Information Circular 8653

Economic Significance of the Florida Phosphate Industry

By Kung-Lee Wang, Barry W. Klein, and Andrew F. Powell
Office of Economic Analysis–Mineral Supply, Washington, D.C.

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

BUREAU OF MINES
Thomas V. Falkie, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

This publication has been cataloged as follows:

Wang, Kung-Lee

Economic significance of the Florida phosphate industry, by Kung-Lee Wang, Barry W. Klein, and Andrew F. Powell. [Washington] U.S. Bureau of Mines [1974]

51 p. illus., tables. (U.S. Bureau of Mines. Information circular 8653)

1. Phosphate industry—Florida. I. U.S. Bureau of Mines. II. Klein, Barry W., jt. auth. III. Powell, Andrew F., jt. auth. IV. Title. (Series)

TN23.U71 no. 8653 622.06173

U.S. Dept. of the Int. Library

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $1.10
Catalog No. I28.27:8653
Stock No. 2404-01692

CONTENTS

ILLUSTRATIONS

TABLES

ECONOMIC SIGNIFICANCE OF THE FLORIDA PHOSPHATE INDUSTRY

by

Kung-Lee Wang,[1] Barry W. Klein,[2] and Andrew F. Powell[3]

ABSTRACT

This Bureau of Mines study illustrates the economic significance of the Florida phosphate industry to the State and to the Nation. Environmental considerations related to phosphate industry activity are discussed briefly. Based on forecasts of Florida phosphate production in 1975, and using 1972 dollars, regional and national output value, income, and employment created by the phosphate industry were estimated for 1975. State and Federal government tax revenues generated by the phosphate industry, are also measured. Further, the concentrated impact of the phosphate industry on certain Florida areas and on regional industries is examined. Finally, the phosphate industry's importance to the U.S. balance of payments, U.S. agricultural production, and the Frasch sulfur industry is considered, in addition to byproduct fluorine, and potential byproduct uranium from fertilizer manufacturing.

INTRODUCTION

The Federal Bureau of Mines has undertaken this study to illustrate the economic significance of the Florida phosphate industry to the State and to the Nation. During the past few years Florida has become increasingly popular for recreation, retirement, and tourism. This situation has reinforced a larger, yet related development--an increased concern for the preservation and enhancement of the environment of the State and a corresponding decrease in the popularity of the phosphate industry among the State's residents. This study briefly discusses environmental problems associated with the phosphate industry, and solutions which have been found, or are being sought, through research. Illuminating the regional and national importance of this industry for a 1-year period, that is, 1975, makes clear the need for continued production of phosphate rock, in conjunction with the successful resolution of environmental problems.

Prior to a background discussion of the phosphate industry, definitions of two terms used throughout the paper are in order. "Phosphate industry" refers to the whole scope of operations, from rock mining and beneficiation

[1]Chief, Quantitative Economics Group, Office of Economic Analysis.
[2]Economist, Office of Economic Analysis.
[3]Economist, now with C. H. Powell Co., Boston, Mass.

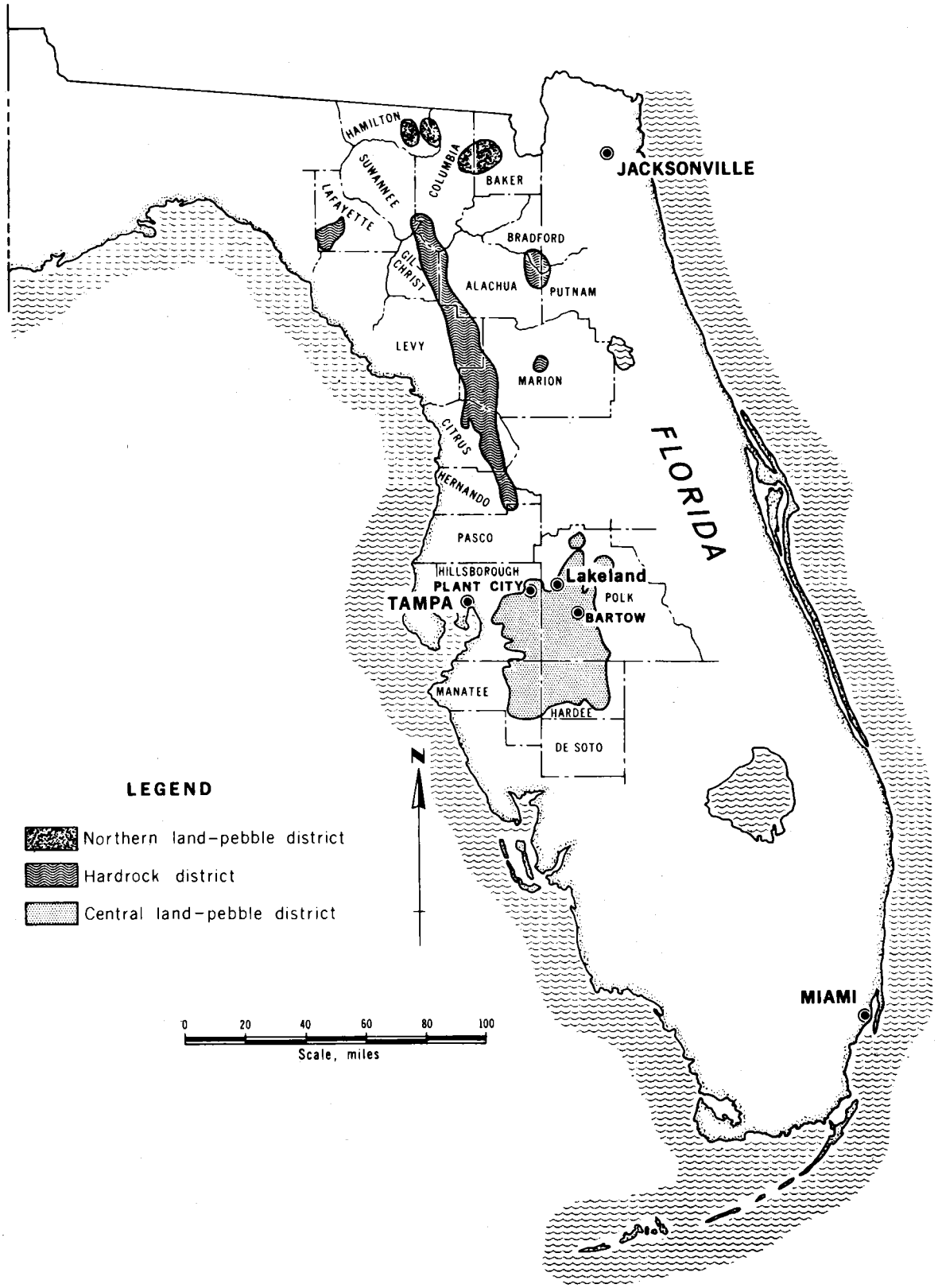

FIGURE 1. - Phosphate deposits in Florida.

through production of finished fertilizers. "Phosphate rock" refers to the marketable product after the mined ore matrix, containing concentrates, sand, and colloidal clay particles, is beneficiated.

Historical Background

In 1887 phosphate rock deposits were discovered in an area about 50 miles long and 40 miles wide (the Bone Valley formation) in Hillsborough, Polk, and Hardee counties approximately 25 miles east of Tampa in central Florida (fig. 1). These deposits occur as sedimentary beds of phosphate pebbles, sand, and clay. Because of deposit-contained phosphate rock pebbles, varying in size from a grain of sand to over 1 inch in diameter, the deposits became known as the Florida land-pebble phosphates.

Mining began in 1890, and by 1892 the value of rock mined exceeded $1 million. Similar deposits were later discovered in Hamilton County (northern Florida), where mining started in 1965.

Prior to the discovery of the land-pebble deposits, some Florida phosphate was produced from the hard-rock phosphate district, located north of the Bone Valley formation. Even though this latter district has reported large reserves, the hardness of the rock and the small size of high-grade pockets made mining more difficult and expensive than pebble phosphate mining. The last hard-rock mining operation was shut down in 1965. The hard-rock area has not been sufficiently evaluated to estimate the size and grade of this reserve. Much of this material will never be mined even if, in the future, it becomes economically attractive because it is owned, and will be developed, by real estate interests.

ENVIRONMENTAL CONSIDERATIONS

Mining and Phosphate Slimes

The Florida phosphate land-pebble deposits are mined by open-pit methods, which disturbs the land. Beneficiating the matrix produces waste sand tailings and phosphatic clay slimes. Sand tailings, that readily dewater, are used to fill in mined-out areas, and after replacement of overburden, mined land may be reclaimed.

About one-third of the mined ore matrix is a colloidal clay material or slime that is separated by washing and sizing at 150 mesh. These clay slimes, initially containing 2 to 3 percent solids, are impounded behind earthen dams. The dams, located near the washing plants, are constructed from organic-free overburden and sand tailings. After several years of settling, the slime ponds dewater to the range of 15 to 25 percent solids. After approximately 20 to 30 years of settling, the slimes compact to the order of 30 to 55 percent solids. Although the slime fraction contains phosphate values, they are not beneficiated because of the difficulty of initial dewatering and extremely high reagent consumption if the slimes were floated to concentrate phosphorus. Only clarified water from the slime and tailing ponds is reused in the processing plants.

An estimated 80 to 90 percent of the water required to beneficiate the ore is recycled from sand tailings and slime ponds. The flotation tailings, composed essentially of 14- by 150-mesh quartz sand, are easily dewatered and suitable for land reclamation.

On December 3, 1971, a phosphate slime dam broke at the Cities Service's Fort Meade plant, spilling an estimated 1 to 2 billion gallons of phosphatic clay slime into the Peace River. It was alleged that the spill caused considerable environmental damage in and along the waterway. This was the second dam break on the Peace River in less than 5 years and it caused an intense reaction from local residents. One Florida State Senator proposed that construction of slime dams after January 1, 1976 be prohibited. This action would threaten the phosphate industry's existence.

Although concern for the environment is certainly justified, slime ponds are not an environmental hazard if dams are correctly designed, constructed, and maintained. Florida slime dams that are properly maintained and continuously inspected have not had a history of failure.

Several government and industry-sponsored research programs are in progress that are intended to develop procedures to permit the return of slimes and tailings directly to mined-out areas at reasonable costs. This would eliminate the need to construct impoundment dams for the slime waste fraction. The Federal Bureau of Mines, in conjunction with the phosphate industry, has been characterizing the phosphatic clay slimes and testing techniques to dewater them. One of the methods for promoting flocculation and consolidation of slime particles is by adjustment of the particle surface charge with various electrolytes. Another method to promote flocculation and consolidation is by freezing/thawing techniques. A third method that is being tested to dewater slimes is electro-osmosis, with and without vacuum filtration.[4] Industry techniques being investigated include alternate layering of slimes and tailings in mined-out holes, and most recently, dewatering of sand tailings prior to mixing with slimes.

It is worthwhile to recognize that as phosphate rock mining shifts in future years into Manatee, Hardee, and DeSoto counties, an area south of Polk County where most phosphate mining is currently practiced, the amount of colloidal clay slimes in the matrix will be significantly less. Less slime content is also probable from northern land-pebble phosphate ores. With less slimes, slime and tailing mixtures will dewater rapidly and can then be used to reclaim mined-out land.

Water-use problems may, however, hamper expansion of the phosphate industry into counties south and west of Polk County. Phosphate mining and beneficiating, using large quantities of water, has lowered the Polk County fresh water table. Government officials in other counties are concerned

---

[4]Stanczyk, M. H., and I. L. Feld. Electro-dewatering Tests of Florida Phosphate Rock Slime. BuMines RI 6451, 1964, 19 pp.
Stanczyk, M. H., I. L. Feld, and E. W. Collins. Dewatering Florida Phosphate Pebble Rock Slime by Freezing Techniques. BuMines RI 7520, June 1971, 20 pp.

over this large water requirement by phosphate operations. One phosphate company has had its mining permit application disapproved by a county commission and is appealing the decision to the State.

Land Reclamation

More than 90,000 acres of phosphate land have been mined in central and northern Florida, primarily in Polk, Hillsborough, and Hamilton counties. According to the Florida Phosphate Council, about 10,000 acres of phosphate land were reclaimed through 1965. Although reclamation was continued, about 65,000 acres of mined-out land remain unreclaimed.

Slime ponds may occupy 60 to 70 percent of the mined-out land. Using a 60 percent figure, an estimated 42,000 acres (.60 × 70,000 acres) are occupied by slime ponds.

The phosphate industry is mining about 4,700 acres per year and it is estimated that about 3,000 acres are required for slime impoundment with the balance of mined-out land used to recover water. Eventually, a portion of the 4,700 acres mined each year will have to be reclaimed. If it is assumed that 40 percent of all mined-out land will be reclaimed, that the economic life of the Florida phosphate industry is at least 30 years, and that mining phosphate rock will continue at the present rate, there will be at least 56,000 (.40 × 4,700 × 30) additional acres of mined-out land available for reclamation. If slime dewatering systems that will permit disposal of both slimes and sands in mined-out land are developed, all land mined each year could be reclaimed for useful purposes.

Land reclamation costs vary depending on the intended use of the land. Costs to reclaim land for pasture are estimated to range from $300 to $600 per acre; costs for homesites are on the order of $1,500 per acre. An average cost of $750 per acre will be assumed. Using the 40 percent land reclamation figure above, there will be about 39,000 acres (.40 × [42,000 + 56,000]) reclaimed, in addition to the portion already reclaimed, during the economic life of the phosphate rock mining industry at a cost of approximately $30 million.

Air and Water Pollution Abatement

When phosphate rock is dried prior to grinding or shipping, phosphate rock dust is generated. As a result of industry efforts to install cyclones and bag collectors, the amount of particulate matter entering the air is minimized and does not alter air quality significantly.

Sulfuric acid is required to convert phosphate rock into fertilizers. When elemental sulfur is converted into sulfuric acid, some generated SO_2 is not converted. The industry has been successful in controlling SO_2 emissions and all new sulfuric acid plants will meet Florida State air-quality standards.

One pollutant which has proven more difficult to control is fluorine that is released in phosphoric acid plants. Phosphate rock to be processed contains 3 to 4 percent fluorine and after processing, water, containing fluorine, is discharged into storage ponds. The fluorine level of these ponds is about 1 percent and vaporization of some of this fluorine contributes to the degradation of air quality. However, rising fluorine prices permit economic fluorine recovery from several plants. Six Florida phosphoric acid producers now recover byproduct fluorine in the form of fluosilicic acid.

Pollution Abatement and Water Conservation Expenditures

The Florida phosphate industry is concerned about air and water quality, and has been working to meet standards set by the U.S. Environmental Protection Agency and the State government. The industry has spent a total of $103.4 million on environmental problems. Of this total, research and development programs and installation of pollution abatement equipment represent expenditures of $42.9 million for air quality control and $31.5 million for water quality control. In addition, $11.5 million has been spent for water conservation. In 1971 alone, operating and maintenance costs associated with these systems exceeded $10.5 million. According to the Florida Phosphate Council, the industry spent an estimated additional $7 million for equipment and systems in 1972.

ECONOMIC SIGNIFICANCE TO FLORIDA

Analytical Framework

Interindustry multipliers have been developed, through input-output analysis, which permit measurement of the total output (direct, indirect, and induced) generated to support the output of any one mining industry. The Bureau of Mines' expanded 136-sector input-output table of the U.S. economy was used to estimate multiplier effects for the Florida phosphate industry.[5]

Although the methodology and supporting data used in the impact analysis appear in appendix C, a brief review of the analytical framework will be helpful prior to presenting the results of the analysis. The Bureau of Mines' Division of Nonmetallic Minerals estimated Florida phosphate industry production, in terms of major products, for the year 1975. Assuming constant wages and productivity, and using 1972 dollars, the employment, income, and value of output of the phosphate industry in 1975 have been computed from this production estimate. National and regional multipliers were then applied to these employment, income, and value-of-output figures to determine the total effects, indirect and induced as well as direct, projected to 1975 based on Bureau of Mines' estimated growth rates. Tax payments attributed to phosphate-related activities have also been estimated for that year.

---

[5]Wang, K.-L., and R. G. Kokat. Interindustry Structure of U.S. Mining Industries--1958. BuMines IC 8338, 1967, 190 pp.
Office of Economic Analysis. Unpublished Research. Available for Consultation at Bureau of Mines, Washington, D.C.

Owing to difficulties in obtaining accurate, comprehensive information, impact estimates show the magnitude, rather than a precise measurement, of the economic effects. To avoid an appearance of spurious exactness, calculated figures have been rounded.

Output Effect

In 1972 marketable production of phosphate rock in Florida (including North Carolina) exceeded 34 million short tons.[6] Based on estimated production for Florida alone of 38 million tons in 1975,[7] projected direct output (sales) of the Florida industry for that year will be approximately $390 million. The total effect of phosphate production is much larger than $390 million. In addition to sales by the phosphate industry, sales of goods and services to the industry by its suppliers, or second level effects, must be included. In turn, third level suppliers' sales, necessitated by phosphate industry activity, to second level suppliers must be included. Fourth, fifth, sixth, etc., level suppliers can also be included, though their contribution to the total output effect becomes less and less significant. (The contribution by the sixth level and all successive level suppliers is, most likely, negligible.)

In addition to the direct and indirect effects, a third type of effect is generated. The wages and salaries paid to employees of the phosphate industry, and all levels of suppliers, lead to consumer expenditures which generate production of goods and services in many industries. This production is called an induced output effect.[8] The total output multiplier for Florida is estimated at 3.82 (Total/Direct). As seen in the following tabulation, the major portion of the estimated $1.49 billion impact is the induced output effect generated during the 1-year period (1975) being considered. The output effect of the phosphate industry in Florida for 1975 is estimated as follows in million 1972 dollars:

Direct impact.....	390
Indirect impact.....	160
Induced impact.....	940
Total impact.....	1,490

Employment Effect

Estimated employment in Florida associated with the impact types described above has been estimated as follows for 1975:

Employment	Number of jobs
Direct.....	9,900
Indirect.....	7,200
Induced.....	43,800
Total.....	60,900

[6] Production from the two States is combined to maintain the confidentiality of the production from the single operation in North Carolina.

[7] This estimate assumes that operating conditions, including availability of fuels, will be similar to that of mid-year 1974.

[8] Miernyk, W. H. The Elements of Input-Output Analysis. Random House, New York, 1963, p. 48.

Phosphate industry workers are among the most highly paid industrial labor in central Florida. A comparison, by industry type, of annual wages and employment levels for Polk County emphasizes the importance of the phosphate industry to the regional economy. The earnings figures cited in table 1 are typical of the entire Florida industry, since approximately 75 percent of the Florida phosphate industry is located in Polk County.

TABLE 1. - Comparison of labor force, earnings, and hours worked during 1972 for selected industries in Polk County, Fla.[1]

Item	Phosphate rock mining and beneficiation	Phosphate fertilizer manufacturing	Citrus food products	All manufacturing[2]
Annual labor force estimates....	4,700	2,800	6,300	14,500
Average annual wages.....	$8,303	$7,179	$6,349	$6,645
Average weekly hours.....	44.3	45.4	47.0	45.1
Average hourly earning.....	$3.60	$3.04	$2.60	$2.83

[1] Florida Department of Commerce, Bureau of Employment Service (Lakeland, Fla.) Florida Labor Market Trends--Polk County. April 1972, p. 4; May 1972, p. 4; June 1972, p. 4; July 1972, p. 4; August 1972, p. 6; September 1972, p. 4; October 1972, p. 4; November 1972, p. 4; December 1972, p. 4; January 1973, p. 4; February 1973, p. 4; March 1973, p. 8.

[2] Includes durable goods--stone, clay, glass, fabricated metal products and nonelectrical machinery; nondurable goods--food and kindred products, printing, publishing, chemicals and allied products. Mining is not included.

Phosphate industry workers earn the highest hourly wage and work the lowest number of hours weekly of all manufacturing industries in Polk County, Fla. Furthermore, they work steadily the year round with little, or no, layoff. On the other hand, employment in the citrus food products industry is seasonal, ranging from a high of 9,700 in January to a low of 3,400 in August, with an annual average of approximately 6,300. The steady flow of wages and salaries generated by the phosphate industry aids in providing a stable economy in central Florida. Similarly, workers at Occidental Petroleum Corporation's Swannee River Phosphate Division were the best paid labor in Hamilton County, northern Florida.

It is estimated that a new investment of $100,000 would be needed to provide one additional job in the Florida phosphate industry. Thus the 9,900 jobs provided by the Florida phosphate industry represent a value of about $990 million. On this basis, if the phosphate industry ceased operation, $990 million and 2 or more years lead time would be necessary to provide similar employment opportunities.

Income Effect

Total employment income of $262 million is estimated to be generated by the phosphate industry in 1975. Already included in the total output figure of $1,490 million, this $262 million is broken down as follows in million 1972 dollars:

Direct income.....	78
Indirect income.....	42
Induced income.....	142
Total income.....	262

Fiscal Impact

State and Local Tax Revenues

Florida has recently enacted a corporate income tax, but its full impact cannot yet be measured. (Florida has no personal income tax.) Corporate State income tax generated by the phosphate industry has been estimated for 1975 by applying a rate of 0.5 percent to the total phosphate-related output in Florida of $1,490 million. On this basis, about $7.5 million (.005 x $1,490 million) will be paid in corporate State income taxes by the phosphate industry and related activities in 1975.

In both 1970 and 1971, according to the Florida Phosphate Council, the phosphate industry paid more than $3.1 million in State sales tax. Tax payments of $3.5 million are forecast for 1975. Including this $3.5 million, State sales tax revenue from total phosphate-related output is forecast to exceed $13 million in 1975.

According to the Florida Phosphate Council, $100,000 in State motor fuel taxes are presently paid annually by the phosphate industry. Although complete data are unavailable, it seems safe to assume that a like amount is paid by other firms and industries as a direct result of phosphate industry activity. Thus, $200,000 per year in fuel taxes currently may be attributed to the phosphate industry.

Since July 1, 1971, Florida has been levying a severance tax on mineral production, based on the value of the mineral at the point of severance. The tax is collected on a fiscal year basis (July 1 to June 30). The tax rate was 3 percent for 1971-72 and 1972-73, is 4 percent for 1973-74 and 1974-75, and will be 5 percent for 1975-76 and thereafter. County property taxes paid by mineral producers may be deducted from severance tax payments up to 20 percent of the total severance tax. One-half of the remaining tax is earmarked for the State Land Reclamation Trust Fund. The Fund will be used exclusively for reclaiming mined-out land, that is, worked out phosphate mines. The remaining one-half of severance tax collection (40 percent of the total severance tax bill before county tax deductions and setting aside the Trust Fund share) is added to general State tax revenue.

For calendar year 1975, the severance tax rate will be 4.5 percent (6 months at 4 percent, and 6 months at 5 percent), of which 40 percent will be added to State general revenue. Therefore, new and uncommitted revenues equaling 1.8 percent of the total value of phosphate rock produced in 1975 will be available to the State of Florida. Florida phosphate rock production was previously estimated at 38 million short tons in 1975. The current State assessed value is $3.50 per short ton at point of severance. Total tax liability would be approximately $6 million, with approximately $2.4 million earmarked for reclamation, $2.4 million available for general State uses, and $1.2 million credited against county tax collections.

The contribution to State tax revenues which may be expected from phosphate industry activity in 1975 is summarized as follows in million 1972 dollars:

State corporation taxes.....	7.5
State sales taxes.....	13.0
State motor fuel tax.....	0.2
State severance tax (unrestricted)....	2.4
Total tax payment.....	23.1

In addition, in 1970 the phosphate industry paid approximately $15 million in county property taxes. Total phosphate-related output of $1,490 million was estimated for 1975. Assuming continuation of strong phosphate rock markets with rising phosphate rock prices, county evaluations of phosphate mining properties could lead to county tax assessments as high as $30 million in 1975.

Cost of Losing the Industry: State Unemployment Assistance

Should the phosphate industry cease operation, an estimated 60,900 jobs in Florida would be eliminated. Florida unemployment compensation may be estimated at $50 per week for a maximum of 26 weeks. Assuming that 60,900 applicants collect only 75 percent of the compensation for which they are eligible, State payments would total over $59 million (60,900 × $50 × 26 weeks × .75 = $59,377,500). Assuming further, that some workers would not easily find new jobs, public welfare assistance expenditures of $7.5 million could be expected. Of this, Florida will pay $3 million. (The Federal government will pay the remainder.) Thus new Florida unemployment and welfare expenditures would be about $62 million in 1975, in addition to lost tax revenues.

Economic Benefits to Particular Regions and Industries

In this section four more important areas of economic impact within the State of Florida will be examined: Polk County, the Port of Tampa, the Seaboard Coast Line Railroad, and the State electric utilities industry. These impacts are included in the previous multiplier analysis, but the importance of the phosphate industry in these specific areas and industries warrants special attention.

Polk County

Approximately 75 percent of phosphate industry activity is located in Polk County and it contributes an estimated one-third of Polk County's revenue. The 1970 available labor force was 91,800, of which 7,500 were employed in the phosphate industry. The economic importance of the phosphate industry work force has been shown to be much larger than the nominal 8 percent of the county work force it represents. Both the County government fiscal base and private economic activity throughout the county are strongly supported by, if not dependent on, the phosphate industry.

The Port of Tampa

The phosphate industry is important to the Port of Tampa, and the Port of Tampa, in turn, is important to Florida and the United States. In 1971 phosphate and related products such as sulfur, accounted for one-third of the revenue generated by the Port of Tampa, 98 percent of Tampa's exports, and 56 percent of the port's total tonnage handled.

In the immediate Tampa region (Hillsborough County), approximately 24,600 jobs and more than $138 million in wages and salaries were directly or indirectly related to port activities in 1967.[9] In the surrounding counties (Citrus, Hernando, Manatee, Pasco, Pinellas, Polk, and Sarasota), another 11,600 jobs and $71.9 million in wages were related to the port in that year. The 36,000 (24,600 + 11,600) jobs represented 13 percent of total employment in the region, and the $210 million ($138 million + $71.9 million) in wages and salaries represented 14.4 percent of total wages and salaries paid within the region in 1967. Since then, the tonnage handled by Tampa has risen by almost 50 percent,[10] proportionately increasing the economic significance of the port.

Tampa is not only Florida's most important port, but a major world port. The Port of Tampa ranked fourth nationally in value of annual tonnage exported ($171 million in 1971), eighth among U.S. ports in tonnage handled, eighth among U.S. ports in total foreign trade, and fifteenth in total imports in 1971. Phosphate exports help make Tampa a favorable balance of payments port.

The Port of Tampa is 34 feet deep. Under normal daylight and full tide conditions, Tampa can safely handle a bulk cargo ship of up to 35,560 long tons gross weight specially adapted to carry phosphatic materials. Such a ship has a draft of 43 feet 5 inches when loaded to capacity (72,000 long tons). Using the full depth of the channel, a ship loaded to a 34 feet draft, can only carry a cargo of 56,000 long tons out of Tampa according to the Tampa Port Authority. If the channel is deepened to 44 feet, as proposed, a 35,560-long-ton gross weight ship can carry approximately 70,000 long tons out of

---

[9] Heidingsfield, M. S. The Economic Impact of the Tampa Port. The International Marketing Research Center, University of Florida, September 1968, pp. 106, 109.

[10] Tampa Port Authority. 1971 Annual Report, Tampa, Fla., 46 pp. plus appendixes.

the port resulting in large-scale economies in freight rates for phosphate and related products and making Tampa an even more important port.

Seaboard Coast Line Railroad

In 1970, the Seaboard Coast Line's last year of independent operations, operating revenue was approximately $506 million, of which nearly $76 million, or 15 percent, was derived from phosphate rock traffic alone. A company executive has stated that "the commodity group involving phosphate rock, phosphate products, and phosphate fertilizers and related fertilizer materials is the largest single commodity group...contributor to (the) railroad's overall revenues..."[11]

Assuming a direct correspondence between revenue and employment, the phosphate industry provided sufficient traffic for 5,000 Seaboard Line jobs and an associated payroll of $49 million. In addition, over 700 miles of Seaboard Line track are maintained to service the phosphate industry. To further serve the industry, Seaboard Line has recently begun operation of a $14 million phosphate terminal at Rockport, in the Port of Tampa.

In 1971, the Seaboard Line merged with the Louisville and Nashville Railroad. The phosphate industry's contribution to traffic and revenues of the new railroad has declined relative to the old Seaboard Line. However, the absolute level of railroad employment, equipment use, and track dedicated to phosphate industry activity has not declined. The phosphate industry has helped build a healthy railroad in central Florida.

Electric Utilities

The Florida electric utility industry receives significant revenues from the phosphate industry. As shown in table 2, $22 million of the $25 million spent by the phosphate industry for electrical power in 1971 was spent in Florida. These revenues are important to Florida power producers.

Phosphate industry payments to Tampa Electric Co. in 1970 exceeded $15.5 million, comprised 17 percent of the company's total revenue, and 65 percent of its industrial revenue. In 1970, Florida Power Corp. received revenues of $11 million from the phosphate industry. These payments comprised 7 percent of Florida Power's total revenue, and 56 percent of its industrial revenue. Florida Power and Light also serves the phosphate industry. In 1971, 59.3 percent of the electrical power consumed by the phosphate industry was purchased from Tampa Electric Co., 39.3 percent from Florida Power Corp., and 1.4 percent from Florida Power and Light.

---

[11] Durham, E. H. Private Communication, May 30, 1972. Available upon request from Office of Economic Analysis, Bureau of Mines, Washington, D. C.

TABLE 2. - Florida phosphate industry expenditures, 1971

Item	Total	In Florida
Trucking	[1] $4,005,816	$4,005,816
Railroads	56,369,886	[2] 50,000,000
Construction	30,845,752	28,572,094
Equipment, supplies	174,764,731	101,255,971
Repairs, maintenance	48,514,288	41,101,944
Electrical power	25,000,000	[2] 22,000,000
Payroll	59,313,664	[3] 59,313,664
Ad valorem taxes, county[4]	5,215,968	5,215,968
Vehicle fuel tax, State	102,603	102,603
	407,267,981	314,703,333

[1] Total expenditures for trucking are not given but they are assumed to be at least equal to expenditures in Florida.
[2] Estimates based on information provided in total expenditures column.
[3] Assumed total payroll is expended in Florida.
[4] Only for phosphate rock mining and beneficiation operations, property and facilities.

Source: Florida Phosphate Council.

Summary

The phosphate industry is forecast to produce the following value of output and provide the following employment, income, and revenue benefits to Florida in 1975 (directly, indirectly, or by induced effects):

Total output	$1,490 million
Total employment	60,900 jobs
Total personal income	$262 million
State tax revenues:	
Corporate income tax	$7.5 million
Severance tax (unrestricted)	2.4 million
Sales tax	13.0 million
Motor fuel tax	0.2 million
County property taxes	30.0 million
Total	$53.1 million

However, if the phosphate industry ceased operation, $62 million in new unemployment compensation and welfare expenditures would have to be borne by the State in addition to lost tax revenues.

NATIONAL SIGNIFICANCE OF THE FLORIDA PHOSPHATE INDUSTRY

Domestic Profile

The central Florida land-pebble district is the largest phosphate-producing region in the world. At the current rate of production it is estimated that reserves will last at least another 30 years. However, production

may decline after 1985, or possibly sooner if an accelerated production rate is established. Since 1972 marketable production of phosphate rock in Florida (including North Carolina) exceeded 34 million short tons, Florida accounts for greater than 75 percent of U.S. phosphate rock production.

FIGURE 2. - Inland and intracoastal water routes available for ship and barge movement of phosphate rock in Eastern United States.

Florida's land-pebble region is accessible to both domestic and international trade through the Port of Tampa, Boca Grande, and Jacksonville. The Mississippi River provides direct access to the farming heartland of the United States (fig. 2). Florida phosphate has shorter distances, and with the use of barges, lower transportation costs, than Western State phosphate to Eastern and many Midwestern markets (fig. 3). In addition, Florida's land-pebble deposits have lower combined mining and beneficiation costs than Western operations. Because of these cost advantages, Florida phosphate producers provide domestic consumers with the lowest cost fertilizers currently available.

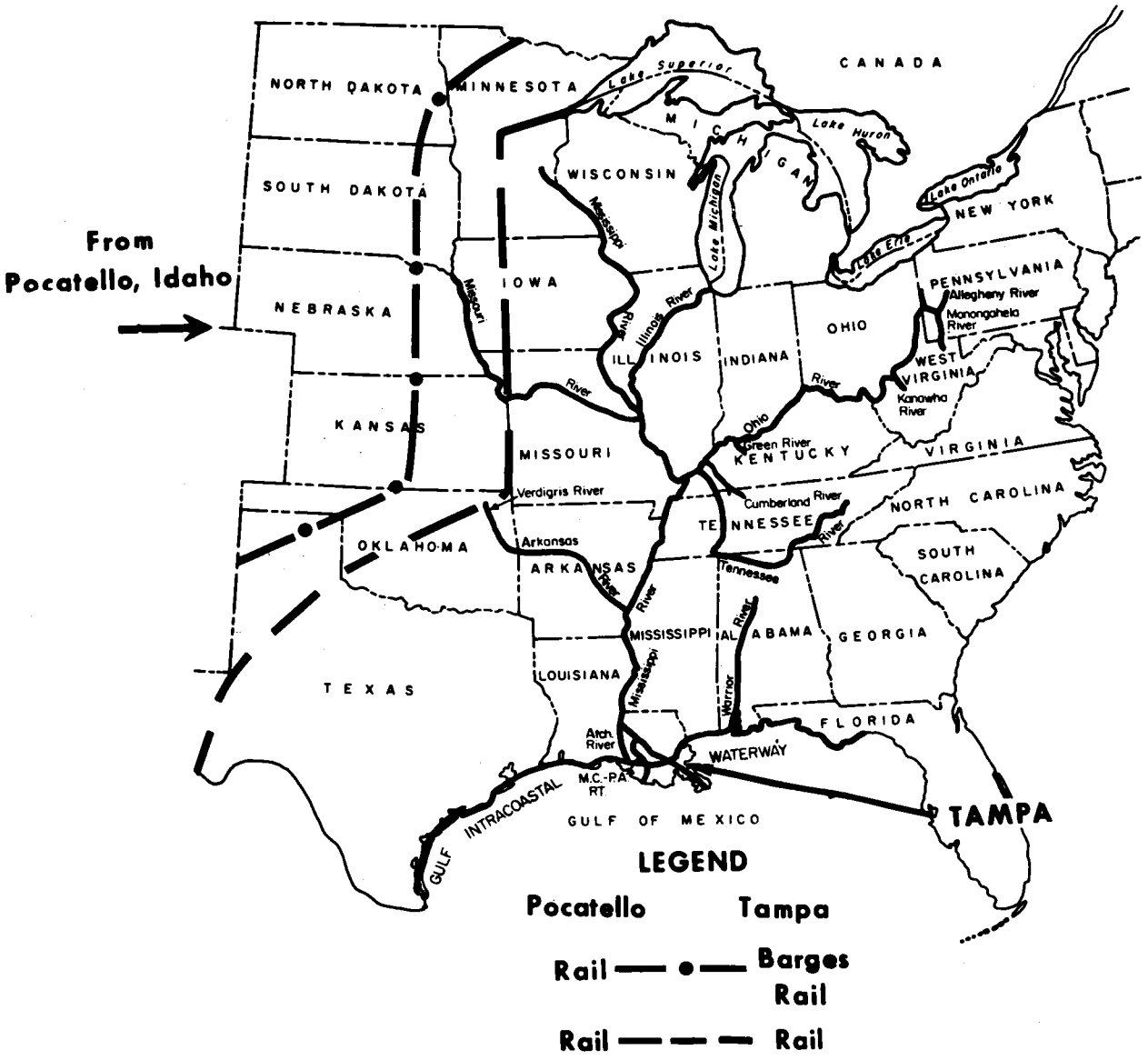

FIGURE 3. - Inland waterways of the Central United States. Lines of equal freight costs for superphosphate fertilizer from Tampa and Pocatello, Idaho, by two modes of transportation.

The Corn Belt accounts for one-third of U.S. phosphatic fertilizer consumption. The Northern Plain States, Great Lakes States, and Appalachia are responsible for an additional one-third of domestic consumption. The Mississippi River and its tributaries provide convenient, inexpensive access to these areas which, in combination with the Delta and Southeastern States, accounts for nearly three-fourths of U.S. phosphatic fertilizer consumption.[12]

Six major crops (primarily grains), grown in the regions noted above, account for approximately 82 percent of U.S. phosphatic fertilizer consumption. In 1971 and 1972, agricultural uses accounted for almost 80 percent of domestic demand for U.S. phosphate rock.

The domestic phosphate rock and fertilizer industry has undergone consolidation recently, as a result of over-expansion in the mid-1960's and a sluggish world market during 1969 and 1970.[13] As a result of increased world demand, phosphate prices have begun to rise significantly for the first time in 5 years and the industry is now operating near full capacity. Rising world phosphate prices may cause domestic phosphate rock prices to increase further in the future.

U.S. Supply and Demand

U.S. phosphate rock production increased steadily during the 1960's, reaching a high of over 41 million short tons in 1968. Production declined in 1969, but then increased for the following 3 years, and by 1972 production had nearly regained its high level of 41 million short tons (table 3 and figs. 4 and 5). Florida and North Carolina accounted for approximately 83 percent of 1971 domestic phosphate rock production and 84 percent of 1972 rock production; the Western States accounted for 11 percent in these 2 years and Tennessee was responsible for 6 percent in 1971 and 5 percent in 1972. Unit prices corresponding to quantities produced in 1960-72 are shown in table 4 and figure 6.

---

[12] Phosphorus and Potassium (London). No. 55, September-October 1971, pp. 25, 27.

[13] Harre, E. A. A Changing Market. Fertilizer Trends--1971. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala., Bulletin Y-40, 1971, pp. 1-2.

TABLE 3. - Marketable production of phosphate rock in the United States by State, 1960-72

(Thousand short tons and thousand dollars)

Year and State	Quantity	Value, constant 1967 dollars	Value, current dollars
1960:			
Florida	13,800	85,110	82,386
Tennessee	2,172	15,931	15,421
Western States[1]	3,647	20,156	19,511
United States total	19,619	121,197	117,318
1961:			
Florida	15,444	99,557	96,371
Tennessee	2,503	19,263	18,647
Western States[1]	2,839	16,189	15,671
United States total	20,786	135,009	130,689
1962:			
Florida	15,623	99,257	96,081
Tennessee	2,708	20,366	19,714
Western States[1]	3,377	21,211	20,532
United States total	21,708	140,834	136,327
1963:			
Florida	16,343	106,298	102,471
Tennessee	2,634	18,635	17,964
Western States[1]	3,260	20,865	20,114
United States total	22,237	145,798	140,549
1964:			
Florida[2]	19,168	126,330	121,908
Tennessee	2,734	19,634	18,947
Western States[1]	3,814	22,884	22,083
United States total	25,716	168,848	162,938
1965:			
Florida[3]	21,563	145,777	141,258
Tennessee	2,953	23,009	22,296
Western States[1]	4,920	30,118	29,184
United States total	29,436	198,904	192,738
1966:			
Florida[3]	29,827	199,084	195,102
Tennessee	3,125	24,373	23,886
Western States[1]	6,092	42,963	42,104
United States total	39,044	266,420	261,092
1967:			
Florida[3]	31,910	207,788	207,788
Tennessee	2,992	22,571	22,571
Western States[1]	4,868	35,588	35,588
United States total	39,770	265,947	265,947

See footnotes at end of table.

TABLE 3. - Marketable production of phosphate rock in the United States by State, 1960-72--Continued

(Thousand short tons and thousand dollars)

Year and State	Quantity	Value, constant 1967 dollars	Value, current dollars
1968:			
Florida[3]	33,032	191,216	193,319
Tennessee	3,149	23,371	23,628
Western States[1]	5,070	33,379	33,746
United States total[4]	41,251	247,966	250,692
1969:			
Florida[3]	29,930	151,820	160,777
Tennessee[5]	3,274	17,836	18,888
Western States[1]	4,521	27,407	29,024
United States total	37,725	197,063	208,689
1970:			
Florida[3]	31,278	142,193	158,972
Tennessee[5]	3,163	13,826	15,457
Western States[1]	4,297	25,750	28,789
United States total[4]	38,739	181,769	203,218
1971:			
Florida[3]	32,151	142,647	167,753
Tennessee	2,571	10,332	12,151
Western States[1]	4,164	20,344	23,924
United States total	38,886	173,323	203,828
1972:			
Florida[3]	34,121	144,684	173,910
Tennessee	2,154	8,928	10,732
Western States[1]	4,555	19,358	23,268
United States total	40,830	172,970	207,910

[1] Includes Arkansas (1963-66), California (1968-70), Idaho, Montana, Utah, and Wyoming.
[2] Includes North Carolina production of approximately 7,000 short tons.
[3] Includes North Carolina.
[4] Data may not add to totals shown because of independent rounding.
[5] Includes Alabama.

Source: Minerals Yearbook, U.S. Bureau of Mines.

TABLE 4. - Average value of marketable phosphate rock production for the United States and by State, 1960-72

(Dollars per short ton)

Year and State	Current dollars	Constant 1967 dollars	Year and State	Current dollars	Constant 1967 dollars
1960:			1967:		
United States.....	5.98	6.18	United States.....	6.69	6.69
Florida.....	5.97	6.17	Florida[2].....	6.51	6.51
Tennessee.....	7.10	7.33	Tennessee.....	7.54	7.54
Western States[1]...	5.35	5.53	Western States[1]...	7.31	7.31
1961:			1968:		
United States.....	6.29	6.50	United States.....	6.08	6.01
Florida.....	6.24	6.45	Florida[2].....	5.85	5.79
Tennessee.....	7.45	7.70	Tennessee.....	7.50	7.42
Western States[1]...	5.52	5.70	Western States[1]...	6.66	6.59
1962:			1969:		
United States.....	6.28	6.49	United States.....	5.53	5.22
Florida.....	6.15	6.35	Florida[2].....	5.37	5.07
Tennessee.....	7.28	7.52	Tennessee[3].....	5.77	5.45
Western States[1]...	6.08	6.28	Western States[1]...	6.42	.06
1963:			1970:		
United States.....	6.32	6.56	United States.....	5.25	4.70
Florida.....	6.27	6.50	Florida[2].....	5.08	4.54
Tennessee.....	6.82	7.07	Tennessee[3].....	4.89	4.37
Western States[1]...	6.17	6.40	Western States[1]...	6.70	5.99
1964:			1971:		
United States.....	6.34	6.57	United States.....	5.24	4.46
Florida[2].....	6.36	6.59	Florida[2].....	5.22	4.44
Tennessee.....	6.93	7.18	Tennessee.....	4.73	4.02
Western States[1]...	5.79	6.00	Western States[1]...	5.75	4.89
1965:			1972:		
United States.....	6.55	6.76	United States.....	5.09	4.23
Florida[2].....	6.55	6.76	Florida[2].....	5.10	4.24
Tennessee.....	7.55	7.79	Tennessee.....	4.98	4.14
Western States[1]...	5.93	6.12	Western States[1]...	5.11	4.25
1966:					
United States.....	6.69	6.83			
Florida[2].....	6.54	6.67			
Tennessee.....	7.64	7.80			
Western States[1]....	6.91	7.05			

[1] Includes Arkansas (1963-66), California (1968-70), Idaho, Montana, Utah, and Wyoming.
[2] Includes North Carolina.
[3] Includes Alabama.

Source: U.S. Bureau of Mines.

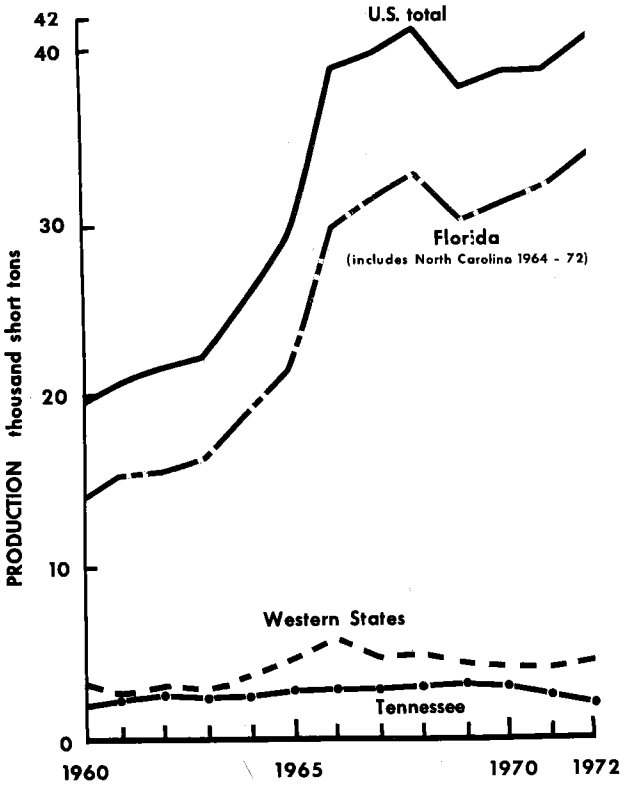

FIGURE 4. - Marketable phosphate rock production in the United States by State, 1960-72.

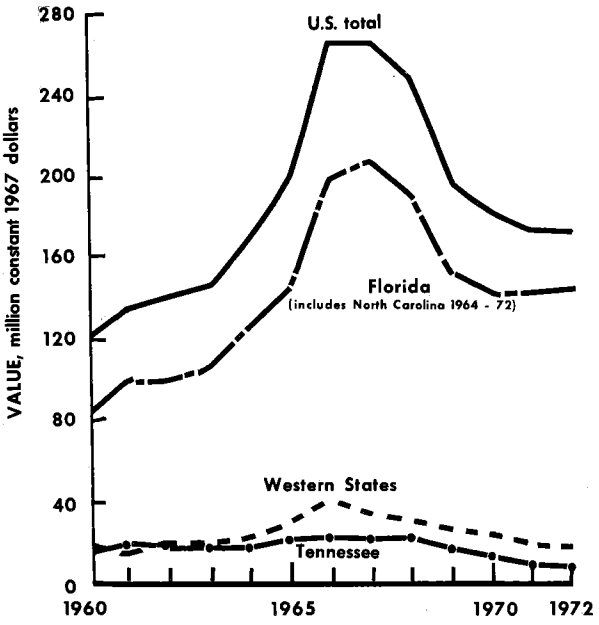

FIGURE 5. - Value of marketable phosphate rock production in the United States by State, 1960-72.

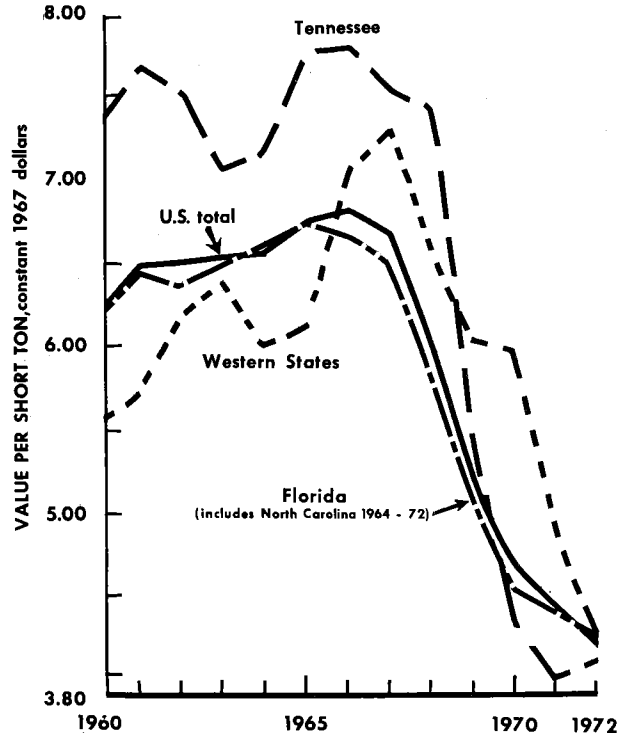

FIGURE 6. - Average value of marketable phosphate rock production for the United States and by State, 1960-72.

The Florida phosphate industry is comprised of relatively few large, vertically integrated companies which mine and beneficiate phosphate rock (table 5) and manufacture fertilizers and related chemicals. Florida phosphatic fertilizer production capacity dominates the domestic fertilizer industry. In 1973, Florida capacity as a percentage of U.S. total capacity was as follows: Wet process phosphoric acid, 58.3 percent; concentrated superphosphate, 77.9 percent; and ammonia phosphate, 31.3 percent (table 6).[14]

TABLE 5. - Florida phosphate rock producers

Type of activity and company	Facilities	County
Land pebble:		
Agrico Chemical Co. Pierce, Fla. 33867	Three open pit mines and plants.	Polk.
Borden Chemical Co. Box 790 Plant City, Fla. 33566	Open pit mine and plant.....	Do.
Brewster Phosphates Box 400 Bradley, Fla. 33835	.....do.....	Do.
W. R. Grace & Co. Box 471 Bartow, Fla. 33830	.....do.....	Do.
International Minerals & Chemical Co. Box 867 Bartow, Fla. 33830	Three open pit mines and plants.	Do.
Mobil Chemical Co. Box 311 Nichols, Fla. 33863	Two open pit mines and plant....	Do.
Occidental Petroleum Corp. Suwannee River Phosphate Div. Box 300 White Springs, Fla. 32096	Open pit mine and plant.....	Hamilton.
P.S.A. Enterprises 9500 Gandy Blvd. St. Petersburg, Fla. 33702	.....do.....	Polk.
Poseidon Mines, Inc. Box 1124 Lakeland, Fla. 33802	.....do.....	Do.

[14]Harre, E. A. Worksheets to Fertilizer Trends--1973. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala.

TABLE 5. - Florida phosphate rock producers--Continued

Type of activity and company	Facilities	County
Société des Participations Gardinier-SOPAG Box 3269 Tampa, Fla. 33601	Open pit mine and plant.....	Polk.
Swift Chemical Corp. Box 208 Bartow, Fla. 33830	Two open pit mines and plant....	Do.
USS Agri-Chemicals, Inc. Fort Meade, Fla. 33841	One open pit mine and plant.....	Do.
Soft rock:		
Howard Phosphate Co. Box 13800 Orlando, Fla. 32809	Open pit mine.....	Citrus.
Kellogg Co. Box 200 Hernando, Fla. 32642	.....do.....	Do.
Loncala Phosphate Co. Box 766 High Springs, Fla. 32643	.....do.....	Gilchrist, Marion.
Manko Co., Inc. Box 577 Ocala, Fla. 32670	.....do.....	Citrus.
Sun Phosphate Co. Box 577 Ocala, Fla. 32670	.....do.....	Do.

Source: U.S. Bureau of Mines, Division of Nonmetallic Minerals--Mineral Supply.

TABLE 6. - Phosphate fertilizer production capacity in Florida, December 1973

(Thousand short tons of P_2O_5)

Plant name and location[1]	Wet process phosphoric acid	Concentrated superphosphate	Ammonium phosphate
Agrico Chemical Co., Pierce, Fla.....	280	161	-
Borden Chemical Co., Piney Point, Fla....	175	33	85
C. F. Industries, Bonnie, Fla.....	630	-	450
C. F. Industries, Plant City, Fla.....	250	243	-
Conserve, Inc., Nichols, Fla.....	150	-	110
Farmland Industries, Pierce, Fla.....	455	87	92
W. R. Grace & Co., Bartow, Fla.....	315	320	105
International Minerals and Chemical Co., Bartow, Fla.....	750	-	-
Occidental Agricultural Chemical Co., White Springs, Fla.....	230	78	115
Royster Co., Mulberry, Fla.....	135	97	45
Société des Participations Gardinier-SOPAG, Tampa, Fla.[2].....	544	375	170
U.S. Agri-Chemicals, Inc., Bartow, Fla...	90	-	14
U.S. Agri-Chemicals, Inc., Fort Meade, Fla.....	176	121	-
Total Florida.....	4,180	1,515	1,186
Florida production as a percentage of U.S. production.....	58.3	77.9	31.3

[1]Three plants with no national significance in Florida produce ammonium (ammonia, nitrate or urea) but do not produce P_2O_5. These plants are Air Products and Chemical Co., Pace Junction, Fla.; Kaiser Agricultural Chemical Co., Tampa, Fla.; Nitram, Inc., Tampa, Fla.

[2]This plant also manufactures 120,000 short tons of ammonia.

Source: Harre, E. A. Worksheets to Fertilizer Trends--1973. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala.

There are 26 companies engaged in phosphate rock mining in the United States. Some companies operate in more than one State. The largest production comes from Florida where 17 firms are located. There are four producers in Tennessee and four producers in Idaho. Alabama, North Carolina, Missouri, Montana, Utah, and Wyoming each have one. Phosphate mining operations in States other than Florida are shown in table 7. It is estimated that, in 1970, Florida operated at over 70 percent of its production capacity, compared with 50 to 60 percent for North Carolina, 91 percent for Tennessee, 77 percent for the Western States, and 71 percent for the United States as a whole. There was only minimal expansion of domestic production capacity in 1971. However, during the summer of 1972 world phosphate demand suddenly turned strongly upward and several major firms announced new expansion programs.

TABLE 7. - Other State phosphate rock producers

State and operation	Type of facility	County
Alabama:		
Monsanto Co. Inorganic Chemical Div. 800 N. Lindbergh Blvd. St. Louis, Mo. 63141	Open-pit mine.....	Limestone.
Idaho:		
Agricultural Products Corp. Box 37 Conda, Idaho 83230	Open-pit mine and plant.....	Caribou.
Monsanto Co. Inorganic Chemical Div. 800 N. Lindbergh Blvd. St. Louis, Mo. 63141	.....do.....	Do.
J. R. Simplot Co. Fertilizer Div. Box 912 Pocatello, Idaho 83201	.....do.....	Bingham.
J. R. Simplot Co. Fertilizer Div. Box 67 Conda, Idaho 83230	Open-pit mine.....	Caribou.
Stauffer Chemical Co. 636 California St. San Francisco, Calif. 94119	Open-pit mine (plant in Montana).	Do.
Missouri:		
Meramec Mining Co. Route 4 Sullivan, Mo. 63080	Underground mine and plant...	Washington.
Montana:		
Cominco American, Inc. Garrison, Mont. 59731	Open-pit mine and plant.....	Powell.
North Carolina:		
Texasgulf, Inc. 200 Park Ave. New York, N.Y. 10017	.....do.....	Beaufort.
Tennessee:		
Hooker Chemical Co. Box 591 Columbia, Tenn. 38401	Open-pit mines..... Open-pit mines and plant.....	Hickman. Maury.

TABLE 7. - Other State phosphate rock producers--Continued

State and operation	Type of facility	County
Monsanto Co. Inorganic Chemical Div. 800 N. Lindbergh Blvd. St. Louis, Mo. 63141	Four open-pit mines and one plant.	Giles, Hickman, Maury, and Williamson.
Stauffer Chemical Co. 636 California St. San Francisco, Calif. 94119	Two open-pit mines and one plant.	Giles and Maury.
U.S. Tennessee Valley Authority Chemical Div. Muscle Shoals, Ala. 35660	Open-pit mine..... .....do.....	Maury. Williamson.
Utah:		
Stauffer Chemical Co. 636 California St. San Francisco, Calif. 94119	Open-pit mine..... Open-pit mine and plant.....	Rich. Uintah.
Wyoming:		
Stauffer Chemical Co. 636 California St. San Francisco, Calif. 94119	Open-pit mine and plant.....	Lincoln.

Source: U.S. Bureau of Mines--Division of Nonmetallic Minerals.

In 1971 the value of U.S. phosphate rock production exceeded $203 million (table 8). Approximately 73 percent of domestically consumed rock was converted by an estimated 5,000 companies into agricultural fertilizers[15] (fig. 7). The remaining share of domestically consumed rock was used in feed for animals, the manufacture of detergents, and miscellaneous applications.

The domestic demand for phosphate rock in 1971 was 27.7 million short tons (table 9). Based on a projected annual growth rate of 2.5 to 3.5 percent, domestic demand for phosphate rock is forecast at almost 40 million short tons by 1975. Fertilizer demand will be the major factor in this growth, accounting for an estimated 85 percent of the 1975 domestic demand for phosphate rock.

[15] A small percentage of fertilizers is applied to golf courses, lawns, etc.

TABLE 8. - Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1968	1969	1970	1971	1972
United States:					
Mine production	148,336	121,712	125,514	127,752	126,651
Marketable production	41,251	37,725	38,739	38,886	40,831
Value	$250,692	$208,689	$203,218	$203,828	$207,910
Average per ton	$6.08	$5.53	$5.25	$5.24	$5.09
Sold or used by producers	37,319	36,730	38,765	40,291	43,755
Value	$228,347	$204,409	$203,810	$211,986	$223,005
Average per ton	$6.12	$5.57	$5.26	$5.26	$5.10
Imports for consumption	116	140	136	84	55
Value	$2,679	$3,554	$3,790	$2,478	$1,416
Average per ton	$23.09	$25.42	$27.87	$29.50	$25.75
Exports	12,099	11,336	11,738	12,587	14,275
P_2O_5 content	3,917	3,685	3,796	4,126	4,673
Value	$75,653	$62,288	$59,980	$64,841	$75,376
Average per ton	$6.25	$5.49	$5.11	$5.15	$5.28
Consumption, apparent[1]	25,336	25,534	27,163	27,788	29,535
World: production	[r]91,466	88,930	93,635	96,040	103,866

[r] Revised.

[1] Measured by sold or used plus imports minus exports.

TABLE 9. - Phosphate rock sold or used by producers, by use and by State

(Thousand short tons)

Use	Florida[1]		Tennessee		Western States		Total[2] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1971: Domestic:								
Agricultural	20,879	6,585	-	-	1,254	366	22,133	6,951
Industrial	385	118	2,596	687	2,590	671	5,572	1,476
Total	21,264	6,703	2,596	687	3,844	1,037	27,704	[r]8,427
Exports	11,931	3,922	-	-	655	204	12,586	4,126
Total[2]	33,195	10,625	2,596	687	4,499	1,241	40,291	12,553
1972: Domestic:								
Agricultural	23,174	7,356	-	-	1,130	361	24,304	7,717
Industrial	W	W	2,240	587	W	W	5,176	1,364
Total	23,174	7,356	2,240	587	1,130	361	29,480	9,080
Exports	W	W	-	-	W	W	14,275	4,673
Total	36,934	11,868	2,240	587	4,581	1,299	43,755	13,754

[r] Revised. W--Withheld to avoid disclosing individual company confidential data.

[1] Includes North Carolina.

[2] Data may not add to totals shown because of independent rounding.

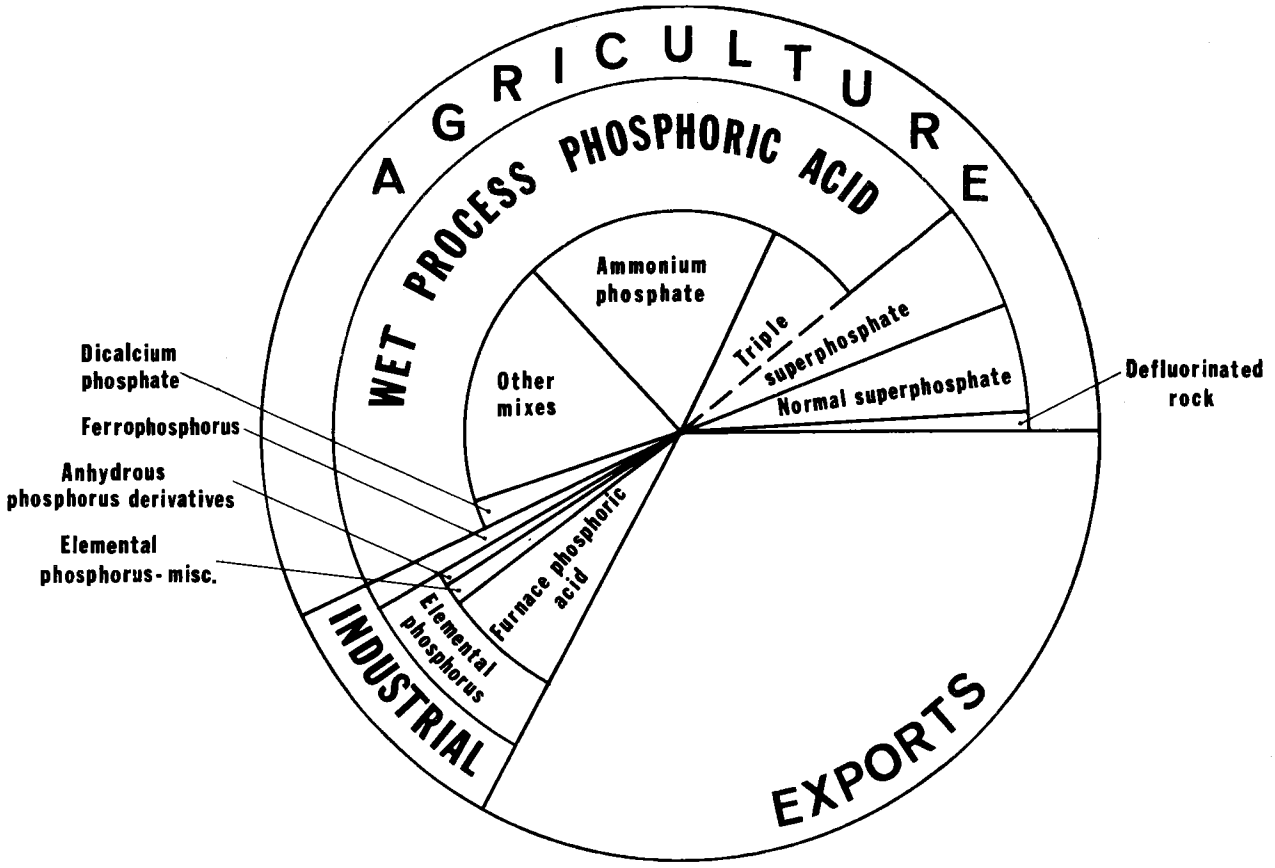

FIGURE 7. - Generalized U.S. phosphate rock use pattern.

The Soviet Union has recently agreed to purchase more than $1 billion worth of U.S. grain over a period of several years. This factor is included in the Federal Bureau of Mines' estimates that domestic fertilizer demand will approach an annual growth rate of 4.2 percent through the 1980's and that domestic demand for phosphate rock will be 39 million short tons in 1975. It is further forecast that in 1975 Florida production will be approximately 38 million short tons, as previously noted, and Florida exports about 9 million short tons.

The Federal Bureau of Mines estimates that despite steadily increasing production from central Florida, the land-pebble phosphates contain sufficient ore (table 10) to support economic production until about 2010. In contrast, there are problems associated with increasing production elsewhere in the United States. Tennessee's relatively small reserves of economically marketable product, processed in electric furnaces, are experiencing rising power costs. Texasgulf, Inc., is the only producer in North Carolina, but has been operating considerably below production capacity. Although North Carolina has large reserves, contamination of the fresh water aquifer from salt water intrusion caused by pumping the mine may restrict or prevent future mining development. (See appendix A on water requirements.) As previously noted, Western operations have higher combined mining and beneficiation costs than Florida. Western State producers also have higher transportation costs to

Eastern and many Midwestern markets than do Florida producers. Therefore, it is unlikely that Western operations will increase production unless there is a significant domestic price increase. At higher prices, some of Florida's phosphate rock production could be replaced by increased production from the Western States and North Carolina.

TABLE 10. - U.S. known marketable phosphate rock reserves at 1973 price level compared with estimated U.S. phosphate rock resources at 2.5 times 1973 price level

State	Million short tons marketable phosphate rock reserves	P content	Estimated million short tons phosphate rock resources	P content
Florida.....	1,200	168	2,500	349
North Carolina.....	380	53	2,400	335
Tennessee.....	30	4	600	84
Idaho.....	200	28	6,000	838
Montana.....	3	(1)	1,200	168
Utah.....	200	28	2,300	321
Wyoming.....	1	(1)	440	61
Total.....	2,014	281	15,440	2,156

[1]Less than 0.5.

Source: U.S. Bureau of Mines.

Output and Employment

Output and employment estimates for 1975 are summarized in table 11.

TABLE 11. - Output and employment estimates for the Florida phosphate industry in 1975

Item	Florida	Rest of Nation	National total
ESTIMATED OUTPUT (IN MILLIONS OF 1972 DOLLARS)			
Direct.....	390	190	580
Indirect.....	160	480	640
Induced.....	940	1,140	2,080
Total.....	1,490	1,810	3,300
ESTIMATED EMPLOYMENT (NUMBER OF JOBS)			
Direct.....	9,900	-	9,900
Indirect.....	7,200	8,400	15,600
Induced.....	43,800	21,600	65,400
Total.....	60,900	30,000	90,900

Income

In addition to the $262 million in wages and salaries paid to Florida workers that is directly, indirectly, and by induced effect attributable to the phosphate industry, $128 million in income is generated in the rest of the Nation by the phosphate industry. Therefore a total income of $390 million

is generated by the Florida phosphate industry, which is included in the national total output figure in table 11.

Fiscal Impact

Personal Income Taxes

The average income of a Florida phosphate industry employee was $7,809 in 1970. The estimated 9,900 employees in the phosphate industry in 1975 will be paid wages and salaries of at least $77.7 million ($7,847 x 9,900). From appendix C, the total income multiplier, 5.02, is used to calculate the income, approximately $390 million ($77.7 million x 5.02), received by an estimated 90,900 phosphate-related employees in that year. Given that an employee is married, has two children, and claims the standard deduction, an effective Federal income tax rate of 7.0 percent is assumed. Federal tax revenues from phosphate-related income will, therefore, be at least $27 million ($390 million x .07) in 1975.

Since Florida has no State personal income tax, there is no such tax revenue from phosphate industry workers. However, personal income tax revenue to States other than Florida generated by the phosphate industry is expected to exceed $1 million in 1975. Therefore, the total Federal and State income tax contribution by Florida phosphate activity will be at least $28 million in 1975.

Corporate Income Taxes

It is assumed that the Federal corporate income tax rate is 4.15 percent of the value of total phosphate-related output of $3,300 million. On this basis, $137 million in corporate income tax payments to the Federal government, will be attributable to the phosphate industry and related activities in 1975.

To estimate corporate income tax revenue generated by the phosphate industry, and paid to States other than Florida, it is assumed that the average nationwide State corporate income tax as calculated from past Internal Revenue Service publications is about 0.85 percent of the gross output. Applying this rate to total phosphate-related output outside Florida of $1,810 million, the estimated contribution to other State corporate income tax revenue will be about $15 million. The total Federal and other State corporate income tax revenue from the Florida phosphate industry and related activities will, therefore, be about $152 million in 1975.

Other States Sales and Property Taxes

Sales tax payments generated by the phosphate industry have been estimated for States other than Florida by applying a rate of 0.31 percent to total phosphate-related output outside Florida of $1,810 million. On this basis, $5.6 million in other States' sales tax revenues will be attributable to the phosphate industry in 1975. Similarly, the Florida phosphate industry will generate more than $35 million in other States' property taxes in 1975.

Summary of Taxes

Fiscal benefits associated with the Florida phosphate industry in 1975 are shown in table 12.

TABLE 12. - State, local, and Federal tax revenues associated with the Florida phosphate industry in 1975

(Million 1972 dollars)

	Florida	Rest of Nation	National total
Personal income taxes	-	28.0	28.0
Corporate income taxes	7.5	152.0	159.5
Florida severance tax (unrestricted)	2.4	-	2.4
Florida motor fuel tax	0.2	-	0.2
State sales taxes	13.0	5.6	18.6
Local property taxes	30.0	35.0	65.0
Total	53.1	220.6	273.7

Cost of Losing the Industry: Federal and State Unemployment Assistance

Should the phosphate industry cease operation, an estimated $35 million in new unemployment compensation would be paid by States other than Florida in 1975, in addition to lost tax revenues. Further, assuming monthly public assistance payments of $100 for a family of four living outside of Florida, welfare costs would total $11.5 million, with a breakdown as follows in million dollars:

Other States' payments	1.6
Federal share of Florida	4.5
Federal share of other States	2.4
Total	8.5
Total plus Florida	11.5

Effect on the U.S. Balance of Payments

Exports of phosphate rock and fertilizer make an important positive contribution to the U.S. balance of payments. In 1971 the United States exported a total of 12,687,000 short tons of phosphate rock of which 11,869,000 short tons were exported by Florida (including North Carolina). In 1972 the United States exported 13,992,000 short tons, Florida's (including North Carolina) share being 13,122,000 short tons. In 1975, exports from Florida alone are forecast at 9 million short tons. Assuming a 1975 average export price f.o.b. Tampa Port of $17.32 per short ton of phosphate rock in 1972 dollars, Florida rock exports in 1975 will be worth approximately $156 million (in 1972 dollars).

In 1971, the United States exported $103.2 million worth of phosphatic fertilizers: ammonium phosphates valued at $72.8 million, superphosphates valued at $30.4 million, and small amounts of other fertilizers. In 1972, U.S. exports increased to $178.5 million: $126.0 million worth of ammonium

phosphates, and $52.5 million worth of superphosphates. In 1973, exports of phosphatic fertilizers from Florida were valued at $176.4 million. Based on the assumption that at least $176 million (in 1972 dollars) worth of fertilizers will be exported from Florida ports in 1975, $332 million ($176 million + $156 million) in phosphate rock and fertilizer is forecast to be exported from the State in 1975.

Florida ranks eighth among States in the U.S. in sulfuric acid capacity, all of which is captive capacity for the phosphate industry. The Florida phosphate industry consumed 450,000 long tons of imported sulfur in 1970, 435,000 tons in 1971, and will consume an estimated 400,000 tons in 1975. Using the 1970 average value for imported sulfur of $22.20 per ton, the 400,000 tons will be valued at $9 million. If there were no phosphate industry in Florida, this sulfur would not be imported. The positive contribution to the U.S. balance of payments by the Florida phosphate industry in 1975 is, therefore, $323 million ($332 million - $9 million).

As mentioned in the environmental section, earlier, fluorine in the form of fluosilicic acid is being recovered from phosphoric acid plants in Florida. Assuming 100,000 tons of fluosilicic acid per year can be recovered from Florida at a value of $65 per ton, $6.5 million worth of fluosilicic acid could be produced annually. Since the U.S. imported 1.1 million tons of fluorspar (fluorine source) or about 80 percent of its fluorine requirements in 1970, this Florida byproduct production would represent a yearly savings of $6.5 million in fluorine imports. Thus, by 1975, the Florida phosphate industry could make an annual positive contribution to the U.S. balance of payments of approximately $329.5 million, as shown in table 13.

TABLE 13. - Estimate of Florida phosphate industry contribution to U.S. balance of payments in 1975

(Million 1972 dollars)

Exports of phosphate rock	156.0
Exports of phosphatic fertilizer	176.0
Imports of sulfur	-9.0
Potential reduction of fluorine imports	6.5
Total (net)	329.5

In 1975, Florida phosphate rock production for domestic consumption is estimated at 29 million short tons. If the Florida phosphate industry ceased operation, about two-thirds of this 29 million tons would have to be replaced by imports assuming domestic sources are able to supply the other one-third of domestic demand. Therefore in 1975 (and each year thereafter) approximately 20 million short tons of phosphate rock would have to be imported.[16] These imports would adversely affect the balance of payments by an estimated

[16] Owing to the lead time necessary to develop new mines, the 9 million tons from domestic sources other-than-Florida could not actually come on stream until 1978.

$866 million (1972 dollars) annually, based on a 1975 average sale price for phosphate rock (in 1972 dollars) delivered to a U.S. east coast port of $43.29 per short ton.

Importance to U.S. Agricultural Production

Phosphorus is removed from the soil by crops faster than it is created through natural processes. Phosphatic fertilizer is applied to correct this imbalance. There is no substitute for phosphorus as a plant nutrient, and commercial quantities of soluble phosphorus are only obtainable from phosphate rock.[17]

In 1970 and 1971, 98 percent of the Florida phosphate rock consumed in the domestic market was used to manufacture fertilizers. About 85 percent of U.S. phosphatic fertilizer production is consumed by the agricultural sector, with the remaining 15 percent used to fertilize golf courses, lawns, etc. Florida supplies approximately 95 percent of the U.S. agricultural demand for phosphatic fertilizer.

Six major crops account for approximately 82 percent of U.S. phosphatic fertilizer consumption: corn, 40 percent; hay and pasture, 13.6 percent; wheat, 11.3 percent; cotton, 6.7 percent; oats and barley, 5.4 percent; and soybeans, approximately 5 percent.[18] Over 85 percent of the U.S. corn crop is grown with phosphatic fertilizer.

In 1972, the U.S. balance-of-trade deficit was $6.8 billion. Oil imports valued at $4.2 billion were largely responsible for the deficit. Net agricultural exports, after subtracting out agricultural imports and foreign-aid foodstuffs, made an estimated positive contribution of $3.3 billion to the U.S. balance of payments in fiscal 1973.[19] The positive contribution of agricultural exports to the balance of payments is growing and is expected to continue to grow in the future.

In recent years gross agricultural exports have risen steadily from $5.7 billion in fiscal 1969 to $8 billion in fiscal 1972, $12.9 billion in fiscal 1973, and an estimated $20 billion in fiscal 1974. This trend is expected to continue for at least three reasons. First, the Soviet Union has agreed to purchase more than $1 billion of U.S. grain over the next several years. Secondly, increasing incomes abroad mean a greater demand for meat in many foreign countries. Since it takes approximately 8 pounds of feed (such as corn) to produce 1 pound of beef, grain consumption by foreign countries will rise significantly. Furthermore, soybeans, having a 40-percent protein content compared to about 10 percent for other grains, is in great demand worldwide. There is currently a worldwide soybean shortage. The U.S. supplies about 70 percent of internationally traded soybeans. The U.S. will probably continue to increase soybean exports to help meet world demand.

---

[17] U.S. Bureau of Mines. Phosphorus. Ch. in Mineral Facts and Problems. BuMines Bull. 650, 1970, pp. 1139-1155.

[18] Work cited in footnote 12.

[19] Forbes. v. 111, No. 6, March 15, 1973, p. 32.

Therefore, in addition to the Florida industry's direct positive contribution to the U.S. balance of payments as phosphate rock and fertilizer exports, agricultural products fertilized by Florida phosphate will make a significant positive contribution to the balance of payments.

Four agricultural products--corn, wheat, soybeans, and cotton--fertilized in part by phosphatic materials, are examined quantitatively in table 14.

TABLE 14. - Projections of U.S. value of production and export figures for four crops in the 1974-75 marketing year, that is, July 1, 1974 to June 30, 1975

(Billion dollars)

Crop	Value of U.S. production	Percentage of crop receiving phosphatic fertilizer	Value of U.S. crop receiving phosphatic fertilizer	Value of U.S. exports	Value of U.S. exports receiving phosphatic fertilizer
Corn.....	11.725	86	10.084	2.100	1.806
Wheat.....	7.350	45	3.308	3.500	1.575
Soybeans.....	7.700	32	2.464	2.875	0.920
Cotton.....	2.496	55	1.373	0.960	0.528
Total.....	29.271		17.229	9.435	4.829

Source: U.S. Department of Agriculture, Economic Research Service.

Table 14 shows that an estimated $17.2 billion of domestic crop production and $4.8 billion in crop exports will be grown with phosphatic fertilizers as a necessary input. Therefore, the phosphate industry is far more important when measured by the value of crops grown from phosphatic fertilizer than when measured by the value of the phosphate rock and fertilizer alone.

Were it not for the Florida phosphate industry, the United States would have to import a major share of its phosphate requirements. The price of this imported phosphate rock and fertilizer would be higher than the price of Florida phosphate for at least two reasons. First, there would be the added freight costs in shipping the phosphate from north Africa (largest non-U.S. phosphate exporter) to U.S. ports. More importantly, the U.S. would be competing in a world market where supply has been reduced by approximately 30 percent, because Florida accounts for nearly 30 percent of internationally traded phosphate. Consequently, world phosphate prices would be bid up. Prices of phosphatic fertilizer imported into the United States could be as much as double current domestic prices.

Unless an increase in farm productivity offsets this higher cost of fertilizer, grain prices would increase, leading to higher meat prices. People in the United States and other countries importing from the United States would pay more for cotton, corn, wheat, oats and barley, soybeans, and meats. Real incomes and living standards would decline accordingly.

Impact on the Domestic Sulfur Industry

The Florida phosphatic fertilizer industry consumes about one-half of U.S. Frasch sulfur production. Approximately 3 million long tons of sulfur were consumed by the industry in 1973, and an estimated 4 million long tons will be consumed in 1975. Assuming a sulfur price of $17.50 per ton, the Florida fertilizer industry will represent a $70 million market for sulfur in 1975. The Frasch sulfur industry is heavily dependent on the Florida fertilizer industry, and will continue to be dependent in the foreseeable future.

Potential Source of Uranium

Florida phosphate rock containing between 0.01 and 0.02 percent U_3O_8 can be processed to recover byproduct uranium from phosphoric acid production. During World War II a byproduct uranium plant operated in Florida, but later closed down after the discovery of domestic uranium deposits which could be mined and processed more economically.

Central Florida phosphate rock reserves are conservatively estimated at 1.2 billion short tons. Assuming the mean grade of 0.015 percent, central Florida known U_3O_8 reserves would be 180,000 tons. Using an overall recovery factor of 85.5 percent (95 percent in producing the acid and 90 percent for the byproduct plant), about 153,900 tons of U_3O_8 could feasibly be recovered from wet-process phosphoric acid.

The price of U_3O_8 was depressed at $6 to $7 per pound from 1969 through most of 1973 owing to a uranium glut. Corresponding to the accelerating prices of coal and oil, uranium prices from near yearend 1973 through early 1974 appeared to be escalating rapidly. Even at these higher U_3O_8 prices, the market remains unstable with expectations of prices rising further in the future. As a result, U_3O_8 producers have been reluctant toward entering into long-term contracts with reactor manufacturers and electric utilities.

Based on an estimated July 1975 price of $9 per pound U_3O_8, the 153,900 tons (calculated above) of potentially recoverable U_3O_8 in central Florida would have a value of $2.77 billion. Should the 1975 U_3O_8 price be higher than this estimate of $9, the value of Florida uranium reserves would rise accordingly. W. R. Grace is having a uranium separation plant installed at its Bartow, Fla., phosphoric acid plant. The byproduct uranium plant is scheduled to be in operation by early 1975, and International Minerals and Chemical is also having a uranium plant installed. Both uranium plants are under contracts with Uranium Recovery Corp. of Mulberry, Fla. Also, Gulf Oil Corp. has developed an economically feasible method of recovering uranium during processing of phosphate rock into phosphoric acid.[20] It is clear that rising uranium prices are making recovery of byproduct uranium economically viable. If, however, uranium was the only product from Florida phosphate ores (instead of a byproduct of phosphatic fertilizer manufacturing), mining engineers of the Bureau of Mines calculate that production costs based on 1969 data would be $67 per pound U_3O_8. Using the gross national product

[20]Wall Street Journal, April 11, 1974, p. 6.

implicit price deflator, production costs are estimated to increase to about $84 per pound U_3O_8 in 1974. At this price, Florida uranium would not be recovered in the foreseeable future.

Byproduct Fluorine Production

Fluorine is principally recovered from the mineral fluorite, commonly known as fluorspar. The domestic fluorine industry has historically been only marginally economical. Domestic fluorspar reserves are small, of low grade, and will probably be depleted in 25 to 30 years.

Fluorine is critical to the production of aluminum, steel, and many chemical compounds. In 1970 the aluminum industry accounted for 20.7 percent of U.S. fluorine consumption, or 127,200 short tons, and the fluorocarbon industry accounted for 36.4 percent, or 223,200 short tons.

In 1970, the United States produced about 20 percent of its fluorine requirements (6 percent of world production) and consumed about one-third of world supply. Apparent U.S. consumption was approximately 600,000 short tons in 1970 and is forecast at four times this quantity or 2.4 million tons in the year 2000. A straight line projection of the last 20 years' domestic production indicates that only about 40,000 tons of fluorine would be produced in the year 2000. Therefore, unless new domestic sources of supply are developed, the United States will have to depend on imports for about 98 percent of its projected demand in the year 2000.

The largest known source of fluorine in the United States exists in phosphate rock deposits. Florida phosphate rock contains 3 to 4 percent fluorine. Fluorine was generally not economically recoverable from phosphatic fertilizer operations in the past, but owing to rising fluorine prices, it can now be economically recovered in large-scale fertilizer manufacturing plants. Two large fertilizer producers in Florida, U.S. Steel Corp.'s Agri-Chemical Division and Farmland Industries, are supplying fluosilicic acid, a former waste product, to Alcoa and Kaiser Aluminum and Chemical Corp. for manufacturing cryolite and aluminum fluoride. In addition, at least four other companies producing phosphoric acid in Florida are known to be salvaging and marketing fluosilicic acid.

Future fluosilicic acid production of 100,000 tons per year by Florida firms is anticipated. Based on a value of $65 per ton of fluosilicic acid, and an assumed minimum 30 year productive life of the land-pebble deposits, total byproduct fluosilicic acid production would have a value, undiscounted for the time value of money, of $195 million (100,000 X 30 years X $65).

The Value of Capital Assets

Should the Florida phosphate industry cease operation, shovels, trucks, rock crushers, and other nonspecialized equipment could be salvaged, that is, sold to other industries. However, specialized equipment in the beneficiation, phosphoric acid, and fertilizer manufacturing plants as well as railroad facilities and more than 700 miles of track maintained to serve the industry,

would become useless. It is estimated that the non-salvageable capital assets would be valued at $850 million and that the affected companies' assets would be correspondingly reduced.

Summary

In 1975 the Florida phosphate industry will have the following estimated economic impacts on the Nation, excluding Florida:

Estimated totals:	
Output	$1,810 million
Employment	30,000 jobs
Personal income	$128 million
Fiscal benefits:	
Personal income taxes:	
Federal	$27.0 million
States other than Florida	$1.0 million
Corporate income taxes:	
Federal	$137.0 million
States other than Florida	$15.0 million
Sales tax revenues to States other than Florida	$5.6 million
Property tax revenues to States other than Florida	$35.0 million
Total fiscal benefits	$220.6 million
Positive contribution to the U.S. balance of payments	$329.5 million
Benefits to Frasch sulfur industry:	
Percentage of Frasch sulfur production sold to the Florida phosphate industry	50 percent
Value of Frasch sulfur sold to the Florida phosphate industry	$70 million (included in total output figure above)

In addition, $195 million (undiscounted) worth of byproduct fluosilicic acid and $2.77 billion of byproduct uranium may be recovered over the life of the land-pebble deposits.

Should the phosphate industry cease operation, in addition to the loss of the above benefits in 1975 (and each subsequent year to the end of the century), there would be new fiscal expenditures totaling $43.5 million: other State unemployment compensation of $35 million, other States' share of public assistance of $1.6 million, and the Federal share of public assistance for all States (including Florida) of $6.9 million. Furthermore, the United States would have to import phosphatic fertilizer at increased prices which, in turn, would mean increased food prices for people in the United States and other countries importing from the United States. Finally, an estimated $850 million in capital assets would be lost.

WORLD PRODUCTION CAPACITY

The year 1971 marked the beginning of a period of expansion of world phosphate rock capacity. Additions to capacity were made in Morocco in that year and the Spanish Sahara is expected to initiate large shipments in 1974. Additions are planned throughout north Africa, and work continues on the development of Australian deposits. "The new capacity which came on stream in 1970-71, however, should not have any significant impact on the overall supply/demand situation, which will not experience any marked changes until the Bu-Craa mine comes on stream in Spanish Sahara (in 1973) and even then the changes will be graduated."[21] In general, added capacity is barely keeping pace with the growing world demand for phosphate which is expected to increase at a rate of approximately 5 percent annually for the remainder of this century.

This situation relates directly to the Florida phosphate industry and its future prospects. The industry has a secure domestic market, and growing world demand and accompanying higher prices will encourage shipments into the export market. With two strong and growing markets available, Florida has flexibility should one market weaken.

The existing relationship between world capacity and world demand bears directly upon the availability of alternative sources of supply to that of Florida. In 1972 Florida (including North Carolina) produced over 34 million short tons of phosphate rock, equivalent to one-third of world production (table 15), and in 1975 production for Florida alone is estimated to increase to 38 million short tons. Furthermore, in the mid-70's it is forecast that world demand will be growing by at least 5 million short tons per year. If the Florida phosphate industry ceased operation, other-than-Florida producers would be faced with the necessity of producing an additional 38 million short tons of rock in 1975 to meet U.S. and foreign demand. If world capacity in 1975 is 122 million short tons of marketable phosphate rock, the rest of the world would have to increase capacity by almost 50 percent to meet the anticipated demand. Such increases are simply not possible in the short run and would result in massive national and regional economic dislocation, and a worldwide fertilizer shortage lasting for several years.

[21] P.13 of work cited in footnote 12.

TABLE 15. - Phosphate rock: world production, by country

(Thousand short tons)

Country[1]	1970	1971	p1972
North America:			
United States	r38,739	38,886	40,831
Mexico	52	64	69
Netherlands Antilles[2]	r158	172	66
South America:			
Argentina (guano)	([3])	1	e1
Brazil	194	220	248
Chile (guano)	16	14	17
Colombia	13	11	7
Peru (guano)	55	25	e25
Venezuela	34	29	e33
Europe:			
France (phosphatic chalk)	29	21	36
Poland[e]	33	-	-
U.S.S.R.:			
Apatite (marketable concentrate, 39 percent P_2O_5)	12,460	12,840	13,230
Sedimentary rock (marketable concentrate, 19-25 percent P_2O_5)	10,500	11,000	11,600
Germany, West	76	66	83
Africa:			
Algeria	543	546	519
Egypt, Arab Republic of	r790	786	e780
Morocco	12,566	13,237	16,503
Senegal:			
Aluminum phosphate	144	162	183
Calcium phosphate	1,100	1,541	1,378
Seychelles Islands (guano)[2]	7	e8	e8
South Africa, Republic of	1,857	1,906	2,167
Southern Rhodesia	94	116	e120
Togo	1,662	1,891	2,125
Tunisia	3,325	3,485	3,734
Uganda (apatite)	18	18	e18
Asia:			
China, People's Republic of[e]	r1,900	2,400	2,900
Christmas Islands (Indian Ocean)	r1,200	1,092	e1,100
India:			
Apatite	17	12	13
Phosphate rock	165	256	239
Israel	1,280	843	1,219
Jordan	927	717	765
Khmer Republic (formerly Cambodia)	3	-	-
Korea, North (apatite)[e]	r270	300	330
Philippines:			
Guano	2	1	2
Phosphate rock	2	5	3

See footnotes at end of table

TABLE 15. - Phosphate rock: world production, by country--Continued

(Thousand short tons)

Country[1]	1970	1971	[p]1972
Syrian Arab Republic	-	7	83
Vietnam, North[e]	[r]500	610	660
Oceania:			
Australia	16	11	[e]11
Nauru Island	2,330	2,058	2,205
Ocean Island	558	683	555
Total	93,635	96,040	103,866

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, Belgium, Indonesia, and Tanzania produce phosphate rock, and South-West Africa produces guano, but information is inadequate to make reliable estimates.

[2]Exports.

[3]Less than 1/2 unit.

Although there are substantial phosphate rock reserves outside of the United States (table 16), these reserves are largely undeveloped, and their development would require considerable time and money. In order to develop new capacity equal to that of Florida, a period of at least 10 years would be needed and an investment of about $1 billion would be required. Were it not for the Florida phosphate industry, the United States would have to import approximately 20 million short tons of phosphate rock (or fertilizer equivalent of P_2O_5) to meet agricultural demand, assuming one-third of Florida's production for domestic consumption is replaced by increased domestic production elsewhere. One certain consequence of a reliance on non-Florida phosphate sources would be increased fertilizer prices, reflecting the cost of importation, the bidding up of phosphate prices owing to reduced world supply in the face of increasing world demand, operation of higher cost Western U.S. mines, and higher transportation costs from Western U.S. mines to Eastern and many Midwestern markets. Another effect of relying on non-Florida phosphate sources would be higher costs of detergents and other products made from elemental phosphorus.

TABLE 16. - Estimate of world marketable phosphate rock reserves--price per recoverable ton

(Million short tons)

Continent	$8 per short ton	$12 per short ton	$20 per short ton
North America	1,836	5,350	16,340
South America	53	290	930
Europe	829	2,050	4,100
Africa	1,770	8,430	20,500
Asia	335	1,186	4,600
Oceania	120	750	1,300
Total	4,943	18,036	47,770

Source: U.S. Bureau of Mines.

WORLD TRADE

World trade in phosphate rock and phosphatic fertilizer is complex, with phosphate rock and fertilizer dependent on each other. Exports of phosphate rock and fertilizer from Florida have helped sustain the phosphate industry during recent years of overcapacity and depressed prices. Florida (including North Carolina) exported an estimated 47 percent of its phosphates as rock and fertilizer in 1970 and 1971, and accounted for approximately 95 percent of U.S. rock exports in these years. Unlike the rapid growth in exports of Florida phosphate rock in the past, it is expected that rock exports will not increase in the near future with the remainder of world demand for Florida phosphate being supplied by increased fertilizer exports.

Several developing nations are expanding their phosphate industries. Spanish Sahara, with phosphate rock reserves estimated to be 450 million short tons of recoverable product at current prices, is expected to ship 3 million tons of phosphate rock per year in 1974. Morocco is adding phosphoric acid capacity. Mexico, Japan, and Iran have become large exporters of finished fertilizers.

World trade in phosphate rock reached a record 31.5 million short tons in 1970. Florida and Morocco furnished two-thirds of the free world phosphate rock exports in that year (table 17). Morocco, with its higher grade ore and lower transport costs to European markets, has increased its share of phosphate rock exports to 50 percent of the growing Western European market, largely at the expense of the United States. "(Florida) sales to Western Europe expanded only fractionally (in 1970) because of increased competition from north African sources."[22] However, Western Europe will, most likely, continue to rely heavily on Florida because of the reliability of this source and the demand by consumers for a diversified source of supply. For these reasons Western Europe will continue to be a viable market for Florida rock exports.

[22]Phosphorus and Potassium (London). No. 52, March-April 1971, p. 9.

TABLE 17. - Major phosphate rock exporters

(Thousand short tons)

Country	1966	1967	1968	1969	1970	1971	[p]1972
Morocco:							
Marketable production.....	10,389	10,971	11,595	11,753	12,565	13,242	16,503
Exports.....	10,144	10,309	11,126	11,313	12,472	13,102	14,946
Tunisia:							
Marketable production.....	3,307	3,150	3,810	2,866	3,333	3,485	3,734
Exports.....	2,639	2,463	2,712	2,045	2,325	2,657	2,542
Togo:							
Marketable production.....	1,225	1,238	1,516	1,624	1,662	1,890	2,125
Exports.....	1,225	1,238	1,496	1,614	1,672	1,942	2,045
U.S.S.R.:							
Marketable production.....	16,740	18,030	19,500	21,250	22,470	23,800	24,800
Exports (to Western Europe only).....	NA	NA	NA	2,327	2,156	2,364	-
U.S. total:							
Marketable production.....	39,044	39,770	41,251	37,725	38,739	38,886	40,831
Exports.....	9,255	10,282	12,083	11,369	11,738	12,587	13,739
Florida: Exports.....	8,118	8,804	11,052	10,407	10,923	11,869	13,112

[p]Preliminary. NA Not available.

Source: U.S. Bureau of Mines.

Despite strong foreign competition, Florida phosphate rock production has achieved a position of importance throughout the world (table 18). Exports of Florida (including North Carolina) rock rose from almost 12 million short tons in 1971 to about 13 million short tons in 1972. Approximately 40 percent of 1972 Florida exports went to Western Europe, with another 30 percent going to Asia, principally Japan. The balance was exported to Canada, and Central and South America.

Recently, world phosphate rock prices have risen significantly.[23] Effective January 1, 1974, the U.S. rock for export price for 75 percent bone phosphate of lime (BPL) became $24.55 per short ton, f.o.b. vessel. At this same time, Moroccan phosphate rock (75 percent BPL) rose to $38.83 per short ton, f.o.b. vessel. Currently strong world demand for phosphate is expected to continue, thereby supporting these high rock prices.

[23]Effective July 1, 1974, U.S. rock exported prices rose to $37.50 per short ton f.o.b. vessel for a high-grade type (approximately 75 percent BPL) and increased to $29.46 per short ton f.o.b. vessel for a common grade (approximately 70 percent BPL).

TABLE 18. - U.S. exports of phosphate rock, with destinations

(Thousand short tons and thousand dollars)

Destination	1971		1972	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Aden	29	131	-	-
Austria	117	817	147	938
Belgium-Luxembourg	673	4,037	732	4,544
Brazil	619	4,533	791	5,867
Canada	2,030	14,392	2,205	16,492
Chile	15	119	55	483
Colombia	73	475	31	229
El Salvador	13	75	12	78
France	536	3,814	497	3,904
Germany, West	1,273	7,660	1,455	8,965
India	407	2,610	454	2,994
Iran	128	979	415	2,965
Italy	1,227	8,878	864	5,962
Japan	2,171	18,598	2,220	20,449
Korea, Republic of	573	4,021	574	3,974
Mexico	803	4,728	785	5,058
Netherlands	557	3,709	715	4,248
Norway	3	28	8	59
Peru	13	136	9	79
Philippines	174	1,282	126	945
Romania	-	-	421	2,770
Spain	135	974	293	2,033
Sweden	49	298	86	563
Switzerland	24	162	3	29
Taiwan	107	768	82	760
United Kingdom	64	454	54	353
Uruguay	23	216	40	484
Other	33	295	48	335
Total	11,869	84,189	13,122	95,560
Other phosphate rock total[1]	818	10,627	870	11,878
Grand total	12,687	94,816	13,992	107,438

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

Source: Minerals Yearbook, U.S. Bureau of Mines, 1972.

MAJOR FINDINGS

1. Florida is the largest phosphate rock producing region in the world, accounting for one-third of world production. Maintaining current levels of world consumption necessitate Florida phosphate production in the short run. A period of at least 10 years would be required to develop additional world production capacity to equal that of Florida.

2. In 1975 the phosphate industry will contribute the following benefits to the Florida economy (all monetary estimates are in 1972 dollars): approximately 61,000 jobs, and nearly $1.5 billion in gross output, of which $262 million is personal income. These economic benefits are concentrated in those areas where the phosphate rock mining and fertilizer industry, and transportation and other related industries are located, that is, Polk, Hillsborough, and Hamilton counties.

3. The Florida phosphate industry has a substantial impact on the national economy. Outside Florida, 30,000 jobs and over $1.8 billion in gross output, including $128 million in personal income, will be generated by the Florida phosphate industry in 1975. Throughout the Nation, the Florida phosphate industry will account for approximately 91,000 jobs, and $3.3 billion of gross output, including $390 million in personal income, in 1975.

4. It is estimated that total national tax payments generated by the phosphate industry will exceed $270 million in 1975, with over $50 million of that paid to Florida jurisdictions. The cessation of industry operations would result in increased unemployment compensation and public welfare assistance expenditures of approximately $62 million for Florida and more than $43 million for the rest of the Nation.

5. The net positive contribution to the U.S. balance of payments from the Florida phosphate industry will be approximately $329.5 million in 1975.

6. If Florida phosphate operations ceased, the balance of payments would be adversely affected by an estimated $866 million (1972 dollars) worth of phosphate imports in 1975.

7. Were it not for the Florida phosphate industry, the United States would have to import a major share of its phosphate requirements at increased prices. This, in turn, would mean higher food prices, if not offset by an increase in agricultural productivity. Real incomes and living standards would decline accordingly.

8. The Florida phosphatic fertilizer industry consumes about one-half of U.S. Frasch sulfur production. It is estimated that in 1975, the Florida fertilizer industry will represent a $70 million market for sulfur.

9. The book value of non-salvageable capital investment in the Florida phosphate industry (including related railroad facilities) is estimated at $850 million.

10. The fluorine contained in phosphate rock is capable of supplying a major share of U.S. demand thereby reducing fluorine imports proportionately. Over the productive life of the phosphate land-pebble deposits, an estimated $195 million worth of fluorine can be recovered.

11. Uranium with an estimated value of $2,770 million can potentially be recovered from Florida phosphate rock processing, if the U_3O_8 (uranium oxide) price is assumed to be $9 per pound in 1975. This uranium, if produced

as a primary product rather than as a byproduct of phosphoric acid production, would not be economically competitive with other uranium ores.

CONCLUSIONS

This study has presented a quantitative analysis of the Florida phosphate industry's economic significance to the State and to the Nation based on Florida phosphate rock production estimated at 38 million short tons in 1975. If the production estimate of 38 million tons were changed, the employment, value of output, and tax payments attributable to phosphate industry activity would change proportionately. For example, if Florida phosphate rock production were estimated at 34 million short tons, previous impact estimates for output and employment in 1975 would change as follows:

	Florida	Rest of Nation	National total
OUTPUT (MILLION 1972 DOLLARS)			
Direct.....	350	170	520
Indirect.....	140	430	570
Induced.....	840	1,030	1,870
Total...	1,330	1,630	2,960
EMPLOYMENT (NUMBER OF JOBS)			
Direct.....	8,800	-	8,800
Indirect.....	6,400	7,500	13,900
Induced.....	39,100	19,300	58,400
Total...	54,300	26,800	81,100

State and county tax revenues in million dollars would change as follows:

State corporate income taxes.....	6.0
State sales taxes.....	13.0
State motor fuel tax.....	.2
State severance tax (unrestricted).....	2.1
Total revenue to State.....	21.3
County property taxes.....	30.0
Total revenue contribution to State and counties.	51.3

Tax revenues to States other than Florida would change similarly, resulting in a slightly different total national tax revenue figure.

The balance of payments figure of $329.5 million in 1975 is based mainly on two estimates: (1) phosphate rock exports of 9 million short tons with a 1975 value of $17.32 per short ton in 1972 dollars and (2) Florida phosphatic fertilizer exports in 1975 assumed at the same level as in 1973. If these projections for 1975 are changed, the balance of payments figure would change accordingly.

The Florida phosphate industry has been shown to be economically important to the State and the Nation. The benefits from the industry are of significant magnitude. The impact is widespread both geographically and in its effect on various sectors of the economy. These benefits make clear the need for continued operation of the Florida phosphate industry.

APPENDIX A.--A PROCESS DESCRIPTION OF THE PRIMARY PRODUCTS OF THE PHOSPHATE INDUSTRY[1]

Although the phosphate industry is perhaps best characterized by the assorted agricultural and industrial products which comprise the bulk of its final output, the existence of the industry is totally dependent upon the mining of phosphate rock. In its processed form, phosphate rock accounts for a significant portion of the final sales of the industry, in addition to being the basic material from which all other phosphate products are made.

Marketable Phosphate Rock

Mining

Florida land-pebble phosphate deposits are characterized by pebbles and fine phosphatic sand dispersed in a nonphosphatic, sandy clay. This matrix, varying in thickness from 1 to 50 feet but averaging about 16 feet, is covered by overburden of quartz sand and clay that averages 20 feet in thickness.

The standard mining practice in the Florida land-pebble phosphate fields is to strip the overburden and mine the phosphate matrix with draglines. Electric-powered walking draglines with 35- to 49-cubic yard buckets work in cuts varying from 150 to 250 feet in width, from a few hundred yards to a mile or more in length, and from 50 to 70 feet in depth. Overburden is stacked on unmined ground adjacent to the initial cut by a dragline. As successive cuts are made by the dragline, overburden is cast into adjacent mined-out cuts. As each cut is stripped of overburden and then mined, the ore is stacked in a suction well or sluice pit that has been prepared on unmined ground. High pressure water is used to produce a slurry of about 40 percent solids from the matrix. The slurry is then pumped via pipe to the washer plant. In this manner, a typical operation will mine about 400 acres of land per year, remove 13 million cubic yards of overburden, and mine 9 million yards of matrix per year.

Water is used in the beneficiation process, in addition to being used as a transportation medium. Both fresh water from deep wells and reclaimed water from slime settling ponds are used by the phosphate industry. Approximately 10,000 gallons of water are necessary to produce 1 ton of marketable phosphate rock.

As the mining progresses, mined-out areas are used for the disposal of tailings and slimes, in addition to overburden. One ton of phosphatic clay and one ton of sand tailings must be disposed of for each ton of marketable phosphate rock produced. Some of the sand tailings and overburden is used to construct retaining dams in mined-out areas, behind which phosphatic clay slimes settle and dewater.

---

[1]Adapted from material prepared by William F. Stowasser, Phosphate Rock Specialist, Division of Nonmetallic Minerals, U.S. Bureau of Mines.

Beneficiation

Beneficiation methods differ slightly and are dependent on screen analysis of the feed; the ratio of washer rock to flotation feed; the proportions of phosphate, sand, and clay in the matrix; and equipment preference. Through a series of screens, in closed circuit with hammer mills and log washers, the matrix is broken down to permit separation of the sand and clay from the phosphate-bearing pebbles. Three concentrates of marketable phosphate rock are produced: a 3/4-inch by 14-mesh pebble, a coarse 14- by 35-mesh fraction, and a fine 35- to 150-mesh fraction. The washed, oversize pebble fraction is a final product. The minus 14- plus 35-mesh fraction is called the coarse feed from which a coarse concentrate is obtained by gravity and flotation processes. The tailings or waste from this fraction is used in dam construction or land reclamation. The minus 35- plus 150-mesh fraction is processed through a flotation section to recover a fine concentrate. The waste, a clay slime, is impounded in areas that have been mined.

As mentioned above, the marketable phosphate rock derived from this process is either sold as a final product (primarily to foreign consumers), or used as a raw material in the production of a variety of industrial products.

Wet Process Phosphoric Acid

Wet process phosphoric acid is produced by digesting phosphate rock with sulfuric acid. Wet process acid contains impurities that restrict its use in pharmaceuticals and similar products where high purity levels are required. Acid produced from furnace-grade elemental phosphorus is used in these applications. Wet process acid is almost exclusively used to manufacture fertilizers. Various concentrations of wet process phosphoric acid are used for different fertilizers. Although some dilute acid of approximately 32 percent P_2O_5, is used directly to manufacture some products, and acid concentrated to 38 to 40 percent is used for some ammonium phosphates, most of the acid is concentrated to approximately 54 percent P_2O_5. Most wet process plants sell only a small part of their production to the merchant market. The bulk of the acid is captive and used to produce ammonium phosphates and triple superphosphates.

Normal Superphosphate

Normal superphosphate (NSP) is produced by acidulating phosphate rock with sulfuric acid, temporarily holding the phosphatic material in a vat or den while the reaction proceeds to form a solid (denning), and then storing for completion of the reactions (curing, 4 to 6 weeks), resulting in an available P_2O_5 content of about 20 percent. The production rate of NSP has been declining each year as it becomes more difficult for NSP to compete with fertilizers with higher P_2O_5 concentrations. NSP was the first major phosphatic fertilizer produced, and today most of the older production facilities are outmoded. The trend toward reduced NSP production is accelerating because (1) the per unit cost of shipping P_2O_5 in a 20-percent concentration is higher than that of higher concentration products, and because of (2) the high cost of updating facilities to efficient operating levels with acceptable air pollution controls.

Triple Superphosphate

Triple superphosphate (TSP) is made by acidulating phosphate rock with wet process phosphoric acid. The product may be either pulverized or in granular form. The P_2O_5 content is approximately 46 percent. Because TSP is relatively concentrated, shipping costs per unit of P_2O_5 are minimized. The phosphorus content is almost entirely in plant-available form.

Ammonium Phosphates

The term "ammonium phosphates" describes a number of products prepared by combining phosphoric acid and ammonia. About three-fourths of ammonium phosphate production is diammonium phosphate (DAP) which is typically 18 percent nitrogen, 46 percent available P_2O_5, and 0 percent K_2O.

Elemental Phosphorus--"White" Phosphoric Acid

Elemental phosphorus is produced by electric furnace smelting of phosphate rock with silica and coke. The phosphorus is volatilized and emitted from the furnace in a carbon dioxide gas stream. Particulate matter is removed from the stream. The phosphorus is condensed in a direct-contact scrubber/condenser.

Three steps--burning, hydration, and collection--are involved in converting elemental phosphorus to phosphoric acid. Liquid phosphorus is burned in a combustion chamber to produce phosphorus pentoxide gas. The gas is sprayed with water in the hydrator to produce the acid concentration required.

Defluorinated Phosphate Rock

Phosphate rock can be used as an animal or poultry feed supplement when the fluoride content is reduced to a level too low to cause adverse biological effects. The phosphate rock must be reduced from about 3.5 percent to less than 0.2 percent fluorine. High-grade phosphate concentrate, phosphoric acid, silica, and caustic soda or sodium chloride are blended and pugged to a thick slurry, which is dried and agglomerated to a 1/2-inch by 20-mesh prepared feed. This feed is defluorinated in either rotary kilns or fluid bed reactors at temperatures ranging from 2,650° to 2,800° F.

Dicalcium Phosphate

The normal process of manufacturing dicalcium phosphate involves mixing defluorinated phosphoric acid with finely ground limestone, drying, and sizing the product. The critical factors in the process are control of the phosphorus content and the size of the product.

APPENDIX B.--ECONOMIC PROFILE OF SOUTHWEST FLORIDA[1]

Southwest Florida is a 14-county area on the Gulf Coast, with Tampa as its focal point. This region, which includes Hillsborough and Polk counties, is the primary phosphate producing area in the State. The population of southwest Florida is estimated at 1,882,700 (26 percent of the State population), and is projected to reach 2.5 million by 1982, a growth rate of over 30 percent. The influx, primarily of retired persons, will continue to be the major source of the area's growth in population. Much of this growth is expected to occur in the Lakeland-Winter Haven area (Polk County) as a result of the commercial-residential impetus provided by Disney World, which is located in neighboring Orange County. The salient feature of the area's population is its age distribution: 22 percent of the population is 65 and over, as compared with the national average of 9.9 percent.

Manpower

During the past decade, the number of jobs in southwest Florida increased by 187,560, while the labor force grew by 181,900. As a result, regional unemployment dropped from 6.7 percent in 1961 to 4 percent in 1971, 0.5 percent below the State unemployment rate. There are presently 661,620 people in the labor force, comprising 24 percent of the State total. It is predicted that by 1980 there will be an additional 202,000 persons in the labor force, again due primarily to in-migration.

Income

Personal income in southwest Florida exceeded $5.9 billion in 1970, nearly 24 percent of the State total. However, not one county in the region had a per capita income as high as the national or State per capita income. This low level of per capita income is the result of two major factors: (1) the low percentage of income in the region which is derived from wages (55.6 percent, as compared with the national average of 67.2 percent), which is, in turn, attributable to the fact that approximately one-fourth of the region's population is retired, and (2) the high percentage of employment which is concentrated in the relatively low-paying trade, service, and self-employed sectors (54.2 percent as compared with 40.5 percent nationally).

Polk County

Polk County has the highest per capita income in the region, largely as a result of its role as the major producer of both citrus fruits and phosphate rock and fertilizer. It has the third largest manufacturing payroll in the region and, together with Hillsborough and Pinellas counties, accounts for over 83 percent of the manufacturing in the region.

---

[1] Florida Trend. Solid Gains Made in Southwest. v. 14, No. 12, April 1972, pp. 79-114.

Phosphate Industry

Mining and fertilizer manufacturing, have, respectively, the third and fifth highest average weekly wages in the region ($149 for mining and $139 for fertilizer manufacturing). All manufacturing is the source of only 15.9 percent of the wages paid in southwest Florida. Mining alone accounts for 0.9 percent of total wages. The phosphate industry adds strength and diversity to the economy of southwest Florida.

APPENDIX C.--METHODOLOGY OF IMPACT ANALYSIS[1]

In general, most firms involved in the mining of phosphate rock are involved in its subsequent processing as well. However, in the framework provided by the Standard Industrial Classification (SIC), mining and processing constitute two distinct industries: SIC 1475 represents phosphate rock mining; the phosphatic fertilizer component of SIC 2871 (fertilizers) and the captive sulfuric acid manufacturing component of SIC 2819 (industrial inorganic chemicals, not elsewhere classified) represent processing, as given in the 1967 edition of the SIC Manual.[2] (In the 1972 SIC edition, phosphatic fertilizer was isolated as SIC 2874.) In the unpublished Bureau of Mines' expanded 136-sector input-output model,[3] SIC 2871 and SIC 2819 are grouped with other related industries to form Interindustry Sales and Purchases (ISP) Sector 27, Chemicals and selected products. Thus, in terms of the Bureau of Mines' model from which the multipliers used herein were derived, the phosphate rock and fertilizer industries are represented by two distinct classifications: phosphate rock mining, sector 49; and chemicals and selected products, sector 77.

Available data treats both sectors as a single, unified industry. Since it has been assumed that the discontinuance of mining would lead to the closing of all processing operations as well, this presents no problem to the analysis as a whole. However, it does mean that there is little basis for a meaningful differentiation between "industries," a separation which would be necessary if the individual multipliers were to be applied. Therefore a single multiplier, that for phosphate rock mining (sector 49), is used. Since the aggregate multipliers for sectors 49 and 77 are quite close, the effect of this simplification will be of little consequence.

The national multipliers (interindustry and total)[4] for phosphate rock mining, derived from the Bureau of Mines' expanded input-output model, are as follows:

	Interindustry multiplier (direct and indirect)	Total multiplier (direct, indirect, and induced)
Employment.....	2.574	9.186
Income.....	2.302	5.020
Output.....	2.098	5.693

[1]For a detailed discussion of the methodology of input-output impact analysis see Chapter 5 in Interindustry Structure of U.S. Mining Industries--1958. (Wang, K.-L., and R. G. Kokat. Interindustry Structure of U.S. Mining Industries--1958. BuMines IC 8338, 1967, 190 pp.)

[2]Office of Statistical Standards, Executive Office of the President, Bureau of the Budget. Standard Industrial Classification Manual 1967, Government Printing Office, Washington, D.C., 1967, 615 pp.

[3]Office of Economic Analysis. Unpublished Research. Available for consultation at Bureau of Mines, Washington, D.C.

[4]The interindustry multiplier is the same as the Type I multiplier and the total multiplier is the same as the Type II multiplier of The Elements of Input-Output Analysis. (Miernyk, W. H. The Elements of Input-Output Analysis. Random House, New York, 1965, pp. 42-55.)

These multipliers were reduced as follows, prior to their inclusion into a regional (State) analysis:

	Interindustry multiplier (direct and indirect)	Total multiplier (direct, indirect, and induced)
Employment.....	1.725	6.155
Income.....	1.543	3.363
Output.....	1.406	3.814

Such a reduction is necessary to allow for "leakage"--that part of the industry's purchases of goods and services from outside the region (State) under consideration. The indirect and induced effects of such expenditures occur outside Florida. On the basis of information provided by the Florida Phosphate Council, industry expenditures for 1970 and 1971 were calculated. For both years, industry expenditures within Florida amounted to between 72 and 77 percent of total expenditures. Assuming approximately one-third of the industry's expenditures would be outside Florida, two-thirds of the expenditures would be within the State. The regional multipliers were derived by reducing the national multipliers by one-third.

The following estimates for the analysis were developed for the 1975 output of the Florida phosphate industry by W. F. Stowasser, Division of Nonmetallic Minerals, Bureau of Mines:[5]

Phosphatic product	Marketable phosphate rock equivalent (short tons)
Marketable phosphate rock[1].....	38,000,000
Wet phosphoric acid (intermediate).....	23,651,250
Normal superphosphate (final).....	1,391,250
Triple superphosphate (part final).....	2,226,000
Defluorinated rock (final).....	556,500
Elemental phosphorus (final).....	175,000
Estimated products from wet phosphoric acid:	
Triple superphosphate (final).....	3,784,200
Ammonium phosphate (final).....	10,643,063
Dicalcium phosphate.....	1,182,562
Other.....	8,041,425

[1]Based on this analysis, approximately 10 million tons of marketable phosphate rock would be exported from Florida in 1975.

Employing process and operations analyses, and using both the estimated 1975 output of the Florida phosphate industry and the 1972 value of phosphate rock and fertilizers, the 1975 direct employment, direct personal income, and direct output were calculated for Florida and the rest of the Nation under assumptions of constant wages and productivity. The resultant figures used as the basis for the multiplier analysis are as follows: employment, 9,900; personal income, $77.7 million; and output, $580 million.

[5]Stowasser, W. F. Unpublished data. Available for consultation at Division of Nonmetallic Minerals, Bureau of Mines, Washington, D.C.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1974 O—559—157