
Olin Mathieson Chemical Company	Joliet, Illinois	80	92	-	-
	Pasadena, Texas	210	105	-	-
Phosphate Chemicals, Inc.	Houston, Texas	-	150	-	-
Shell Chemical Company	Pittsburg, Cal.	5[b]	5[b]	-	-
J. R. Simplot Company	Pocatello, Idaho	35	N.A.	-	-
Socony Mobil Oil Company (V-C Chemical Co.)	Nichols, Fla.	60	-	-	-
Stauffer Chemical Company (Western Phosphates)	Garfield, Utah	10	10	-	20
Susquehanna Corporation	Riverton, Wyoming	-	-	-	N.A.
Swift & Company	Agricola, Fla.	45	-	-	-
Tennessee Farmers Assn.	Sheffield, Alabama	-[c]	-	-	-
Tennessee Valley Authority	Muscle Shoals, Ala.	15[b]	-	-	-
Texas Gulf Sulfur Co.	Lee Creek, N. C.	-	-	100	-
United Chemical Corp.	Dothan, Alabama	-	-	-	39
Valley Nitrogen Producers, Inc.	Helm, California	11	48	-	-
Total Announced Capactiy		1,757	2,761	3,277	3,384

a. Based on published announcements and correspondence with industry. Corrections and additions would be appreciated by the authors.
b. Diammonium phosphate 21-53-0 analysis.
c. Nitric phosphate process.

Table E

PHOSPHATE FERTILIZER PLANTS IN CANADA, PLANNED EXPANSIONS, AND NEW PLANTS UNDER CONSTRUCTION OR PLANNED BY 1967[a]
(January 1, 1966)

Company	Location	Capacity July 1, 1965	Planned Additional Capacity 1965	1966	1967
		(Thousand Short Tons of P_2O_5/Yr.)			
Phosphoric Acid					
Border Fertilizer Company	Transcona, Manitoba	18	-	-	-
Brunswick Fertilizer Corporation Ltd.	Belledune, New Brunswick	-	-	-	300
Canadian Industries Ltd.	Sarnia, Ontario	-	-	65	-
Consolidated Mining & Smelting Co.	Kimberly, British Columbia	120	-	-	-
	Trail, British Columbia	120	-	-	-
Dow Chemical Company	Sarnia, Ontario	10[c]	-	-	-
Electric Reduction of Canada Ltd.	Port Maitland, Ontario	100	-	-	N.A.
	Buckingham, Quebec	-[b]	-	-	-
Multi-Minerals Ltd.	Sudbury, Ontario	2[c]	-	-	-
Northwest Nitro-Chemicals Ltd.	Medicine Hat, Alberta	38	10	-	-
Sherritt Gordon Mines Ltd.	Fort Saskatchewan, Sask.	-	44	-	-
J. R. Simplot Company	Brandon, Manitoba	-	-	85	-
St. Lawrence Fertilizers Ltd.	Valleyfield, Quebec	-	-	53	-
Western Cooperative Fertilizers Ltd.	Calgary, Alberta	-	36	-	-
Total Announced Capacity		408	498	701	1,001
Concentrated Superphosphate					
Canadian Industries Ltd.	Beloeil, Quebec	63	-	-	-
Cyanamid of Canada Ltd.	Welland, Ontario	68	-	-	-
Electric Reduction of Canada Ltd.	Port Maitland, Ontario	50	-	-	N.A.
St. Lawrence Fertilizers Ltd.	Valleyfield, Quebec	-	-	32	-
Total Announced Capacity		181	181	213	213
Ammonium Phosphates					
Border Fertilizer Company	Transcona, Manitoba	37	-	-	-
Brunswick Fertilizer Corp. Ltd.	Belledune, New Brunswick	-	-	-	313
Canadian Industries Ltd.	Lambton, Quebec	-	-	N.A.	-
	Sarnia, Ontario	-	-	64	-
Consolidated Mining & Smelting Co.	Kimberly, British Columbia	79	-	-	-
	Regina, Saskatchewan	-	46	-	-
	Trail, British Columbia	115	-	-	-
Cyanamid of Canada Ltd.	Welland, Ontario	35	-	-	-
Northwest Nitro-Chemicals Ltd.	Medicine Hat, Alberta	55	-	-	-
Sherritt Gordon Mines Ltd.	Fort Saskatchewan, Alberta	-	58	-	-
J. R. Simplot Company	Brandon, Manitoba	-	-	105	-
St. Lawrence Fertilizers Ltd.	Valleyfield, Quebec	-	35	-	-
Western Cooperative Fertilizers Ltd.	Calgary, Alberta	-	84	-	-
Total Announced Capacity		321	544	713	1,026

a. Based on published announcements. Corrections or additions would be appreciated by the authors.
b. Furnace acid plant. Two elemental phosphorus furnaces with 20,000 tons/year capacity are located at Varennes, Quebec.
c. Pilot plant.

Table D

CONCENTRATED SUPERPHOSPHATE PLANTS IN THE UNITED STATES, PLANNED EXPANSIONS, AND NEW PLANTS UNDER CONSTRUCTION OR PLANNED BY 1967[a]
(January 1, 1966)

Company	Location	Capacity July 1, 1965[b]	Planned Additional Capacity 1965	1966	1967
		(Thousand Short Tons of P_2O_5/Yr.)			
American Cyanamid Company	Brewster, Fla.	180	-	-	-
Armour Agricultural Chemical Company	Ft. Meade, Fla.	113	-	-	-
Borden Chemical Company	Port Manatee, Fla.	-	-	83	-
Central Phosphates, Inc.	Plant City, Fla.	-	N.A.	-	-
Cities Service Oil Company (Tennessee Corporation)	Tampa, Fla.	383	-	-	-
Coastal Chemical Company	Pascagoula, Miss.	135[c]	-	-	-
Consumers Cooperative Association	Lakeland, Fla.	-	36	-	-
Continental Oil Company (American Agricultural Chemical Co.)	Pierce, Fla.	-	180	-	-
El Paso Natural Gas Company	Georgetown, Idaho	90[c]	-	-	-
W. R. Grace & Company	Joplin, Missouri	32	-	-	-
	Ridgewood, Fla.	203	-	-	-
International Minerals and Chemical Co.	Bonnie, Fla.	203	-	-	-
Kerr-McGee Incorporated (Baugh Chemical Company)	Baltimore, Md.	N.A.	-	-	-
Occidental Agricultural Corporation	White Springs, Fla.	-	-	68	-
Phillips Chemical Company	Pasadena, Texas	45[c]	-	-	-
F. S. Royster Guano Company	Mulberry, Fla.	32	-	-	-
J. R. Simplot Company	Pocatello, Idaho	162	-	-	-
Socony Mobil Oil Company (V-C Chemical Co.)	Nichols, Fla.	180	N.A.	-	-
Stauffer Chemical Company (Western Phosphates, Inc.)	Garfield, Utah	45	-	-	45
Swift and Company	Agricola, Fla.	77	-	-	-
Tennessee Valley Authority	Muscle Shoals, Ala.	27[d]	-	-	-
Texas Gulf Sulfur Company	Lee Creek, N. C.	-	-	115	-
Total Announced Capacity		1,907	2,123	2,389	2,434

a. Based on published announcements and correspondence with industry. Corrections or additions would be appreciated by the authors.

b. Based on 45% P_2O_5 content.

c. Idle facilities.

d. High-analysis 54% P_2O_5 material.