

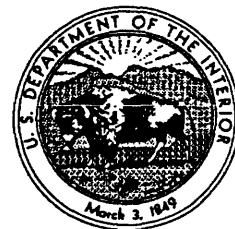
**COUNTY-LEVEL ESTIMATES OF NITROGEN AND  
PHOSPHORUS FERTILIZER USE IN THE UNITED STATES,  
1945 to 1985**

**By Richard B. Alexander and Richard A. Smith**

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# **COUNTY-LEVEL ESTIMATES OF NITROGEN AND PHOSPHORUS FERTILIZER USE IN THE UNITED STATES, 1945 to 1985**

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## **ABSTRACT**

Estimates of nitrogen and phosphorus fertilizer use were made for counties in the United States for the period 1945 to 1985. County fertilizer use estimates were obtained through the disaggregation of state-level fertilizer use in proportion to the amount of state fertilized acreage reported to exist in counties. Numerical values of nitrogen and phosphorus fertilizer use by county are not presented in the text of this report because of the size of the data file, but are available in machine-readable form upon request. Graphical summaries of national, state, and county nitrogen and phosphorus fertilizer use are presented to briefly describe the spatial and temporal variability that exist in the data.

## **INTRODUCTION**

Information on fertilizer use commonly is needed in investigations of surface and ground water quality and particularly in investigations of the variability of surface and groundwater nutrient concentrations over time and space. To date, information on fertilizer use taken from annual reports by the Department of Agriculture (1966, 1976, 1977-1985) has been available only at the state level, which does not provide enough spatial detail for most water-quality investigations. Moreover, state-level fertilizer use data from the Department of Agriculture is currently difficult to use for water-quality investigations because of the limited availability of data in a machine-readable form.

The purpose of this report is to document the compilation of machine-readable estimates of nitrogen and phosphorus fertilizer use by county for the period 1945 to 1985. The technique used to disaggregate state-level fertilizer use data to the county level is described in detail. Numerical values of nitrogen and phosphorus fertilizer use by county are not presented in the text of this report because of the size of the data file, but may be obtained in machine-readable form upon request.<sup>1</sup> Several graphical summaries of nitrogen and phosphorus fertilizer use are provided to give a general impression of the spatial and temporal variability that exist in the data.

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<sup>1</sup> The data are available on magnetic tape at the cost of processing from: U.S. Geological Survey, National Water Data Exchange (NAWDEX), 421 National Center, Reston, Virginia 22092 (telephone: 703-648-5684).

## **DATA SOURCES AND METHODS**

### **FERTILIZER USE DATA**

State-level information on the use of nitrogen (as N) and phosphorus (as P<sub>2</sub>O<sub>5</sub>) in fertilizer products were obtained from the U. S. Department of Agriculture (USDA, 1966, 1976, 1977-1985) for the years 1945 to 1985, and were coded into machine-readable computer files. USDA phosphorus (as P<sub>2</sub>O<sub>5</sub>) fertilizer use data was multiplied by 0.437 to express phosphorus fertilizer use as P in these computer files. Nitrogen and phosphorus fertilizer use data were compiled annually by the Statistical Reporting Service (SRS) of the USDA and were based on fertilizer use information reported by State fertilizer control officials. State officials obtained fertilizer use data monthly from fertilizer industry representatives (primarily fertilizer distributors), who, in many states, were legally required to report this information to regulatory agencies. Additional information on fertilizer use was obtained annually from voluntary surveys of more than 1500 fertilizer manufacturers, blenders, and sale outlets in the United States. The annual data compiled by USDA is for the fertilizer year ending on June 30. Thus, for example, fertilizer use for 1975 spans the period of July 1, 1974 to June 30, 1975. In general, annual fertilizer use data reported by SRS should reflect farm and non-farm uses of fertilizer given that in many states licensed fertilizer distributors are required to report all sales of fertilizer chemicals to state regulators.

For certain years and states, fertilizer use data is either incomplete or reflects a fundamental change in the estimation method which may affect the comparability of the data from one year to another. Fertilizer use data for the states and years listed in Table 1 reflect these types of problems. For states with annual fertilizer use data that were incomplete, the SRS estimated current use from the previous year's use data as well as from any monthly data that may have been available for the current year. Annual survey data (as described above) were also used by SRS to supplement state fertilizer use data that was found to be incomplete.

### **FERTILIZED ACREAGE DATA**

Estimates of county fertilized acreage compiled as part of the 1974, 1978, and 1982 Census of Agriculture were obtained from the U. S. Department of Commerce (1974, 1978, 1982). In responding to the Census, farm operators with annual sales in excess of \$1000 were requested to report the total amount of acreage including cropland, pastureland, and rangeland that was treated with fertilizer chemicals. Farm acreage that received multiple fertilizer treatments was to be reported only once in the Census.

### **COUNTY DISAGGREGATION OF STATE-LEVEL FERTILIZER USE DATA**

The method used here for disaggregation of state-level fertilizer use assumes that county-level fertilizer use is directly proportional to the amount of fertilized acreage present within counties. Thus, state-level fertilizer use was

**Table 1.** States and years with fertilizer use data that required additional estimation or is not comparable with previous data. Data on fertilizer use is from the U. S. Department of Agriculture (1966, 1976, 1977-1985).

YEAR	STATES	DESCRIPTION OF PROBLEM
1980	LA	Complete data not available. Current data estimated from previous year's data
1981	LA, CONN, ND	"
1982	NH, VT, DEL, MONT	"
1983	DEL, SD	"
1984	CONN, MD, NH, VT, DEL, MINN, ND, SD	"
1985	Utah, MD, DEL, MINN, SD	"
1985	MO	Previous data not comparable (new reporting method used)
1985	ND	Data includes sources not previously considered
1985	TEX	New fertilizer year used (June 1 to May 31)

disaggregated to the county level in proportion to the amount of state fertilized acreage present in counties. This method is described in equation 1 as

$$FC_{ik} = FS_i \cdot FAC_{ik} / FAS_i \quad (1)$$

where,

$FC_{ik}$  is county-level fertilizer use for the  $i$ th state and  $k$ th county,

$FS_i$  is state-level fertilizer use for the  $i$ th state,

$FAC_{ik}$  is county fertilized acreage for the  $i$ th state and  $k$ th county,

$FAS_i$  is state fertilized acreage for the  $i$ th state.

Because of the availability of only three annual estimates (1974, 1978, 1982) of county fertilized acreage, state-level fertilizer use was disaggregated to the county level by using fertilized acreage data that most closely corresponded in time to the fertilizer use data. The temporal correspondence of fertilizer use and fertilized acreage data that was used to estimate county-level fertilizer use is shown in Table 2.

**Table 2.** Annual fertilizer use data and corresponding annual fertilized acreage data used to estimate county-level fertilizer use.

<b>Fertilizer Use<sup>1</sup></b>	<b>Fertilized Acreage<sup>2</sup></b>
1945 - 1976	1974
1977 - 1980	1978
1981 - 1985	1982

<sup>1</sup> U. S. Department of Agriculture (1966, 1976, 1977-1985)

<sup>2</sup> U. S. Department of Commerce (1974, 1977, 1982)

### DATA RELIABILITY

Because pre-1970 county fertilized acreage may differ significantly from 1974 estimates of county fertilized acreage, county estimates of fertilizer use made prior to the early 1970s should be used with some caution. This is especially true in those states where the amount of fertilized acreage in 1974 is believed to be significantly different than existed in years prior to this date.

Although state-level fertilizer use data reported by USDA (1966, 1976, 1977-1985) should generally include farm and non-farm uses of fertilizer, this data was disaggregated to U. S. counties in proportion to only reported county farm uses of fertilizer chemicals. Consequently, this disaggregation method underestimates fertilizer use in those counties with large non-farm fertilizer uses.

In general, the accuracy of the county-level estimates of fertilizer use is potentially affected by differences that may exist in fertilizer application rates among counties. For a given state, the degree of proportionality between county fertilized acreage and fertilizer use is dependent upon the magnitude of differences in fertilizer application rates among counties. Intrastate variability in fertilizer application rates, which should generally reflect variability in nutrient requirements of different crops, would be expected to be smaller (and estimates of county fertilizer use more accurate) in those states where crop types are not very diverse or where crop types are uniformly distributed throughout the state.

Evaluation of the accuracy of the disaggregation method in light of these factors requires information on county-level crop types and acreages as well as estimates of typical fertilizer application rates for various crop types. Because this information was not readily available during the preparation of the report, this analysis was not undertaken. Improvements in the accuracy of county fertilizer use could probably be attained in future studies with the use of an algorithm that disaggregates state-level fertilizer use according to estimated fertilized acreage and fertilizer application rates in counties.

## RESULTS

County-level estimates of nitrogen (as N) and phosphorus (as P) fertilizer use (expressed as kilograms per year) were generated according to the above methods, and are available in machine-readable form upon request.<sup>2</sup> Counties are identified by the standard FIPS code designation in the files. Data for Alaska and Hawaii are not included as part of these files.

Several graphical summaries of nitrogen and phosphorus fertilizer use are provided as examples of the spatial and temporal variability that exist in the data. County maps of estimated nitrogen and phosphorus fertilizer use are shown in figures 1 and 2, respectively, for the year 1985. County nitrogen fertilizer use for 1985 is mostly between 640,000 kilograms per year (25th percentile) and 4.7 million kilograms per year (75th percentile) with a median of nearly 2 million kilograms per year (see Figure 3). County phosphorus fertilizer use for 1985 is typically about 15 percent of that estimated for nitrogen. Phosphorus fertilizer use for 1985 ranged mostly from 128,000 kilograms per year to 833,000 kilograms per year with a median of 272,000 kilograms per year. Nationally, the spatial pattern of fertilizer use for 1985 is very similar for nitrogen and phosphorus (see Figure 1 and 2). As expected, the highest fertilizer use was observed in those states with the greatest amounts of cropland. These included states in the northern portions of the Midwest, many throughout the Central Plains, and several in the extreme western and northwestern portions of the U.S.

Nationally, nitrogen and phosphorus fertilizer use has increased markedly over the period 1945 to 1985 (see Figure 4 and 5). A nearly twenty-fold increase is observed in nitrogen fertilizer use during this period with peak use occurring in 1981. Nitrogen fertilizer use declined from 1981 to 1983, but increases in 1984 and 1985 brought total use to a level approaching that for 1981. Nationally, phosphorus fertilizer use increased approximately four fold from 1945 to 1985. Phosphorus fertilizer use peaked in 1978 and remained largely unchanged until 1983 when phosphorus fertilizer use declined approximately 25 percent.

State estimates of nitrogen and phosphorus fertilizer application rates were computed for 1982 as the ratio of state fertilizer use to state fertilized acreage. These application rates are displayed in Figure 6 and 7 and expressed as kilograms per acre. Estimated nitrogen fertilizer application rates ranged from a minimum of 20 kilograms per acre to a maximum of 90 kilograms per acre with a median of 40 kilograms per acre. The highest nitrogen application rates are found in states in the northern midwest, central plains, and far west. Estimated phosphorus fertilizer application rates ranged from a minimum of 4 kilograms per acre to a maximum of 24 kilograms per acre with a median of 9 kilograms per

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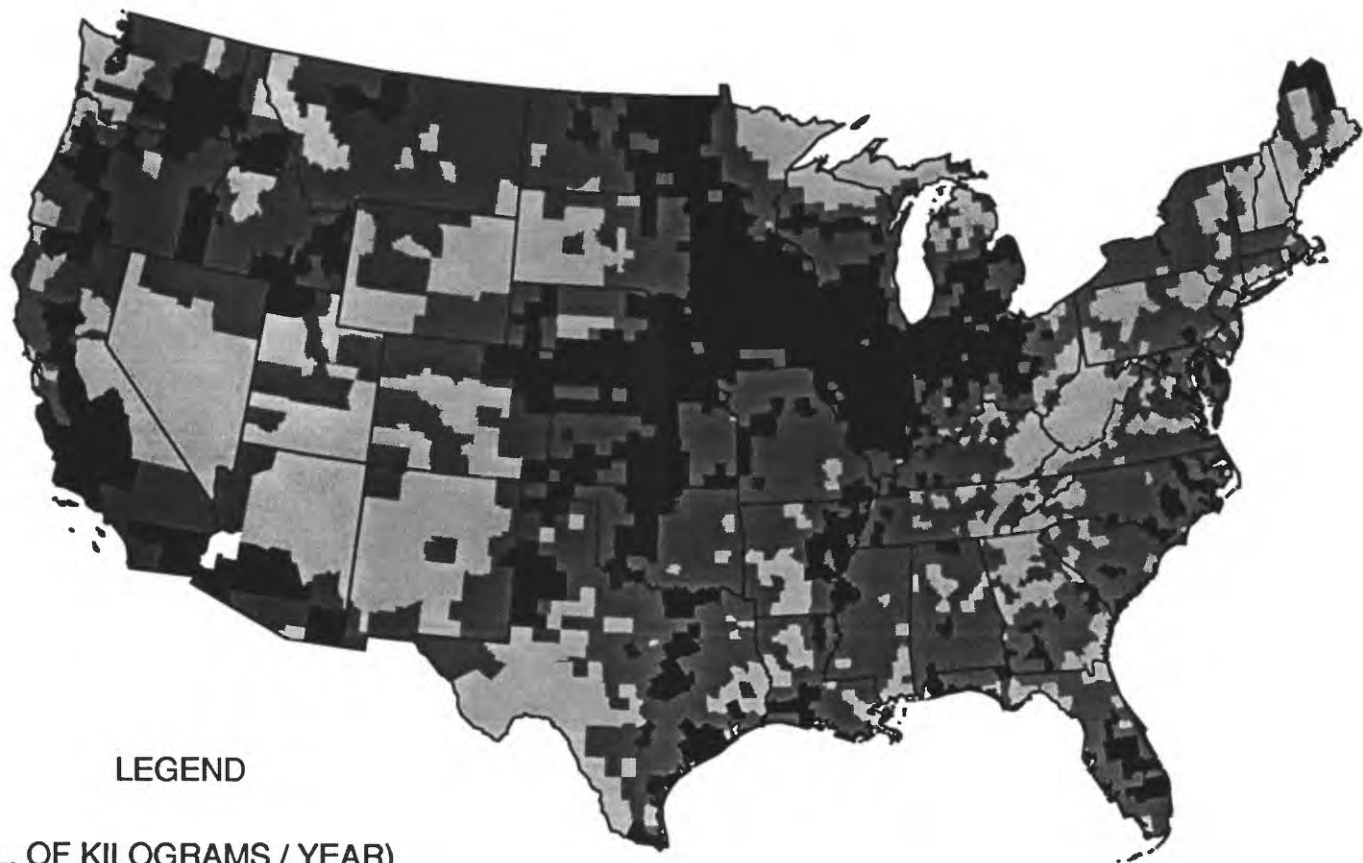
<sup>2</sup> The data are available on magnetic tape at the cost of processing from: U.S. Geological Survey, National Water Data Exchange (NAWDEX), 421 National Center, Reston, Virginia 22092 (telephone: 703-648-5684).



acre. The highest phosphorus fertilizer application rates are found largely in states in New England, the Mid-Atlantic, and the Great Lakes region.

## REFERENCES

- U. S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, *Consumption of Commercial Fertilizers and Primary Plant Nutrients in the United States, 1850-1964*, Statistical Bulletin No. 375, June, 1966, 84 p.
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- U. S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, *Commercial Fertilizers: Consumption for Year Ended June 30, 1977-1985* (Annual Data Released in November of Years 1977-1985).
- U. S. Department of Commerce, Bureau of the Census, *Census of Agriculture, Final County File, Technical Documentation*, Washington, D. C., 1974, 1977, 1982.



LEGEND

(MIL. OF KILOGRAMS / YEAR)

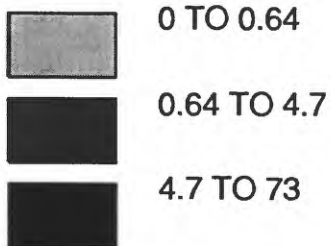
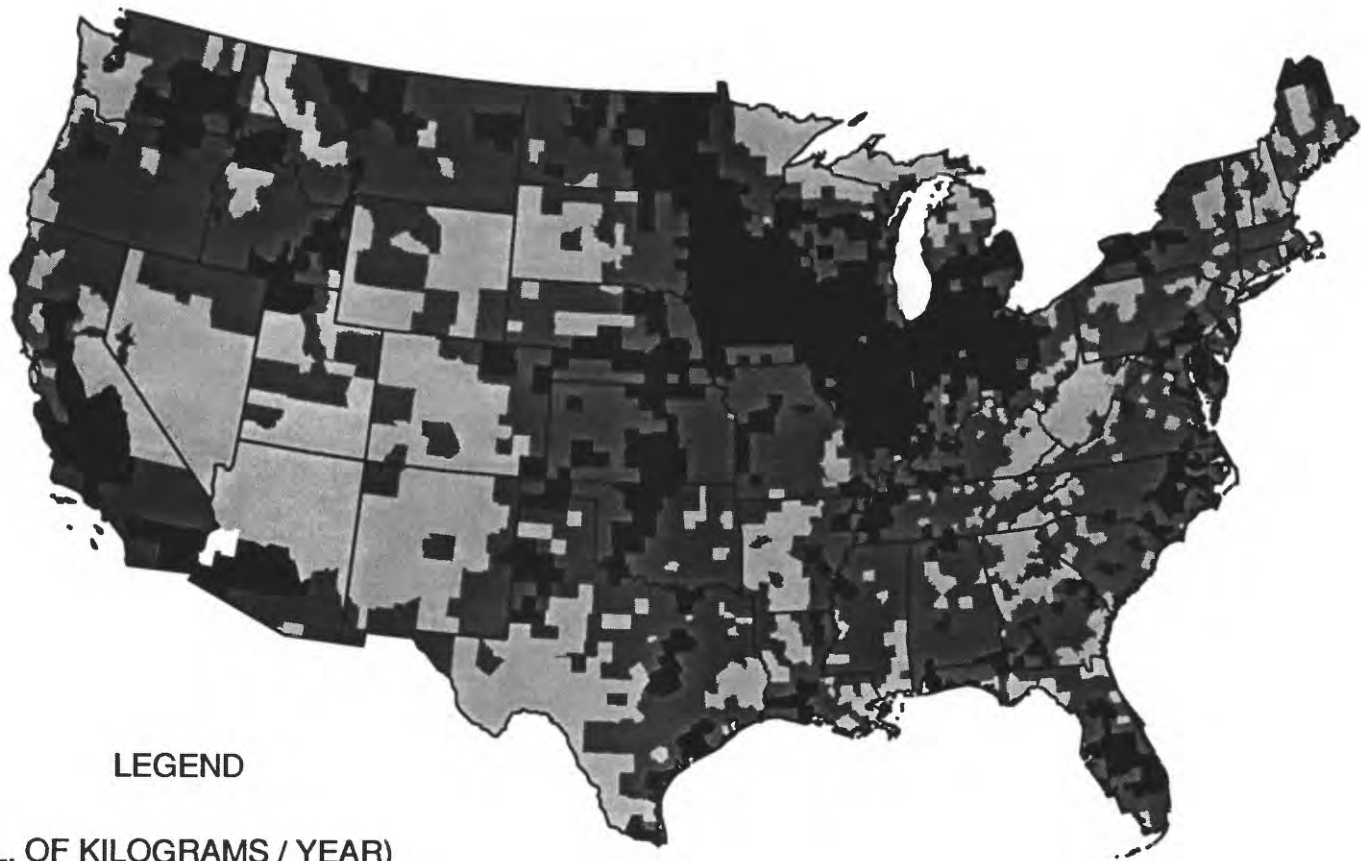


FIGURE 1. ESTIMATED COUNTY NITROGEN (AS N) FERTILIZER USE (1985).



LEGEND

(MIL. OF KILOGRAMS / YEAR)



0 TO 0.13



0.13 TO 0.83



0.83 TO 9.5

FIGURE 2. ESTIMATED COUNTY PHOSPHORUS (AS P) FERTILIZER USE (1985).

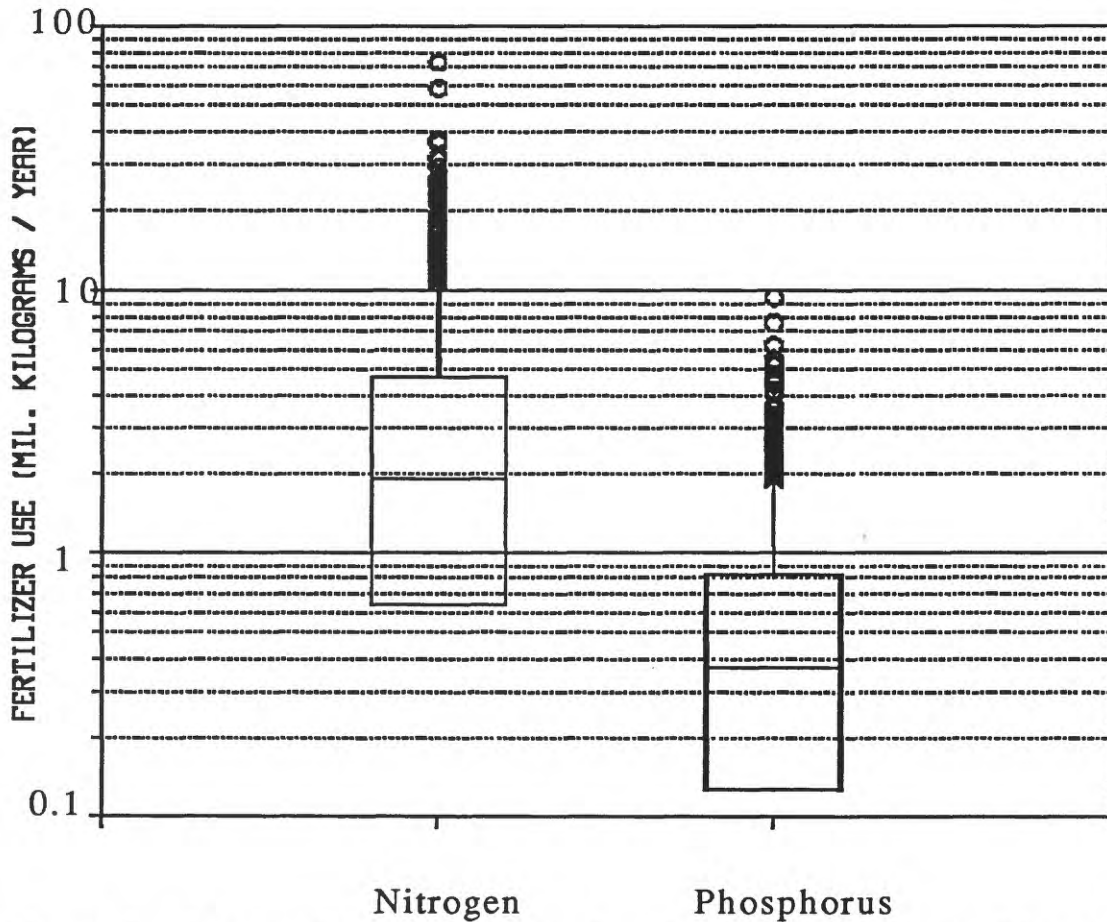


Figure 3. Box and whisker plots of estimated nitrogen (as N) and phosphorus (as P) fertilizer use (1985) for U. S. counties (N=3077). In the figure, the lower and upper edges of each box gives the 25th and 75th percentiles, respectively. Each box is divided at the median value. The upper tails are drawn to the largest value within 1.5 times the interquartile range (IQR). Values that lie between 1.5 and 3 times the IQR are represented by an "X", and values exceeding 3 times the IQR are represented by an "O".

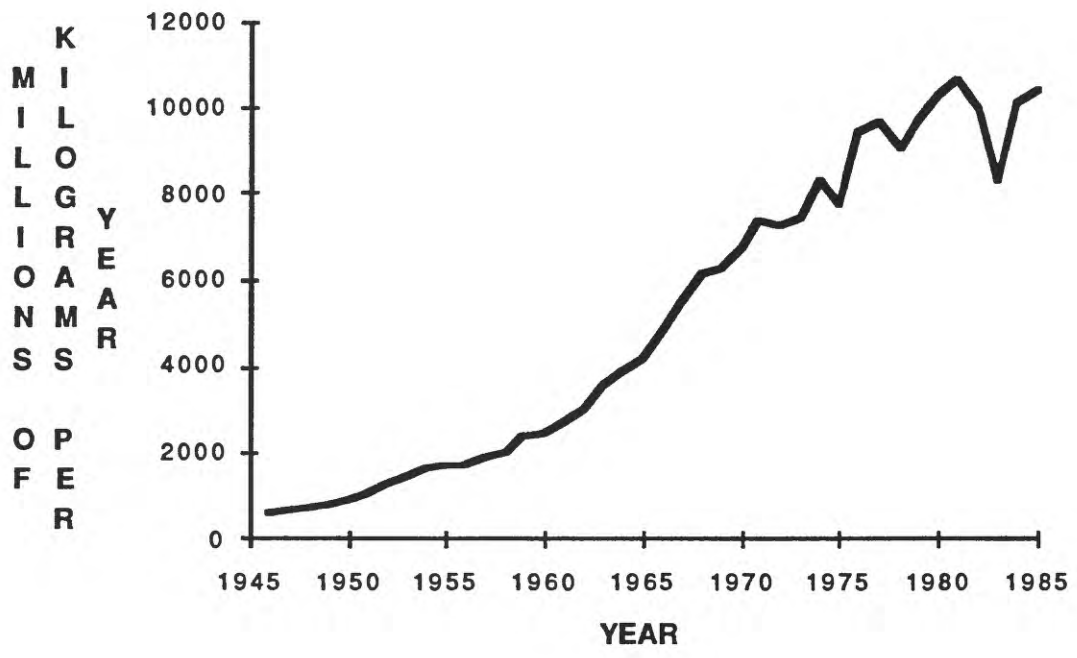


Figure 4. Nitrogen (as N) fertilizer use in the U. S., 1945-1985.

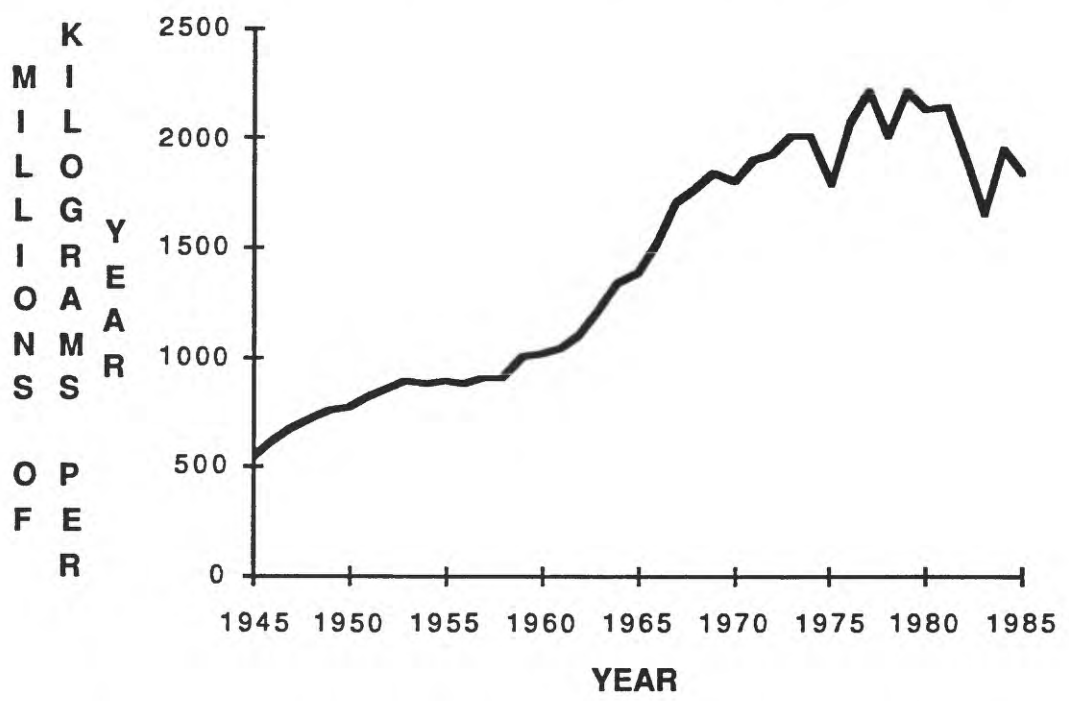
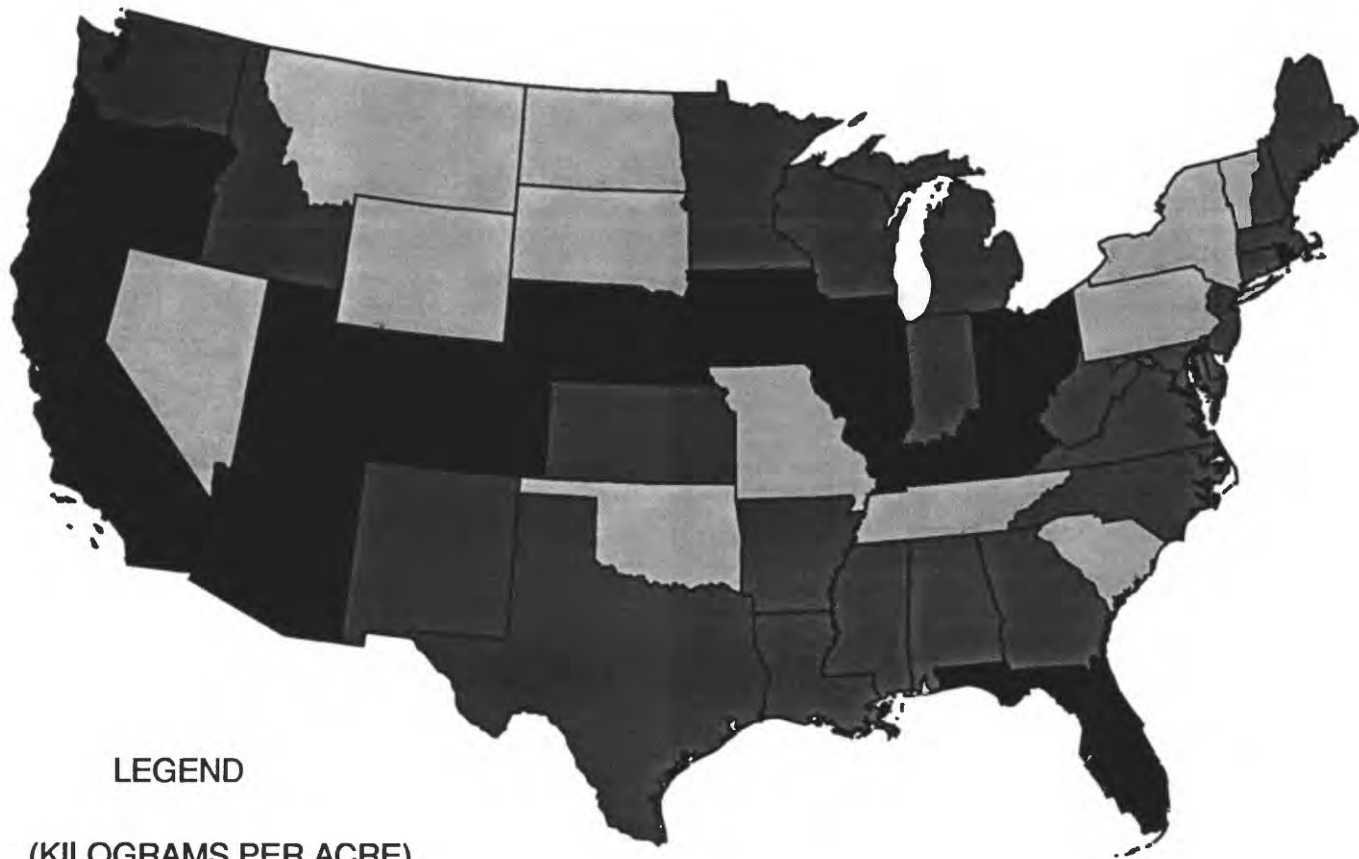


Figure 5. Phosphorus (as P) fertilizer use in the U. S., 1945-1985.



LEGEND

(KILOGRAMS PER ACRE)

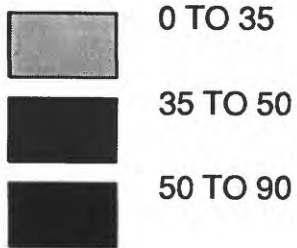
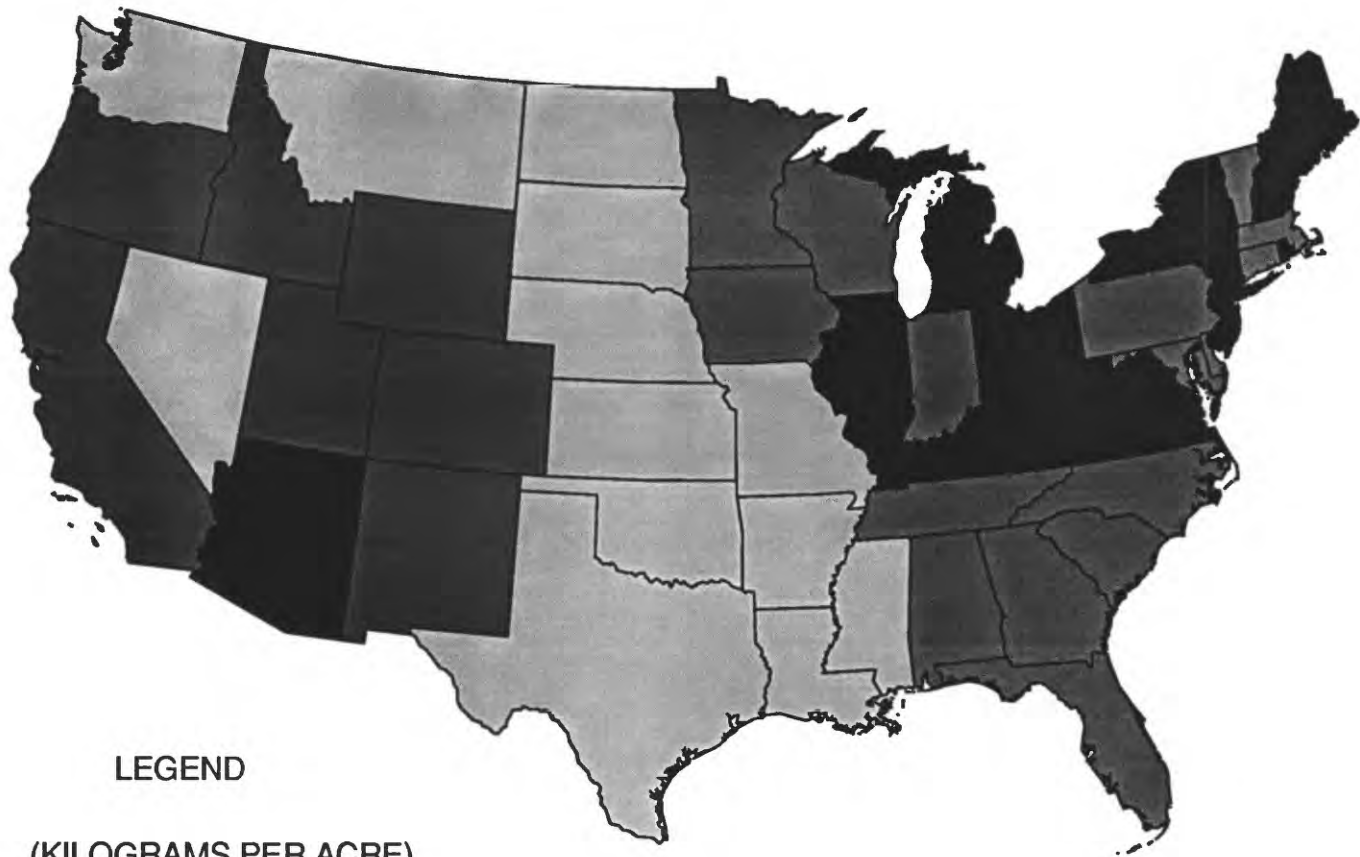


FIGURE 6. ESTIMATED NITROGEN (AS N) FERTILIZER APPLICATION RATES (1982) BY STATE.



LEGEND

(KILOGRAMS PER ACRE)

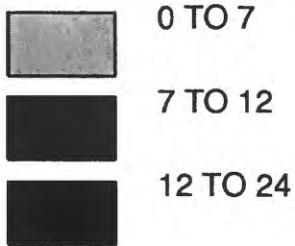


FIGURE 7. ESTIMATED PHOSPHORUS (AS P) FERTILIZER APPLICATION RATES (1982) BY STATE.