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Non-Point Source—Stream Nutrient Level Relationships: A Nationwide Study

Supplement 1: Nutrient Map Reliability

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NONPOINT SOURCE—STREAM NUTRIENT LEVEL RELATIONSHIPS: A NATIONWIDE STUDY

SUPPLEMENT 1: NUTRIENT MAP RELIABILITY

By

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DISCLAIMER

FOREWORD

Effective regulatory and enforcement actions by the Environmental Protection Agency would be virtually impossible without sound scientific data on pollutants and their impact on environmental stability and human health. Responsibility for building this data base has been assigned to EPA's Office of Research and Development and its 15 major field installations, one of which is the Corvallis Environmental Research Laboratory (CERL).

The primary mission of the Corvallis Laboratory is research on the effects of environmental pollutants on terrestrial, freshwater, and marine ecosystems; the behavior, effects and control of pollutants in lake and stream systems; and the development of predictive models on the movement of pollutants in the biosphere.

This report clarifies the reliability and applicability of an earlier CERL study that related phosphorus and nitrogen levels in stream to the non-point influences present in their drainage areas and also demonstrated the regionalities in stream nutrient levels in the conterminous United States. As such the information provided herein should be of interest and utility to water quality managers.

Thomas A. Murphy
Director, CERL

ABSTRACT

The National Eutrophication Survey (NES) national maps of nonpoint source-related nitrogen and phosphorus concentrations in streams were evaluated for applicability and reliability. Interpretations on these maps, which were based on data from 928 sampling sites associated with nonpoint source watersheds and the relationships of these data to general land use and other macro-watershed characteristics, were compared with a nationwide set of nonpoint source stream nutrient data collected largely by the U.S. Geological Survey (USGS).

In most areas where comparisons could be made the mapped interpretations agreed relatively well with USGS data. Where disagreements did occur regarding nitrogen concentrations, NES mapped interpretations tended to be higher than USGS values more often than lower; where disagreements occurred regarding phosphorus concentrations, the reverse was apparent.

Revised reliability map insets based on these analyses are provided for maps of total nitrogen and total phosphorus concentrations.

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SECTION 1

INTRODUCTION

The primary objective of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) is "...to restore and maintain the chemical, physical, and biological integrity of the Nation's waters". Section 208 of PL 92-500 requires that each state identify areas which have substantial water quality control problems. It appears evident that these problem areas should be identified on the basis of local and regional variations in the sources and concentrations of specific pollutants. Accurate identification of sources and reliable assessment of the contribution of each source to pollution are essential if effective pollution control strategies are to be implemented.

Historically, the principal strategy employed to protect water quality has been to control pollution from urban-industrial point* sources. However, it is now recognized that in many cases water quality cannot be adequately protected without also controlling nonpoint sources* of pollution (i.e., pollution resulting from agricultural, silvicultural, mining, and construction activities). Section 208 of PL 92-500 requires that state and local governments develop areawide waste treatment management plans which identify point and nonpoint sources of water pollution. For areas in which pollution from nonpoint sources (NPS) is a problem, the plans must include procedures for controlling that pollution to the extent feasible.

Pollution from nonpoint sources varies spatially and temporally due to natural as well as anthropogenic influences. Agencies reponsible for "208 planning" must be able to identify geographic variations in water quality and determine whether those variations are related to changes in "natural," background conditions or to pollution from man-related point and/or nonpoint sources. These distinctions must be made both at a general, regional level to identify areas with water quality problems and at a site-specific, local level to identify and control sources of pollution.

Unfortunately, the water quality data needed for 208 planning have not been collected in many areas. Planning agencies lacking data often do not have the time, money, and/or expertise required to conduct systematic water sampling programs. Expediency has forced many agencies to use water quality prediction models to estimate concentrations of various pollutants, particu-

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* According to Pisano (1976), point sources are: 1) discrete and confined; i.e., effluent from a pipe; and 2) controlled through best practices technology for industry and secondary waste treatment for municipalities. Paisano defines nonpoint sources as: 1) dispersed, diffuse and intermittent; 2) influenced by local climatic, hydrologic, and terrestrial conditions; and 3) controlled through land management and conservation practices.

larly those attributable to nonpoint sources. Generally, these models are based on empirically-derived relationships between land use or other basin characteristics and concentrations of selected water quality parameters (e.g., nutrients such as nitrogen and phosphorus*). The state-of-the-art for models used to predict concentrations of nitrogen and phosphorus in streams is particularly primitive, relying primarily on regression equations (i.e., Dillon and Kirchner, 1975; Omernik, 1976; 1977) or on adaptations of the Universal Soil Loss Equation** (i.e., McElroy et al., 1976). The reliability of these empirical models is questionable, particularly when the models are extended beyond the design and geographic limits of the original studies. Therefore, those concerned with accurate local assessments of nonpoint source pollution may find that the reliability of these empirical models is unsatisfactory. On the other hand, those concerned with regional variations in stream nutrient levels, or with the preliminary identification of areas with potential water quality control problems, may find that obtaining the detailed land use, soils, terrain, and climatic data required by these empirical models is exorbitantly expensive and time consuming (and unwarranted considering the level of information needed). Clearly, alternative NPS assessment methodology is needed.

One alternative to the assessment methodology mentioned above has recently been developed. This alternative is based on a set of maps which illustrate ranges in mean annual NPS-related nutrient concentrations that one might generally expect in streams draining any area within the conterminous United States (Omernik, 1977). The maps were compiled by comparing patterns of land use in the United States (U.S. Geological Survey, 1970) with water quality data mapped for 928 NPS-type watersheds sampled for the Environmental Protection Agency's (EPA) National Eutrophication Survey (NES). Apparent regional relationships between land use patterns (and other human-related activities such as fertilizer usage and livestock densities) and nutrient concentrations in streams sampled for the NES were used to classify areas according to the range in mean annual concentration of total nitrogen (N), inorganic nitrogen (IN), and total phosphorus (P) expected in streams in each area. Therefore, concentrations illustrated on the NES maps do not represent actual nutrient concentrations in a particular stream at a particular time; however, general areal patterns of NPS-related stream nutrient levels can be interpreted from the NES maps in the same manner that one can interpret the areal distribution of precipitation from an isometric map.

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* Nitrogen and phosphorus are usually the limiting factors influencing eutrophication (the nutrient enrichment of water bodies), and are generally considered to be the nutrients having the greatest potential for affecting water quality.

** The Universal Soil Loss Equation (USLE; see Wischmeier and Smith, 1965) was originally developed to estimate long-term average annual soil loss due to sheet and rill erosion on agricultural fields in the midwest; however, it has been extended beyond the original design by McElroy et al. (1976) to estimate NPS concentrations of sediment, nutrients and other chemicals in streams. Problems encountered when using the USLE to predict NPS pollutant levels are discussed by Wischmeier (1976), Omernik (1977), U.S. Forest Service (in press), and McDowell (1979).

OBJECTIVES

The purpose of this paper is to evaluate the utility and the reliability of the NES maps of stream nutrient concentrations attributable to nonpoint sources. We will clarify the utility of the NES maps by briefly reviewing their basis, strengths (including possible applications), and limitations. Most of this paper, however, is concerned with clarifying the reliability of the NES map interpretations. Reliability is evaluated by comparing the NES map interpretations with mapped patterns of mean annual total nitrogen and total phosphorus concentrations primarily determined by the U.S. Geological Survey (USGS). The NES map of inorganic nitrogen concentration was not evaluated because of a lack of suitable data for comparison. Only those USGS stations monitoring NPS-type watersheds are used in the comparisons. Results of the comparisons are mapped and discussed. Finally, new reliability maps are presented to clarify the spatial variations in reliability associated with each NES map examined.

SECTION 2

CONCLUSIONS

The NES maps can be valuable tools for individuals or agencies concerned with regional comparisons of NPS-related stream nutrient levels. However, the strengths, limitations, and reliability of NES map interpretations should be considered carefully before those interpretations are used to estimate NPS-related stream nutrient levels in any basin or region. Although NES map interpretations are not an equivalent substitute for stream nutrient data (particularly for assessments of streams draining small watersheds), agencies lacking such data could use the NES maps either to make regional NPS assessments or to identify potential problem areas that may require sampling programs.

Data from 330 USGS stations monitoring total nitrogen concentrations and 601 monitoring total phosphorus concentrations were used to evaluate the reliability of the NES map interpretations. In most areas where comparisons could be made, NES map interpretations agree relatively well with mean annual nutrient concentrations calculated from USGS water quality data, particularly in areas where streams had also been sampled for the NES and in regions with relatively homogeneous environmental (soils, geology, climate, terrain) and land use characteristics. Results of these comparisons tend to confirm the conclusion of the NES-NPS study that there is a strong relationship between land use and stream nutrient levels (Omernik, 1977).

Assessment of the NES map of Total N concentrations reveals that USGS data and NES map interpretations disagree only in a few areas. Areas of apparent disagreement tend to be small, with the exception of areas in New York, Wyoming, Arizona, and northern California. Where disagreements do occur, NES map interpretations of mean annual Total N concentrations tend to be higher than USGS values more often than lower.

NES map interpretations are in general agreement with Total P data from nearly 80 percent of the 601 USGS stations used in the comparisons. In nearly all cases of disagreement, NES map interpretations are lower than the mean annual Total P concentrations calculated from USGS water quality data. The most notable areas of disagreement are located along the Atlantic and Gulf Coastal Plains, particularly in Florida and New Jersey, and along the Appalachian system, primarily in Pennsylvania and Kentucky.

SECTION 3

BACKGROUND

HISTORY AND OBJECTIVES OF THE EPA/NES-NPS STUDY

The NPS-stream nutrient maps were produced by interpreting data from the Environmental Protection Agency's National Eutrophication Survey (NES). The NPS assessment portion of the NES was undertaken to study the relationship between watershed land use characteristics and lake trophic conditions. It was hoped that this subproject of the NES would result in "...a quick, relatively accurate method of assessing nutrient loadings to lakes based on analysis of land use in their watersheds" (Omernik, 1976; 1977). Originally, aerial photography and topographic maps were to have been used to identify and map land use types in each drainage area associated with the approximately 800 lakes sampled for the NES. However, for a variety of reasons, the analysis was limited to nonpoint source-stream nutrient level relationships using only those tributary sampling sites associated with NPS-type watersheds. Of the more than 4000 NES tributary sampling sites, 928 met this criterion.

The principal objectives of the NES-NPS land use study were: 1) to investigate the relationships between nonpoint watershed characteristics and stream nutrient levels; 2) to "...develop a means for predicting stream nitrogen and phosphorus levels based on land use and related geographical characteristics"; and 3) to investigate and define regionalities in the relationships between macro-watershed characteristics and stream nutrient levels and provide "...some accountability for these regionalities in the predictive methods" (Omernik, 1977).

DATA COLLECTION AND ANALYSIS

Generally, of the 928 NPS-type watersheds included in the study, each was sampled approximately once a month for one year. However, the NES sampling program consisted of three phases, and not all watersheds were sampled in the same year. Sampling began in 1972 at 133 sites in the northeast; in 1973 at 340 sites in the east and southeast; and in 1974 at 455 sites in the west and midwest (Figure 1). Stream samples were collected by National Guard units in each state and sent to the Corvallis (Oregon) Environmental Research Laboratory for nutrient analysis. Sample collection, preservation, storage, and analyses were done according to methods described in NES Working Paper No. 175 (U.S. EPA, 1975).

Comparable data collected from a relatively large number of watersheds dispersed across the conterminous United States provided a unique opportunity to examine the regionalities of land use—stream nutrient level relationships. Two methods were used to analyze the NES data. First, regression analysis was

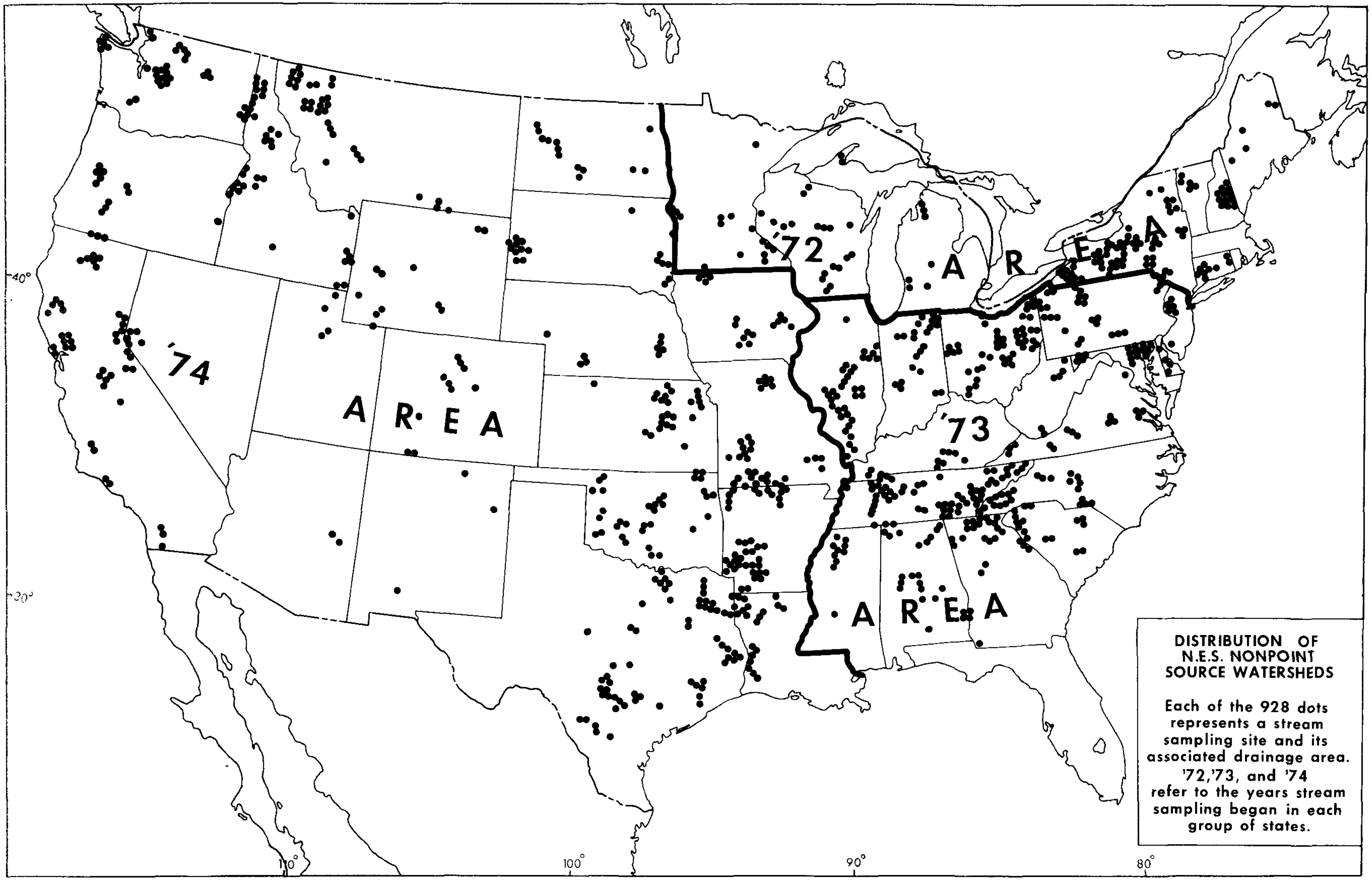


Figure 1. Distribution of individual NES nonpoint source study watersheds.

used to examine the relationships between areally-expressed watershed characteristics (delineated from aerial photography and topographic maps) and the mean annual concentrations of total nitrogen (total Kjeldahl-N + NO_2 + NO_3), inorganic nitrogen (NH_3 + NO_2 + NO_3), total phosphorus, and orthophosphorus (PO_4 as P; technically, soluble reactive phosphorus) calculated for each stream. Good correlations were found between general land use and nutrient concentrations in streams. Nutrient concentrations were much lower in streams draining forested watersheds than in those draining agricultural or urban watersheds (Figure 2). The second method involved mapping the location and nutrient concentrations of each of the 928 sampling sites. The areal patterns of the nutrient concentrations were then overlaid and compared with general land use patterns, as well as patterns of other macro-watershed characteristics (e.g., fertilizer use, farm animal density, and acid rainfall) that in many areas appeared to correlate spatially with certain nutrient forms. Then areas, which frequently coincided with land use map units on the USGS national map (1970), were assigned what appeared to be the most appropriate range in mean annual nutrient concentrations. Separate maps were constructed to illustrate ranges for total nitrogen, inorganic nitrogen, and total phosphorus.

NPS ASSESSMENT METHODOLOGY

The analysis of NES data resulted in two methods that can be used to predict NPS stream nutrient levels:

1. Regional regression equations in which general land use data (percent of drainage area occupied by selected land use types) are used as the independent variables; and

2. Mapped interpretations of national and regional patterns of land use-stream nutrient level relationships.

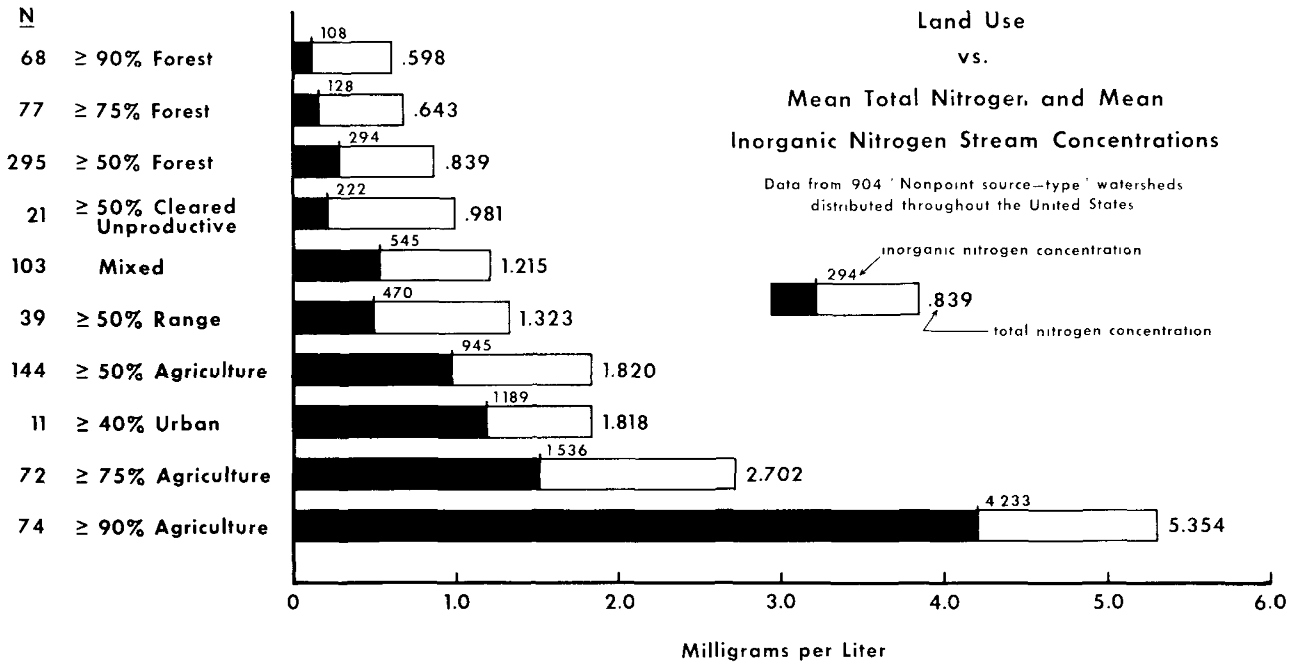
Both methods provide only limited prediction capabilities, particularly when applied for NPS assessments of small watersheds which tend to exhibit greater variability than larger drainage areas (Onstad et al., 1977). Although neither may be adequate for precise assessments of local NPS stream nutrient levels, they may be quite useful for regional comparisons when other data are unavailable.

The second NPS assessment method is particularly interesting for several reasons:

1. It is the first attempt to produce national maps illustrating general NPS-stream nutrient patterns;

2. It requires no detailed data collection, only basin delineation and calculation of areally weighted means for mapped nutrient classes within the basin (the mean of the areally weighted class means represents that part of the mean annual nutrient levels in the basin attributable to nonpoint sources);

3. It can be used (or, unfortunately, misused) by almost anyone regardless of their level of expertise, although interpretations will be improved with knowledge of important NPS relationships and addi-



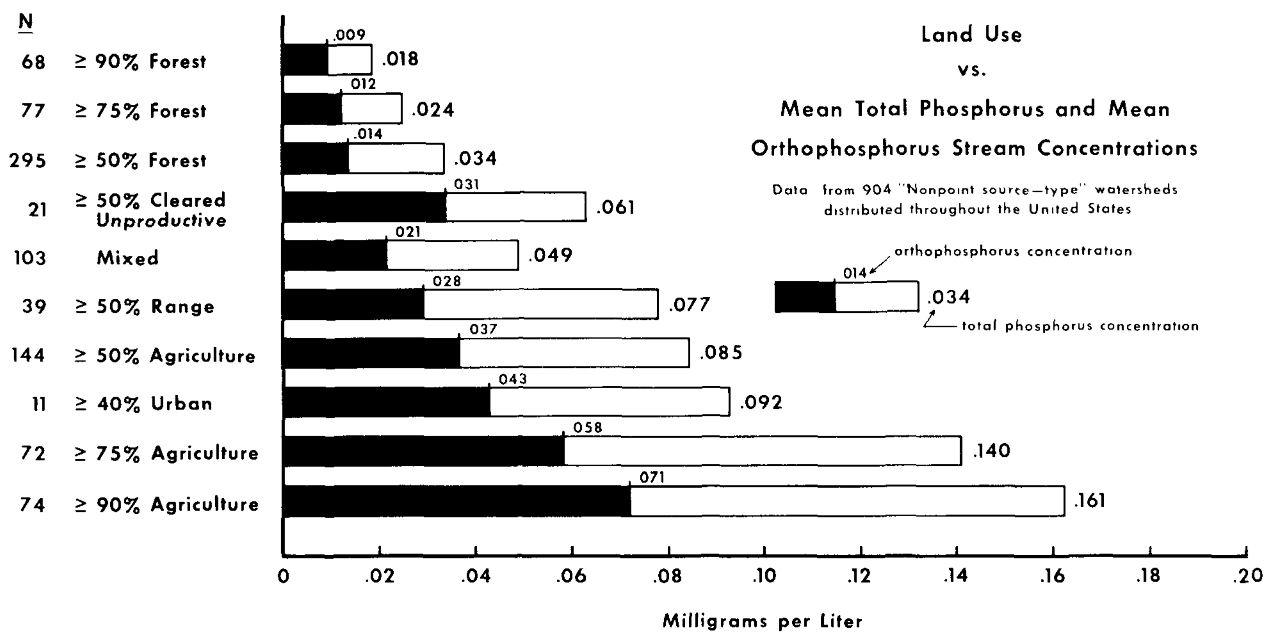


Figure 2. Relationships between general land use and nutrient concentrations in streams.

tional local information. The step by step procedure for utilizing the stream nutrient maps is illustrated and explained by Omernik (1977, pp. 8-10).

The usefulness of these maps can best be illustrated by comparison with another small-scale graphic more familiar to most people—an isometric map of mean annual precipitation. One should not use a precipitation map to predict the precipitation that will occur during a particular year at a given location. Rather, the map illustrates patterns of long term *mean conditions*. Many parts of the United States seldom experience a truly "normal year" climatically. Generally, precipitation totals are somewhat higher or somewhat lower than the mean; and (occasionally) totals deviate extremely from the mean conditions. Admittedly, precipitation maps may provide a more accurate indicator of their subject than the nutrient maps because of their more extensive data base (from both temporal and spatial standpoints). However, precipitation maps are compiled using data from different geographical locations together with knowledge of apparent associations of these data with physiographic characteristics, water bodies, ocean currents, latitude, and other environmental factors. For example, precipitation patterns in mountainous areas, where data are scarce or lacking, are drawn to reflect the expected orographic effects of elevation and exposure to weather systems. Much the same kind of qualitative analysis was employed in compiling the nutrient maps. They are based on values from stream samples from nearly 1000 locations throughout the United States, as well as knowledge of the apparent associations between the nutrient data and other spatial phenomena such as land use. Although the nutrient data were collected for only one year at each sampling site, there were generally a sufficient number of data sites to indicate regional patterns.

Strengths and Limitations of the NES Tributary Sampling Data

The NES data provide a good base for identifying geographic variations in NPS stream nutrient levels. NES stream sampling was conducted nationwide and data were collected for 928 NPS-type watersheds (unaffected by point sources). Due to their number, their wide distribution, and the great variations in drainage characteristics, it may be stated that the watersheds examined in the study are representative of NPS-type watersheds in many parts of the conterminous United States. Consistent definition and analysis of water-quality parameters at the EPA Corvallis Laboratory and consistent interpretation of basin characteristics permitted direct comparisons of geographic variations in stream nutrient levels, and facilitated the statistical analysis of land use—stream nutrient level relationships.

However, the NES data have several important limitations. Each of the 928 sites was sampled periodically for one year, and data were not flow-weighted. Therefore, the mean annual concentrations reported for each watershed do not reflect or explain year-to-year, month-to-month, or storm-to-storm variations in stream nutrient levels. Erroneous and unrepresentative assessments may result if the NES maps are used to predict nutrient levels at a given time in a specific stream. This problem will be most pronounced if the NES maps are used to predict nutrient levels in streams draining small watersheds which tend to exhibit greater hydrologic variability than large basins (Onstad et al., 1977). For example, the Lakes Region Planning Commission (LRPC) monitored nutrient levels in 14 streams draining into Lake Winnnipesakee, New Hampshire and found that mean annual nutrient concentrations varied markedly from stream to stream (Lakes Region Planning Commission, 1977). In general, land use patterns were similar in the watersheds associated with the 14 stream sampling sites. Eleven of those streams were also monitored by the NES in 1972, and mean nutrient concentrations again varied between streams (from 0.011 to 0.035 mg Total P/l). However, when Total P concentrations were averaged for those 11 streams to produce a single mean for the entire basin, the 1972 basin mean calculated from NES data (0.019 mg Total P/l) was in close agreement with the 1976 basin mean calculated from LRPC data (0.016 mg Total P/l) for the same streams. These findings suggest that annual variability may not be a serious problem if the NES maps are used only for regional comparisons or to estimate stream nutrient levels averaged over time and over a large basin.

Another major limitation of the NES-NPS data base is the lack of sampling sites in several large areas of the country (i.e., the southwest, the intermountain west, and the coastal plains of the southeast). Many areas in the west were not sampled because they lacked sufficient precipitation to produce perennial streams and lakes, and lake eutrophication was the primary concern of the NES.

Even in regions that supported perennial streams, streams were not sampled unless they could be readily associated with a definable drainage area. Regions dominated by plains, particularly those in the southeast, including most of Florida, often lacked sufficient relief to identify topographic divides on maps. Bayous, canals, and interbasin water transfers further complicated the identification of discrete drainage areas.

Finally, since the main purpose of the NES-NPS nutrient study was to examine relationships between land use and stream nutrient levels, land use characteristics had to be classified and delineated for each drainage area used in the analysis. Because of project limitations, the only feasible way to evaluate land use in the 928 watersheds was to use maps and aerial photography. Therefore, it was mandatory that complete, current photo coverage be available for all watersheds used in the study. Unfortunately, data from many NES sampling sites could not be used because those sites were located in areas which lacked usable aerial photography.

Limitations associated with the NES data have caused concern regarding the reliability of the mapped interpretations of NPS stream nutrient levels. Although reliability insets were provided for each map, they were compiled using no data other than that collected for the NES. The reliability assessments were based on the distribution of NES stream sampling sites and the apparent spatial correlations of these data with NPS watershed characteristics. Recognizing problems inherent in the original reliability assessment, the decision was made to examine other data sources to reevaluate the reliability of the NES map interpretations. Nutrient concentration values from such data sources would increase the number of data points and possibly provide data for areas not sampled by the NES.

SECTION 4

APPROACH

SELECTION OF COMPARABLE DATA SOURCES

Collection of a data base comparable to the NES/NPS stream nutrient data was essential for evaluating the reliability of the NES map interpretations. Several criteria were established to insure that the best available, most comparable data would be selected for the evaluation. Data from other studies would be used only if the following conditions were met:

1. At least six Total N and/or Total P concentrations were determined at each stream sampling site per year.

2. The sampling sites were on streams draining watersheds not influenced by point sources.

3. The sampling sites were on streams draining watersheds without major areas of indirect drainage (i.e., data from streams with greater than 50% of the basin draining to upstream reservoirs and lakes would not be used).

4. The sampling sites were on streams draining watersheds with definable topographic divides.

Drainage characteristics and potential point sources were identified from U.S. Geological Survey maps (scale, 1:250,000) and surface water records (by state and year).

A review of NPS water-quality literature revealed that the parameters sampled, sampling procedures, and data reporting varied markedly between individual water quality studies (e.g., studies reviewed by the U.S. Forest Service [1977]). Many private, state, and Federal studies of stream nutrient concentrations reported values for inorganic and/or dissolved forms of N and P, but not for Total N or Total P. The period of record and sample frequency also varied between studies, further complicating data comparisons.

The U.S. Geological Survey had the only data source reviewed which was based on a national network of stream sampling sites, many of which potentially met the data selection criteria. USGS water quality records can be quite useful for data comparisons because the agency employs standard sampling, analytical, and reporting procedures. Also, USGS water quality data are accessible through the STORET computer system—the same national system that stores the NES data. The number of USGS water quality stations, the comparability of USGS data, and the lack of consistently comparable data from other sources made USGS water quality records the best source of stream nutrient data to evaluate the reliability of the NES map interpretations.

DATA ACQUISITION AND HANDLING

An initial search of the STORET system was made to identify USGS water quality monitoring stations with nutrient concentration data comparable to those recorded for NES stream sampling sites. A list was compiled of all USGS stations recording six or more Total N and/or Total P concentrations during any year since 1969. The location of each station was plotted on a USGS 1:3,168,000-scale base map. Using additional USGS 1:250,000-scale maps and USGS surface water records, those stations located on reservoirs, lakes, canals, bayous, or on rivers affected by urban-industrial centers were identified and eliminated from the list. It was assumed that the remaining USGS stations monitored streams draining NPS-type watersheds.

After the initial screening, another search of the STORET system was conducted to obtain additional information regarding each USGS station remaining on the list, including:

1. The station number and name.

2. The water year(s) (October-September) since October 1969 during which Total N and/or Total P were measured.

3. The number of Total N samples recorded each water year.

4. Means of Total N concentrations (calculated for each water year with ≧ 6 samples of Total N).

5. The mean concentration of Total N, calculated over the period of record, as the mean of the annual means of Total N concentrations for all water years with ≧ 6 samples of Total N.

6. The number of Total P samples recorded each water year.

7. Means of Total P concentrations, calculated for each water year with ≧ 6 samples of Total P.

8. The mean concentration of Total P, calculated over the period of record, as the mean of the annual means of Total P concentrations for all water years with ≧ 6 samples of Total P.

The location of each remaining USGS station was plotted on two USGS 1:3,168,000-scale base maps. Each USGS station monitored for Total N and the mean concentration of Total N for that station were color coded and plotted on one map. Mean concentrations of Total P were plotted on a second map. The watersheds of all stations were rechecked for potential point sources and areas of indirect drainage using USGS 1:250,000-scale topographic maps and USGS surface water records again for the screening process. However, it was infeasible to conduct a more detailed analysis of land use and other watershed chararacteristics associated with each USGS station as was done for NES-NPS sites. Although there may be some uncertainty regarding the effectiveness of the screening process, it was assumed that the remaining USGS stations provided the best available, most comparable data base for evaluating the reliability of the nutrient maps.

An effort was made to obtain the greatest number and the widest distribution of USGS stations possible and, especially, to obtain representation for areas where NES-NPS data were lacking, thus enabling a test of the map interpretations for these areas. However, some large areas of the country had no USGS stations meeting the selection criteria, while some small areas had too many stations to map individually on the small-scale base maps. The shortage of sites monitoring Total N was particularly noticeable. Only 330 USGS stations monitoring Total N concentrations met all selection criteria, while 601 stations monitoring Total P concentrations passed the screening process. Nutrient data from a small number of streams sampled in other studies were added to fill data gaps for a few key areas. The number of supplemental sites (35 monitoring Total P and 18 monitoring Total N) was restricted to minimize the possibility of data incompatability often encountered when comparing data from a number of studies using different collection, analysis, and reporting procedures. Supplemental sites selected for this study were located in the following states: Ohio (Weidner et al., 1969; Taylor et al., 1971); Oklahoma (Olness et al., 1975); South Dakota (Dornbush et al., 1974); Iowa (Jones et al., 1976); Washington (Sylvester, 1961); and Oregon (U.S. EPA, unpublished data). Most of the supplemental studies monitored nutrient runoff from small agricultural and/or forested watersheds. The distribution of all non-NES sites used for comparisons are illustrated in Figure 3.

DATA COMPARISIONS

After screening, nutrient concentrations from each of the remaining stations were compared with nutrient concentrations illustrated on the NES maps (the sets of nutrient-concentration classes used on the maps are shown in Table 1).

TABLE 1. NES-NPS STREAM NUTRIENT CONCENTRATION MAP CLASSES (Omernik, 1977)

Total Nitrogen Concentrations* (milligrams/liter)		Total Phosphorus Concentrations* (milligrams/liter)	
Map Unit	Map Class	Map Unit	Map Class
1	≦ 0.500	1	≦ 0.010
2	0.501 to 0.700	2	0.011 to 0.015
3	0.701 to 0.900	3	0.016 to 0.020
4	0.901 to 1.100	4	0.021 to 0.030
5	1.101 to 1.400	5	0.031 to 0.050
6	1.401 to 1.700	6	0.051 to 0.070
7	1.701 to 2.000	7	0.071 to 0.100
8	2.001 to 3.000	8	0.101 to 0.200
9	3.001 to 5.000	9	> 0.200
10	> 5.000		

* Representative of mean annual values.

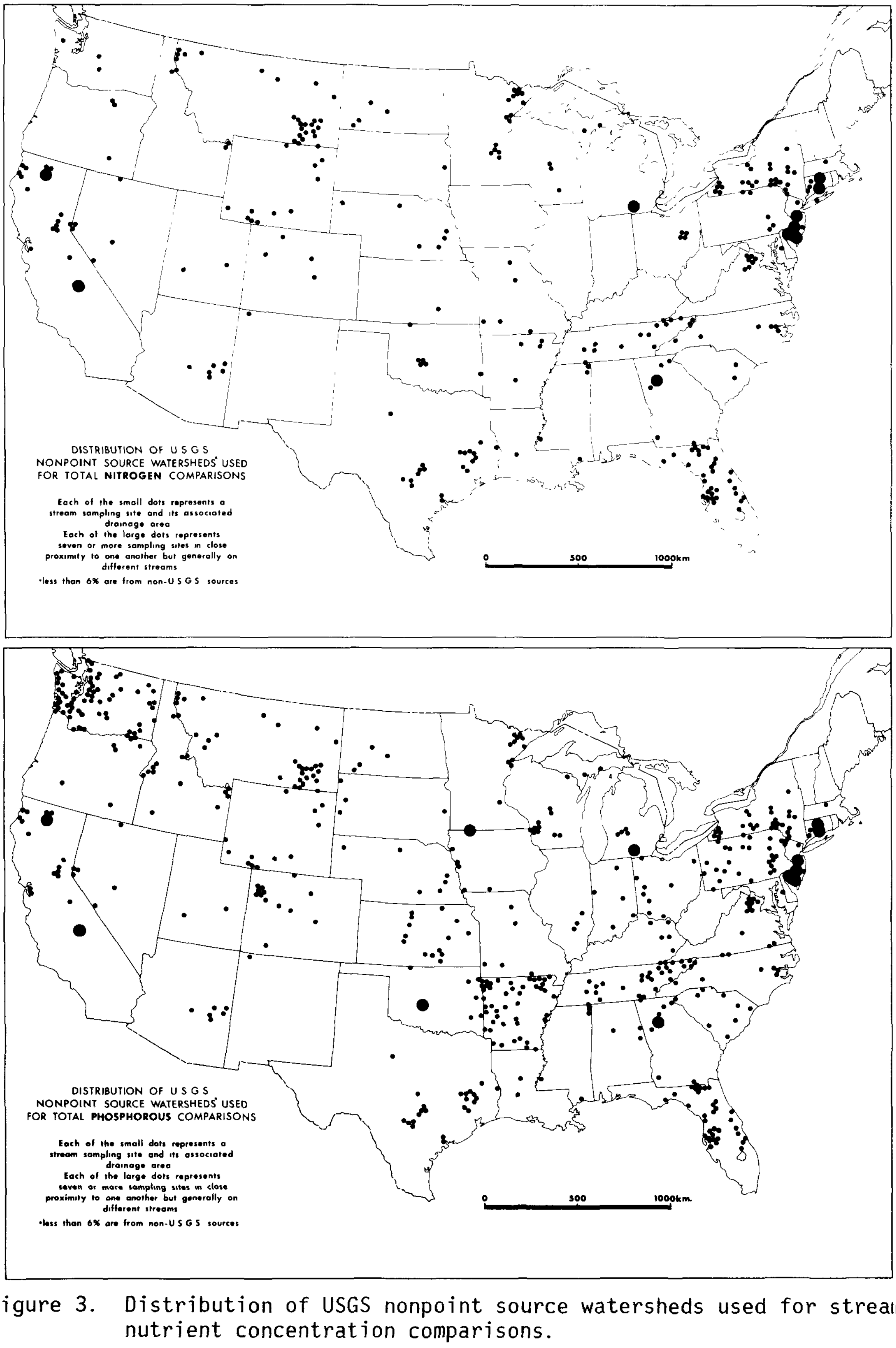


Figure 3. Distribution of USGS nonpoint source watersheds used for stream nutrient concentration comparisons.

If several stream sampling stations were in close proximity and within the same NES map unit, nutrient concentrations representative of the majority of those sites were used for the comparison. Comparisons revealed that Total N or Total P data from stream sampling stations in some areas disagreed with the Total N or Total P concentrations illustrated for those areas on the NES maps. Apparent disagreements were noted directly on the NES map, and areas were classified according to the following scheme:

1. General agreement—differences between NES map values and comparable concentrations were within ± 1 map class of NES map interpretations excluding obvious outliers;

2. Comparable concentrations were mostly higher (≧ 2 map classes) than NES map unit interpretations;

3. Comparable concentrations were mostly lower (≧ 2 map classes) than NES map interpretations; or

4. The areas had insufficient data to make comparisons (i.e., areas with too few of the supplemental USGS stations and/or too few of the original NES sites to assess the reliability of the NES map interpretations).

Areas were identified on the basis of the criteria listed above, but the boundaries for each area were drawn to correspond with regional land use patterns, NES map unit boundaries, and the general distribution of sampling stations within each region. Results of these comparisons are illustrated on Figures 4 and 5 (see Section 5).

SECTION 5

RESULTS

TOTAL N COMPARISONS

With some important exceptions, Total N concentrations illustrated on the NES map were in general agreement with mean concentrations calculated from USGS water quality data. However, it should be noted that few of the USGS stream sampling stations were located in areas that had not been sampled for the NES; therefore, several large areas still lacked the nutrient data needed to assess the reliability of the NES map interpretations. The paucity of USGS and NES sampling stations was particularly acute in areas west of the hundredth meridian and in the Gulf and southeastern coastal plains.

Areas of Agreement

Areas of agreement were defined as all areas in which mean annual Total N concentration calculated from USGS water quality records were within ± 1 map class of the concentrations illustrated for those areas on the NES map (Figure 4). This definition was later expanded to include those areas intensively sampled for the NES but with too few USGS stations to make meaningful comparisons. This decision was made because preliminary comparisons revealed that USGS data and concentrations illustrated on the NES map were generally in close agreement in those areas where interpretations were based on Total N data from a large number of NES sampling sites. Understandably, NES map interpretations should be more reliable in those areas than in areas not sampled in the original survey.

Northern Florida was an important area of agreement because no streams in Florida had been selected in the NES/NPS study since lack of relief precluded accurate watershed delineation. Nutrient concentrations illustrated on the NES maps were assigned mainly on the basis of land use-stream nutrient level relationships observed in other poorly drained parts of the southeast. Total N concentrations for Florida USGS stations were in general agreement with NES map values, apparently supporting the conclusion in the NES-NPS study that Total N concentrations in streams are closely correlated with watershed land use (Omernik, 1977). Although this area is considered part of the southeast coastal plain, drainage and land use characteristics differ from those in the coastal plains of neighboring states. Therefore, relationships observed in northern Florida may not apply in other areas, particularly since small areas of disagreement did exist along Florida's northwest coast and the Georgia-Florida border.

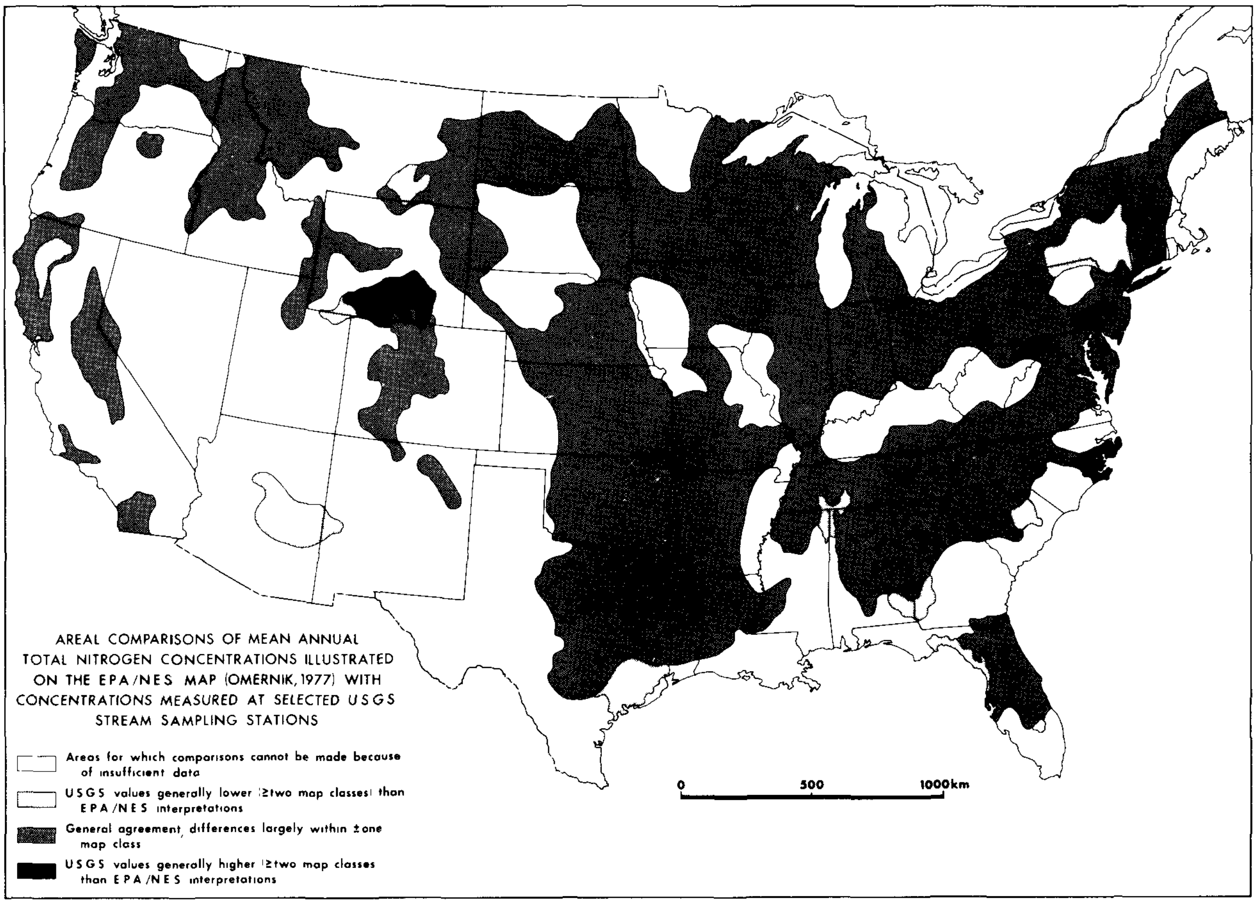


Figure 4. Areal comparisons of stream nitrogen concentration data.

One relatively large area of agreement extends along the Appalachian Mountains and the Piedmont* from northern Alabama and Georgia through Pennsylvania. The central portion of this region is comprised of alternating ridge and valley systems and is primarily forest land with limited areas of crop and pasture land. To the east of the ridge and valley system is the Piedmont, and the Appalachian plateaus are to the west. Various mixtures of cropland, pasture, woodland, and forest are found in these two areas. Although land use and terrain were quite variable throughout the Appalachian system, Total N concentrations calculated from USGS stream samples generally agree with concentrations illustrated for the same areas on the NES maps. Data comparisons reveal only three relatively small enclaves of disagreement which will be discussed later. However, it should be noted that although many streams in the region were sampled by the NES for Total N concentrations, relatively few were sampled by USGS.

Another region of apparent agreement, but with considerably more NES sites than USGS sites, includes most of New England and northern New York

* Names and descriptions of physiographic provinces are from Fenneman (1946); descriptions of regional vegetation patterns are from Bailey (1976).

Northern hardwoods and spruce forests are the dominant cover type, but several areas are important agriculturally. USGS stations monitoring Total N concentrations were found only in Connecticut and Massachusetts, and much of Maine and the Atlantic coastal areas were lacking sufficient data to make the desired comparisons. Due to the general homogeneity of the region, the large number of NES sites, and the general agreement between NES map interpretations and USGS stream nutrient values from Connecticut and Massachusetts, as well as Lakes Region Planning Commission (1977) values from New Hampshire, it is likely that the NES map interpretations of Total N concentrations are fairly reliable for much of New England.

The largest area of apparent agreement between USGS and NES stream nutrient values is centered in the agricultural midwest from Ohio to Nebraska and from North Dakota to central Texas. This region is characterized by large homogeneous agricultural subregions of mainly cropland with grazing more important on the western margins. Regional homogeneity and a dense network of NES sites provided the basis for NES map interpretations which agree quite well with Total N concentrations recorded for USGS stream sampling stations. However, the number of USGS stations in this region was small, and the stations were widely dispersed. Enclaves with insufficient data for comparisons are located along the Mississippi River in western Illinois and eastern Arkansas, along the Missouri River in western Iowa and northern Missouri, and along the Ohio River in southern Indiana and Kentucky.

Another region of agreement extends from central Missouri into northern Louisiana and east Texas. The Ozark Plateaus, a mix of hardwood forests and agricultural lands, dominates the northern half of the region. The southern half, which includes the lowland plains of Louisiana and east Texas, is primarily forest land mixed with some cropland and pasture. Total nitrogen was monitored at only a few USGS stream sampling sites in the region; however, mean concentrations calculated for those sites are in general agreement with NES map interpretations. Although some areas exhibit a great deal of variability, many of the region's streams were sampled for the NES, and the variability was considered when developing the NES map.

West of the hundredth meridian, regions with insufficient data are extensive, and areas of agreement are rather limited. One area of agreement includes the semiarid high plains of southeastern Montana, northeastern Wyoming, and the western edges of Nebraska and South Dakota. The area is primarily used for grazing, but forests and cropland are important in some locations. Nutrients were sampled in some of the area streams during the NES, and several more were sampled for Total N by USGS. Total N concentrations illustrated on the NES map were in general agreement with USGS data except for one area in southeastern Montana.

The Southern Rocky Mountains, located primarily in Colorado but extending into Wyoming and New Mexico, comprise another area of apparent agreement in the West. The area is a mixture of sagebrush, semiarid grassland, forest and alpine vegetation. Grazing is a major land use, with irrigated agriculture also important in some locations. Only a few of this area's streams were sampled for the NES, and only four were sampled for Total N by USGS. However, sampling sites were widely distributed, and data from those sites are in agreement with NES map interpretations.

The Middle Rocky Mountains in northern Utah and along the Idaho-Wyoming border and the Northern Rocky Mountains in western Montana and northern Idaho were also areas of apparent agreement. These areas differ with regard to geologic structure, vegetation, and climate. The Middle Rockies group is a complex anticlinal system and is covered primarily with semiarid brush, woodland, and some forest. The more extensive northern group is not anticlinal and is primarily forested. Grazing is important in both areas, but other land use characteristics differ between the two mountain subsystems. The NES sampled nutrient concentrations in many streams in both areas, whereas only a small number of USGS stream stations recorded Total N concentrations in either area; however, Total N data from the USGS stations fell within the ranges illustrated on the NES map. Therefore, the NES map classifications were considered to be reasonably representative of mean Total N concentrations in streams flowing from the Rocky Mountains.

In the Pacific Northwest, a zone of apparent agreement was found to extend from the areas of irrigated and dryland agriculture along the Snake River on the Oregon-Idaho border, into and along the northern parts of the Palouse Hills and Columbia Basin in Idaho and Washington, and into the intensively farmed Willamette Valley of western Oregon. As was the case with some of the other regions, the quality of these assessments is somewhwat limited by the fact that representative USGS data were extremely scarce, although NES-NPS stream data for nitrogen concentrations were numerous.

The Cascade Range of Washington and Oregon was another area of the Pacific Northwest identified as a zone of apparent agreement, again based mainly on the number and distribution of NES sites. None of the USGS sampling stations in this area were sampled for Total N. However, based on the NES data and relationships observed by USGS in other forested mountain regions of the West (including the Olympic and the Sierra Nevada Mountain Ranges where mean annual Total N concentrations were generally less than 0.5 mg/l), the NES map classifications were considered to be representative of Total N concentrations in streams draining the Cascade Range.

In the Sierra Nevada Range of California, Total N concentrations reported by USGS were in good agreement with concentrations illustrated on the NES map. This was also true for the foothill areas on the west side of the Range. In general, nutrient classes illustrated for forested areas, whether in mountain or lowlands, were in good agreement with data reported for USGS stream sampling stations. Therefore, Total N data reported for streams draining the coastal forests of northern California fell within the range of concentrations illustrated on the NES map. This area of agreement extended along the California Coast Range from the humid redwood forests in northern California to the drier woodland and rangeland north of San Francisco Bay.

Total N data from other USGS sampling sites were also in agreement with NES map interpretations. However, some of those sites were quite isolated (Figure 3), and data from one or two isolated sampling sites could not be used to make valid reliability assessments for an entire region.

Areas of Disagreement

Generally, NES map interpretations corresponded reasonably well with mean annual Total N concentrations calculated from USGS water quality data. Areas of apparent disagreement were usually small and often surrounded by larger areas of agreement (Figure 4). Although the direction of disagreement was not consistent, NES map interpretations of Total N concentrations tended to be higher than USGS values more often than lower. For example, the largest area of disagreement was in southeastern New York State. There, mean annual Total N concentrations reported by the USGS were substantially lower (generally, 0.29 to 0.75 mg/l) than those illustrated on the NES map (0.07 to 1.7 mg/l). The 1972-73 NES stream samples from this area were collected during a period when weather patterns were extremely atypical. Tropical storm Agnes passed through the area during the sampling period, and the exceptionally heavy precipitation which accompanied the storm may have washed large quantities of nitrogen from the atmosphere and/or land surface into area streams.

Another area of apparent disagreement centers on Atlanta, Georgia. Total N concentrations in streams sampled by the USGS were consistently higher (generally 1.69 to 4.47 mg/l) than those illustrated for that area on the NES map (0.9 to 1.4 mg/l). One possible explanation may be the rapid expansion of the urban and suburban fringe around Atlanta. The boundaries exhibited on the National Land Use Map (USGS, 1970) and the distribution of population centers illustrated on USGS topographic maps (1:250,000 scale) of the area are based on outdated information, which can be very misleading in areas of rapid expansion. Since there were no NES stream sampling sites in the immediate vicinity of Atlanta, map interpretations based on the outdated land use patterns could substantially underestimate nutrient inputs from areas influenced by recent urban development. For this same area, the NES map interpretations for Total P concentrations are also lower than USGS values, further suggesting that urbanization is expanding into the woodland-agriculture fringe of Atlanta.

Other important areas of disagreement are apparent in the western United States. The largest of these is along the southern margin of the Colorado Plateaus and southeastern portion of the Basin and Range province. The uplands of this area are generally forested and receive significant amounts of precipitation, but much of the lowland is desert plain. Here streams sampled by the USGS consistently revealed lower mean annual concentrations of Total N (0.26 to 0.67 mg/l) than were illustrated on the NES map (0.7 to 1.4 mg/l). NES map interpretations for the region were based on samples collected from only 2 streams; therefore, it is quite likely, based on the USGS data, that the NES map overestimates Total N concentrations in streams throughout the entire region.

Another area of disagreement is in the southern portion of the Klamath Mountains in northern California. Mean annual Total N concentrations calculated from USGS stream samples in the area were substantially lower (mostly 0.26 to 0.55 mg/l) than those illustrated on the NES map (0.7 to 0.9 mg/l). Much of the region is forested, but grazing and cropland are important in some locales. Whether the USGS, or the NES values, or both are representative of this particular area is impossible to determine without a more detailed study of the individual watersheds associated with the sampling sites and the region as a whole.

Another area of apparent disagreement is in the southern portion of the Wyoming Basin, an arid to semiarid elevated plain. Grazing and mining are the major activities in the region. The watersheds sampled by the USGS revealed mean annual Total N concentrations consistantly higher (1.52 to 6.43 mg/l) than those illustrated for the area on the NES map (1.1 to 1.4 mg/l). The NES had no sample sites within the area of disagreement but had sampled five streams in adjacent areas. Although topographic maps of the area did not identify any point sources in the USGS-sampled watersheds, they may have been influenced by point sources associated with recent mining activity— activity too recent to show on the dated (1952-1961) 1:250,000-scale USGS topographic maps of the area. Then too, Total N concentrations could be elevated in the basin due to heavy grazing and/or local soil or geologic characteristics.

Other small areas of apparent disagreement are scattered throughout the east, southeast, and midwest; however, these areas will not be discussed in detail. Since these areas are small, the apparent NES map inaccuracies are probably due to local variations in land use, climate, and terrain that cannot be accounted for when illustrating general information on small-scale maps.

TOTAL P COMPARISONS

The 601 USGS stations used for evaluating the NES map of mean annual Total P concentrations was nearly double the 330 used for evaluating the Total N concentrations. Most of the additional USGS sites were located on streams in the states of Washington, Arkansas, Pennsylvania, and Kansas, with smaller numbers of additional sampling sites scattered through several other states. Still, the reliability of NES map interpretations could not be evaluated in several areas, particularly parts of the west and southeast, either because Total P data had not been reported for those areas or because local sampling stations did not meet the criteria established for this study. However, areas without Total P data were generally smaller than those lacking Total N data.

Areas of Agreement

The areas of agreement appear quite similar for evaluations of both NES maps, although some areas of agreement are slightly larger for Total P than for the Total N evaluation due primarily to the increased number and wider distribution of USGS stations sampling Total P (Figure 3). Since the areas of agreement common to both comparisons have already been discussed in the section on Total N, only those areas of agreement unique to the Total P comparisons (Figure 5) will be discussed here. Perhaps the most conspicuous area of agreement unique to Figure 5 occurred in southeastern New York, an area where USGS values of Total N concentrations had been substantially lower than NES map interpretations. The high nitrogen concentrations in streams were probably due to greater atmospheric washout of nitrogen in the period of heavier precipitation, a condition that would not necessarily have the same kind of effect on phosphorus concentrations in streams.

Similar patterns occurred in Arizona, northern California, and several smaller areas in northeastern Mississippi, southwestern Georgia, southeastern Montana, and southeastern South Carolina. Again, USGS water quality records and NPS map interpretations were in general agreement regarding Total P con-

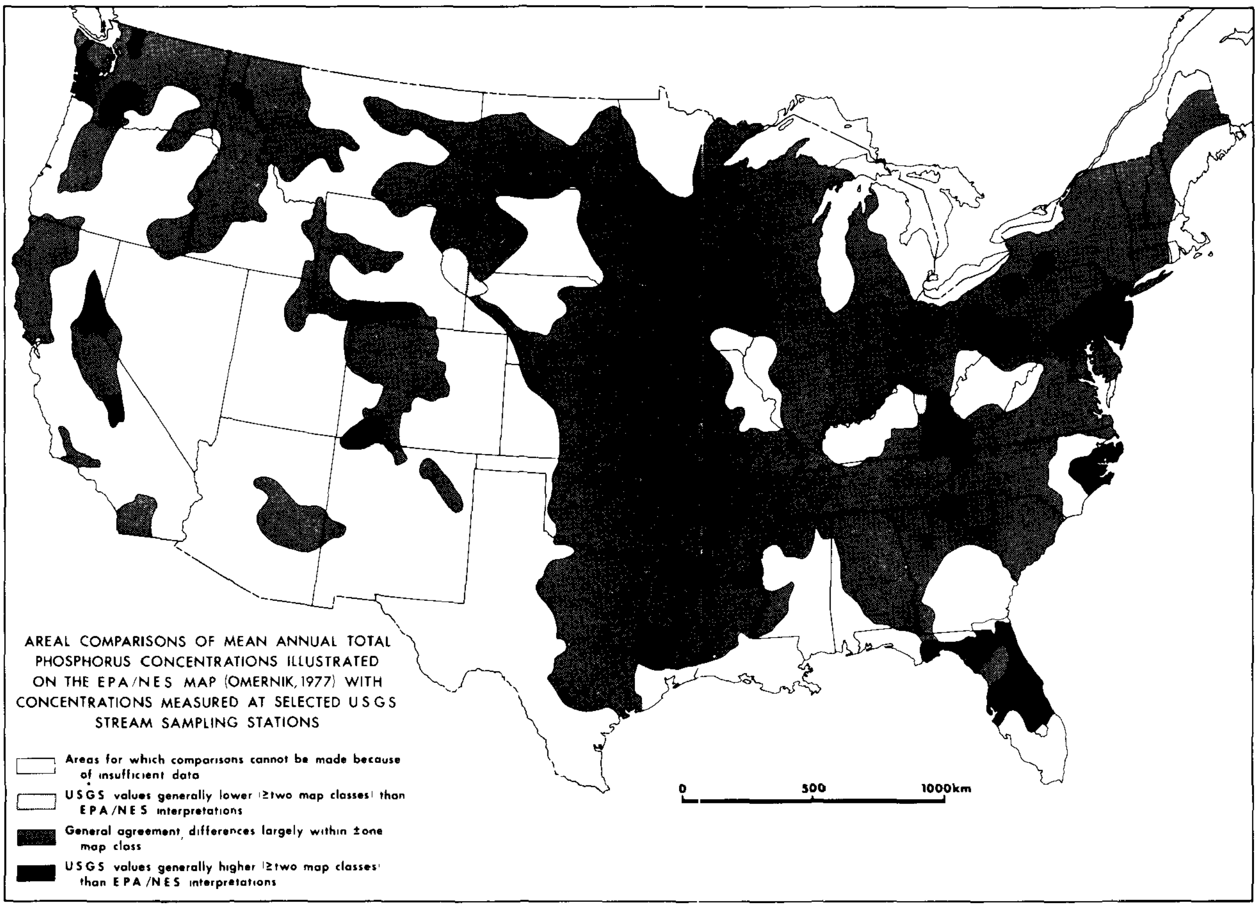


Figure 5. Areal comparisons of NPS stream phosphorus concentration data.

centrations, while in the same areas NES map interpretations were substantially greater for stream concentrations of Total N.

Areas of Disagreement

Areas of apparent disagreement between USGS water quality data and NES interpretations of Total-P concentrations were found in several parts of the country (Figure 5). NES map interpretations underestimated (≧ 2 map classes) mean annual Total P concentrations for more than 100 of the 600 USGS stations used in this study, but at only five stations were concentrations substantially lower than those estimated using the NES maps. This consistent tendency for NES map interpretations of Total P concentrations to be higher than those reported by the USGS was most evident along the Atlantic Coastal Plain from New Jersey to Florida and along the Appalachian System from western New York to northeastern Georgia.

As mentioned previously, because NES-NPS data were lacking for Florida, NES map interpretations for that state had been based mainly on general land use patterns and similarities with other parts of the southeast. The poorly drained, sandy plains of Florida are etched with shallow lakes, swamps, and sinks; and, most significantly, phosphate deposits underlie much of the north and central parts of the state (USGS, 1970, p. 184). The combination of these factors apparently act to elevate Total P concentrations beyond levels that would be expected given the area's general land use patterns.

NES map interpretations also indicate Total P concentrations in streams draining the terraced coastal plain of North Carolina were considerably lower than those which the USGS found. Here, land use is a mixture of forest, cropland, pasture, and swamp. Much of the area is poorly drained, and phosphate deposits are found in some locations. Streams in this part of North Carolina were not sampled for the NES; and map interpretations, based primarily on general land use patterns (as was the case in Florida), appeared to be unrepresentative of mean annual Total P concentrations in streams draining other parts of the Atlantic Coastal Plain. On the other hand, Total P data from coastal plain streams in South Carolina agreed quite well with NES map interpretations. Although regional characteristics appear to be quite similar along the coastal plains of the southeast, local environmental conditions often differ significantly between watersheds, particularly with regard to soils, geology, and mineral availability.

This discontinuous pattern of apparent disagreement also extends into the middle Atlantic Coastal Plain of New Jersey and the Piedmont of New Jersey and southeastern Pennsylvania. Land use in both areas is a mixture of forests, cropland, pasture, and urban developments, while bogs are important primarily in the lowlands of New Jersey. Although some NES stream sampling sites were located in New Jersey and adjacent coastal states, Total P data from nearly 50 USGS sampling stations in New Jersey and southeastern Pennsylvania revealed that NES map interpretations (0.01 to 0.10 mg/l) consistently underestimated Total P concentrations (0.04 to 2.50 mg/l) in both areas. Based on these comparisons, it might be concluded that NES interpretations are relatively unreliable for estimating NPS Total P concentrations in streams draining the Atlantic Coastal Plains. However, much of this part of the United States is very densely populated and industrialized. Because watersheds associated with the USGS sites were not scrutinized as closely for point sources as were the NES watersheds, there is a strong likelihood that point sources were partly responsible for the higher USGS values.

Another major region of apparent disagreement stretched along the Appalachian Plateau and the adjacent ridge and valley system from western New York south to northeastern Tennessee. Land use throughout the region is a mixture of forest, cropland, pasture, mining, and urban development. The two largest areas of apparent disagreement within the region are located in western Pennsylvania and eastern Kentucky. Both are areas with substantial mining activity. Local nonpoint impacts from mining or other man-related activities might have caused Total P values reported by the USGS to be substantially higher than those shown on the NES map (0.08 to 1.10 mg/l vs 0.01 to 0.10 mg/l). However, it is also possible that for these areas the NES data and conclusions relative to land use associations were inadequate to show regionalities due to background environmental sources (i.e., soils, geology, vegetation). Unfortunately, data are too sparse and the level of this assessment is too general to permit definitive identification of nutrient sources. Morover, it should be reemphasized that this project was not designed to identify specific nonpoint sources, only to evaluate the reliability of the NES map interpretations.

NES map interpretations tend to be fairly reliable for estimating Total P concentrations in streams draining the southern portion of the Appalachian system (i.e., Tennessee, northeastern Alabama, and northwestern Georgia); however, two areas of apparent disagreement are found in the southern portion of the Piedmont, a zone of transition between the Appalachian system and the coastal plain. Both areas are located in Georgia—the first around Atlanta and the second in the northeastern corner of the state. Neither area was sampled for the NES, although several streams in adjacent areas were. In both areas NES map interpretations (0.01 to 0.10 mg/l) were considerably lower than USGS-reported concentrations (0.12 to 0.89 mg/l). As in other urban growth areas, development is expanding into the rural landscape around Atlanta. This recent expansion and associated man-related effects may have been responsible, at least in part, for the higher than expected stream nutrient levels in the area (see page 30).

Moving to the middle of the nation, NES map interpretations are considerably lower than Total P concentrations reported by the USGS (0.01 to 0.07 mg/l vs 0.07 to 0.72 mg/l) for streams draining some parts of the Ozark Plateaus in southwestern Missouri, northwestern Arkansas, and eastern Oklahoma. However, data from several USGS stations in adjacent areas indicate that the NES map interpretations are relatively representative of Total P concentrations observed in streams draining most of the Ozarks. Therefore, apparent disagreements between NES map interpretations and USGS data from other parts of the Plateau may be attributable to local variations in land use and other watershed characteristics not distinguishable on generalized, small-scale maps (the NES maps and the USGS national land use map were published at a scale of 1:7,500,000).

NES map interpretations of Total P concentrations were also lower than values reported by the USGS (0.03 to 0.20 mg/l vs 0.01 to 2.40 mg/l) in some parts of southern Arkansas and east Texas. These areas of apparent disagreement are located in the western portion of the Gulf Coastal Plain, where land use is a mixture of forests, swamps, cropland, and pasture. Some of the reason for the disagreement may lie with the fact that although the National Land Use Map (USGS, 1970) neatly generalizes the region's land use characteristics into distinct areal patterns (used for NES-NPS analyses), local watershed conditions can vary substantially from those illustrated on the USGS map. Also, streams in these parts of the coastal plain had not been sampled for the NES, but several streams in similar nearby areas of Texas and Louisiana had been sampled.

Farther west there are several more relatively small areas where NES map interpretations appear significantly lower than USGS values for Total P concentrations. One such area is in the southern portion of the Wyoming Basin. Interestingly, the NES maps for Total N concentrations were also lower for parts of this same area. This region is grazed extensively, and mining activities have been expanding rapidly in many parts of the region. Because differences between NES interpretations and USGS nutrient concentrations are so great, and because the region's resources are being developed so rapidly, there is reason to suspect that some of the region's streams may be receiving substantial amounts of phosphorus from point and nonpoint sources associated with mining and grazing.

A situation similar to that in Wyoming appears to exist in the southern portion of the Colorado Plateaus, but comparisons are inconclusive because at only two USGS stream sample stations in that part of Colorado and New Mexico were Total P concentrations measured. Most of the Colorado Plateaus and almost all of the Basin and Range provinces lack the stream nutrient data needed to assess the reliability of the NES map interpretations.

Although there is a general shortage of Total P data for streams in the arid and semiarid west, data are available for a large number of streams in the western and irrigated portions of Washington State. Comparing NES map interpretations with USGS Total P data, three relatively small areas of apparent disagreement are found in or near Washington's major mountain systems. The first extends south along the Washington coast, from the western slopes of the Olympic Mountains in the north to Willapa Bay in the south. There, NES map interpretations of mean annual concentrations of Total P were lower than values calculated from the USGS water quality data (0.016 to 0.02 mg/l vs 0.03 to 0.04 mg/l). Olympic National Park and its lush, relatively undisturbed forests occupy much of the area, and Total P concentrations in streams draining the Park are not much different than those in adjacent areas influenced by logging. Since NES map interpretations underestimate Total P concentrations (based on comparisons with USGS data) in the undisturbed areas as well as in the logged areas, NES map interpretations may be unreliable for that part of Washington.

Other areas of apparent disagreement are located in Washington's Cascade Mountains. These mountains are heavily forested, particularly on the western slopes. Logging is the principal activity in much of the region. In these areas, the USGS found much higher mean annual Total P stream concentrations than were predicted by the NES maps. However, the areas are relatively small and USGS data from adjacent areas agree fairly well with NES map interpretations. Again regional generalizations mandated by the 1:7,500,000 scale of the NES maps appear to be inadequate for predicting Total-P concentrations in particular streams draining small areas; therefore, using NES maps to make such predictions may be considered inappropriate.

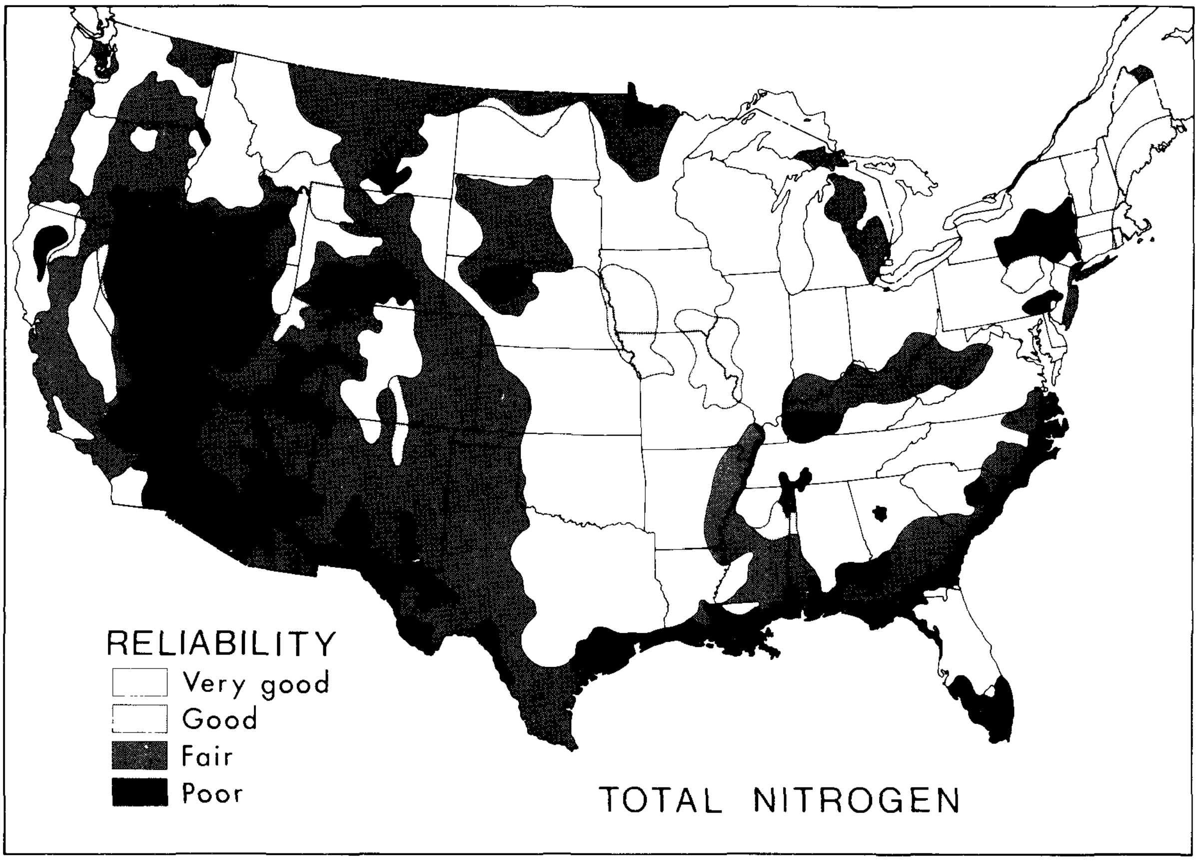
The last areas of apparent disagreement to be discussed are found in the Sierra Nevada Mountains of California. The first is located along the California-Nevada border around Lake Tahoe where NES map interpretations for mean annual Total P concentrations were generally lower than the values reported by the USGS (0.016 to 0.05 mg/l vs 0.03 to 0.26 mg/l). Some of the difference may be explained by the accelerated road building and construction around Lake Tahoe that are reported to have increased nutrient and sediment concentrations in a number of influent (re. groundwater) tributaries (Goldman, 1974). Although recent urban and recreational development may explain elevated Total P concentrations around Lake Tahoe, they do not explain why USGS Total P concentrations sampled in the foothills of central California and in the Sierras around Sequoia and Kings Canyon National Parks in southern California are generally more than twice that predicted by the NES maps. Grazing and development may be important factors influencing nutrient runoff in hills outside the parks; but, other than recreational activity, environmental conditions (soils, geology, and vegetation) are more likely to be responsible for the higher nutrient concentrations in streams draining these National Parks. Differences between NES map interpretations and USGS water quality data cannot be attributed simply to isolated local variations in land use. Instead, the differences appear to be of a regional nature; therefore, the NES map interpretations should be considered unreliable for estimation of Total P concentrations in streams draining the Sierra Nevada Mountains in central and southern California.

Three small areas of apparent disagreement, one in the mountains of northern Idaho and the other two in Wisconsin and Minnesota, have been omitted from this discussion. These areas were relatively small and were surrounded by much larger areas where stream nutrient data from USGS water quality stations agreed quite well with concentrations illustrated on the NES maps.

Revised Reliability Maps

Based on NES-USGS data comparisons, and conclusions drawn from those comparisons, new reliability maps have been constructed (Figure 6). These maps reflect the following: 1) the distribution of NES stream sampling sites used to develop the original NES map interpretations; 2) the distribution of USGS stream sampling sites used to assess the reliability of the NES map interpretations; and 3) the apparent areal patterns of agreement and disagreement between NES map interpretations and stream nutrient data from both USGS and NES stream sampling sites. The reliability maps provide qualitative assessments of the dependability or relative representativeness of mean annual nutrient concentrations calculated from NES map interpretations.

The NES map interpretations represent mean annual nutrient concentrations averaged over time for all streams in any region or major drainage basin within the conterminous United States. The reliability maps do not indicate the dependability of NES map interpretations for predicting stream nutrient levels in a particular stream at a particular time. Although the influence of NES map scale (1:7,500,000) and resolution cannot be illustrated on the reliability maps, those factors must be considered major limitations on the reliability of NES map interpretations, particularly when those interpretations are used to estimate stream nutrient levels in areas which exhibit a great deal of local variability in land use and other watershed characteristics.



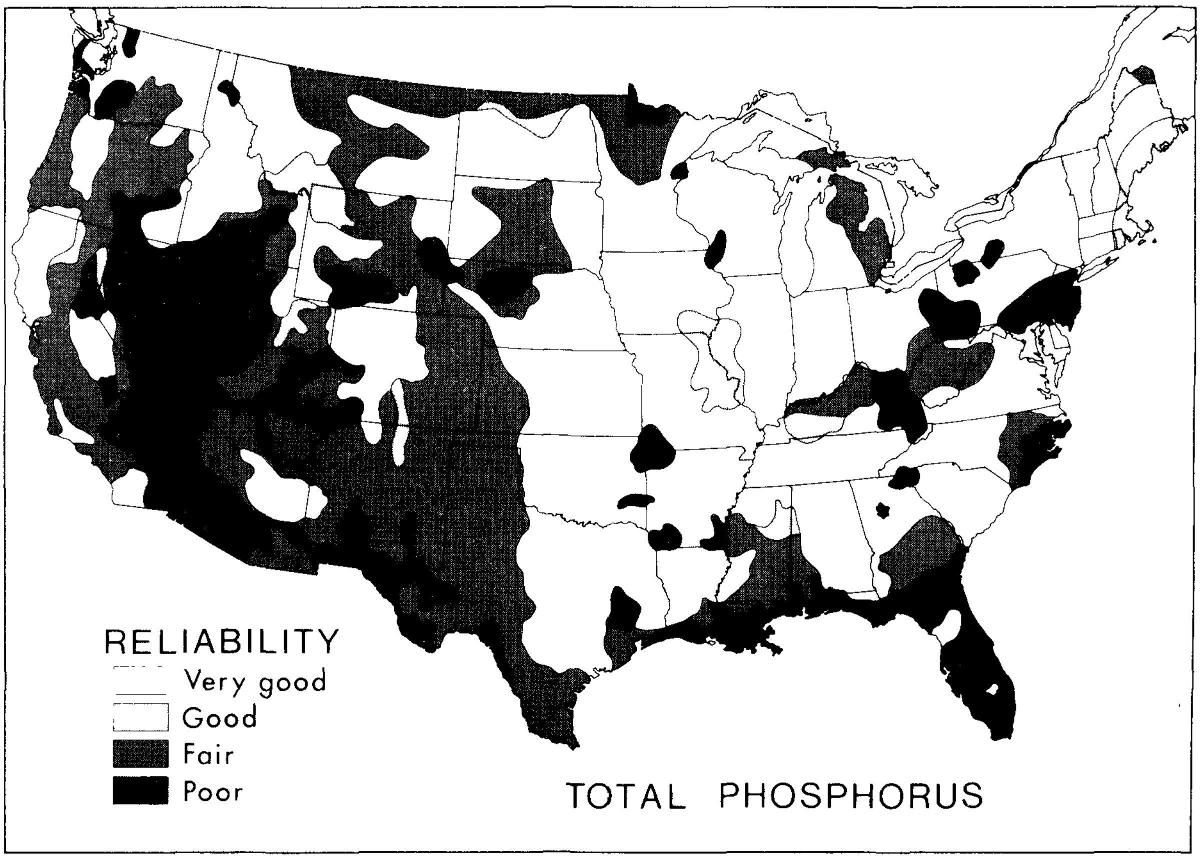


Figure 6. Revised reliability map insets for EPA-NES mapped interpretations of total nitrogen and total phosphorus in streams from nonpoint sources.

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TECHNICAL REPORT DATA

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16. ABSTRACT

The National Eutrophication Survey (NES) national maps of non-point source nitrogen and phosphorus concentrations in streams were evaluated for applicability and reliability. Interpretations on these maps which were based on data from 928 sampling sites associated with non-point source watersheds and the relationships of these data to general land use, and other macro-watershed characteristics, were compared with a nationwide set of non-point source stream nutrient data collected largely by the U. S. Geological Survey (USGS).

In most areas where comparisons could be made the mapped interpretations agreed relatively well with USGS data. Where disagreements did occur regarding nitrogen concentrations, NES mapped interpretations tended to be higher than USGS values more often than lower; where disagreements occurred regarding phosphorus concentrations, the reverse was apparent.

Revised reliability map insets based on these analyses are provided for maps of total nitrogen and total phosphorus concentrations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
land use, nutrients, watersheds, phosphorus, nitrogen, loadings, concentrations, eutrophication, stream flow, soils, geology	nonpoint source nutrients	02/A, E 04/A,C 05/A,C,G

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