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Nutrient Criteria Technical Guidance Manual

Wetlands

Full Guidance Document available in full at:
http://www.epa.gov/waterscience/criteria/nutrient/guidance/

Chapter 8 Criteria Development

8.1 INTRODUCTION

This chapter describes recommendations for setting scientifically defensible criteria for nutrients in wetlands by using data that address causal and biotic response variables. Causal variables (external nutrient loading, soil extractable P, soil extractable N, total soil N and P, and water column N and P), and biotic response variables (vegetation N and P, biomass, species composition, and algal N and P) and the supporting variables (hydrologic condition, conductivity, soil pH, soil bulk density, particle size distribution, and soil organic matter), as described in Chapter 5 provide an overview of environmental conditions and nutrient status of the wetland; these parameters are considered critical to nutrient assessment in wetlands. Several recommended approaches that water quality managers can use to derive numeric criteria in combination with other biological response variables are presented. These recommended approaches can be used alone, in combination, or may be modified for use by State water quality managers to derive criteria for wetlands that are scientifically defensible and protective of the designated use. Criteria developed from multiple lines of evidence using combined approaches will provide the greatest scientific defensibility. Recommended approaches for numeric nutrient criteria development presented here include:

- the use of reference conditions to characterize natural or minimally impaired wetland systems with respect to causal and exposure indicator variables;
- applying predictive relationships to select nutrient concentrations that will protect wetland structure and/or function; and,
- developing criteria from established nutrient exposure-response relationships (as in the peer-reviewed published literature).

The first approach is based on the assumption that maintaining nutrient levels within the range of values measured for reference systems will maintain the biological integrity of wetlands. This presumes that a sufficient number of reference systems can be identified. The second two approaches are response-based; hence, the level of nutrients associated with biological impairment should be used to identify criteria. Ideally, both kinds of information (background variability and exposure-response relationships) will be available for criteria development. Recommendations are also presented for deriving criteria based on the potential for effects to downstream receiving waters (i.e., the lake, reservoir, stream, or estuary influenced by wetlands). States should consider relating these measures to metrics of ecological integrity and periodically assessing measures to verify assumptions made in criteria development. The chapter concludes with a recommended process for evaluating proposed criteria, suggestions of how to interpret and apply criteria, considerations for sampling for comparison to criteria, potential modifications to established criteria, and adoption of criteria into water quality standards.

The RTAG is composed of State and Regional specialists who will help the Agency and States establish nutrient criteria for adoption into their water quality standards. Expert evaluations are important throughout the criteria development process. The data upon which criteria are based and the analyses performed to arrive at criteria should be assessed for veracity and applicability.

8.2 METHODS FOR DEVELOPING NUTRIENT CRITERIA

The following discussions focus on three general methods that can be used in developing nutrient criteria. First, identification of reference or control systems for each established wetland type and class should be based on either best professional judgment (BPJ) or percentile selections of data plotted as frequency distributions. The second method uses refinement of classification systems, models, and/or examination of system biological attributes to assess the relationships among nutrients, vegetation or algae, soil, and other variables. Finally, the third method identifies published nutrient and vegetation, algal, and soil relationships and values that may be used (or modified for use) as criteria. **A weight of evidence approach with multiple attributes that combines one or more of these three approaches should produce criteria of greater scientific validity.**

USING REFERENCE CONDITION TO ESTABLISH CRITERIA

One approach to consider in setting criteria is the concept of reference condition. This approach involves using relatively undisturbed wetlands as reference systems to serve as examples for the natural or least disturbed ecological conditions of a region. These approaches are most useful for estimating reference conditions appropriate to the specific designated use for a class of wetlands. Three recommended ways of using reference condition to establish criteria are:

1. Characterize reference systems for each class within a region using best professional judgment and use these reference conditions to define criteria.

2. Identify the 75^{th} to 95^{th} percentile of the frequency distribution for a class of reference wetlands as defined in Chapter 3 and use this percentile to define the criteria.

3. Calculate a 5^{th} to 25^{th} percentile of the frequency distribution of the general population of a class of wetlands and use the selected percentile to define the criteria.

Defining the nutrient condition of wetlands within classes will allow the manager to identify protective criteria and determine which systems may benefit from management action. Criteria that are identified using reference condition approaches may require comparisons to similar systems in other States that share the ecoregion so that reference condition and developed criteria can be validated. Furthermore, the 95th percentile of the reference population and the 5th percentile of the general population are best used to define the criteria when there is great confidence that the group of reference waters truly reflects reference conditions as opposed, for example, to best available condition.

Reference wetlands should be identified for each class of wetland within a State or ecoregion and then characterized with respect to external nutrient loading, water column N and P, biotic response variables (macrophytes, algae, soils) and supporting environmental conditions. Wetlands classified as reference quality should be verified by comparing the data from the reference systems to general population data for each wetland class. Reference systems should be minimally disturbed and should have biotic response values that reflect this condition.

Conditions at reference sites may be characterized using either of two frequency distribution approaches (see 2 and 3 above). In both approaches, an optimal reference condition value is selected from the distribution of an available set of wetland data for a given wetland class. This approach may be of limited value at this time because few States currently collect wetland monitoring data. However, as more wetlands are monitored and more data become available, this approach may become more viable.

In the first frequency distribution approach, a percentile (75th – 95th is recommended) is selected from the distribution of causal and biotic response variables of reference systems selected *a priori* based on very specific criteria (i.e., highest quality or least impacted wetlands for that wetland class within a region). The values for variables at the selected quartile may be used as the basis for nutrient criteria. The selection of a specific percentile as the basis for the criterion should be determined by the uses designated for that water.

If reference wetlands of a given class are rare within a given region or if inadequate information is available to assign wetlands with historic nutrient data as “reference” versus “impacted” wetlands, another approach may be appropriate. The second frequency distribution approach involves selecting a percentile of: (1) all wetland data in the class (reference and non-reference); or, (2) a random sample distribution of all wetland data within a particular class. Due to the random selection process, a lower percentile should be selected because the sample distribution is expected to contain some degraded systems. This option is most useful in regions where the number of legitimate “natural” reference wetlands is usually very small, such as in highly developed land use areas (e.g., the agricultural lands of the Midwest and the urbanized east or west coasts). EPA’s recommendation in this case is the 5th to 25th percentile depending upon the number of “natural” reference systems available. If almost all systems are impaired to some extent, then a lower percentile, generally the 5th percentile, is recommended for selection of reference wetlands.

Both the 75th percentile for the subset of reference systems and the 5th to 25th percentile from a representative random sample distribution are only recommendations. The actual distribution of the observations should be the major determinant of the threshold point chosen. For example, a bi-modal distribution of sediment or water-column nutrients might indicate a natural breakpoint between reference and enriched systems. To illustrate, Figure 8.1 shows both options and illustrates the presumption that these two alternative methods should approach a common reference condition along a continuum of data points. In this illustration, the 75th percentile of the reference data distribution produces an extractable soil P reference condition that corresponds to the 25th percentile of the random sample distribution.

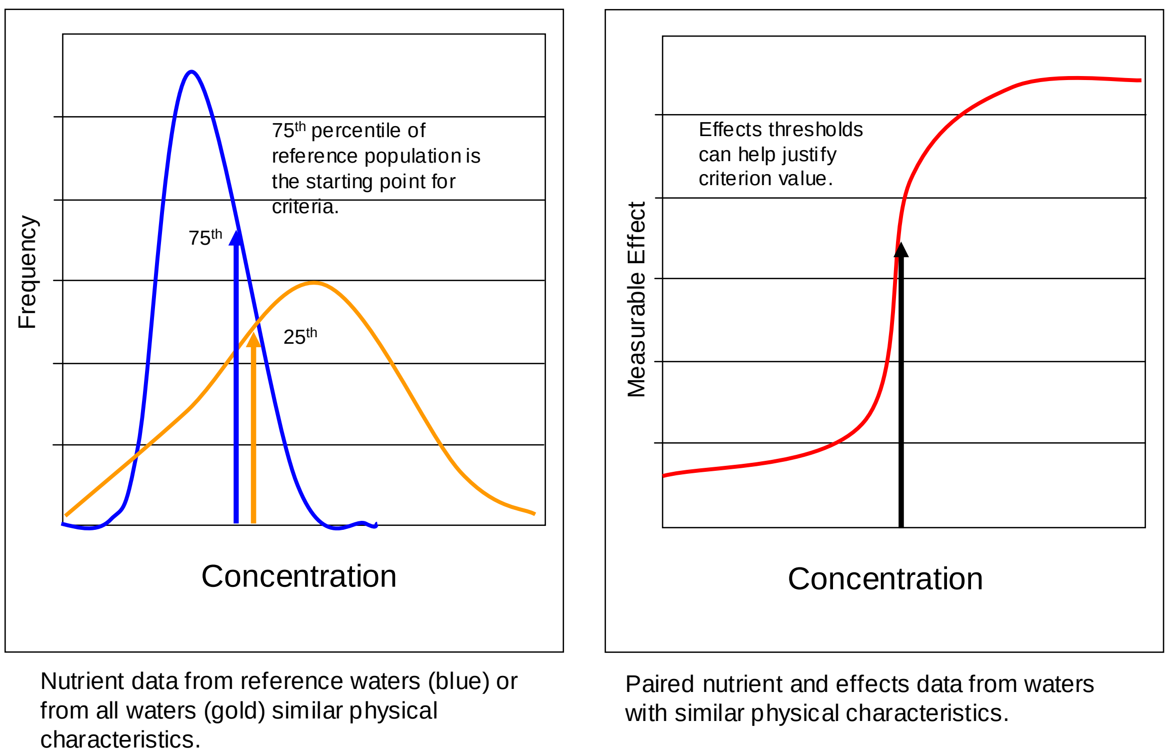

Figure 8.1 Use of frequency distributions of nutrient concentration for establishing criteria (left graphic), and use of effects thresholds with nutrient concentration for establishing criteria (right graphic).

The choice of a distribution cut-off to define the upper range of reference wetland nutrient levels is analogous to defining an acceptable level of Type I error, the frequency for rejecting wetlands as members of the "unimpacted" class when in fact they are part of the reference wetland population (a false designation of impairment). If a distribution cut-off of 25% is chosen, the rate of falsely designating wetlands as impaired will be higher than if a distribution cutoff of 5% is chosen; however, the frequency of committing Type II errors (failing to identify anthropogenically-enriched wetlands) will be lower. As described in Chapter 7, there is a trade-off between Type I and Type II errors. When additional information is available, it may be possible to justify a range of values that are representative of least-impaired wetlands that would reduce Type I errors on a system by system basis.

State water quality managers also may consider analyzing wetlands data based on designated use classifications. Using this approach, frequency distributions for specific designated uses, as opposed to frequency distributions of reference or general populations, could be examined and criteria proposed based on maintenance of high quality systems that are representative of each designated use. For example, one criterion could be derived that protects superior quality wetland habitat (SWLH), and a second criterion could be identified that maintains good quality wetland habitat (function maintained but some loss of sensitive species (Figure 8.2); see Office of Water tiered aquatic life use training module:
(http://www.epa.gov/waterscience/biocriteria/modules/wet101-05-alus-monitoring.pdf). This recommended approach is designated as the Tiered Aquatic Life Use (TALU) and is being developed by the EPA Office of Water in a more detailed publication. Using this approach, a criterion range is created and a greater number of wetland systems will likely be considered protective of the designated use. In this case, emphasis may be shifted from managing wetland systems based on a central tendency,toward more pristine systems associated with Tiers I and II. This approach also will aid in prioritizing systems for protection and restoration. Subsequent management efforts using this approach should focus on improving wetland conditions so that, over time, plots of wetland data shift to the left (i.e., improved nutrient condition) of their initial position.
p.p

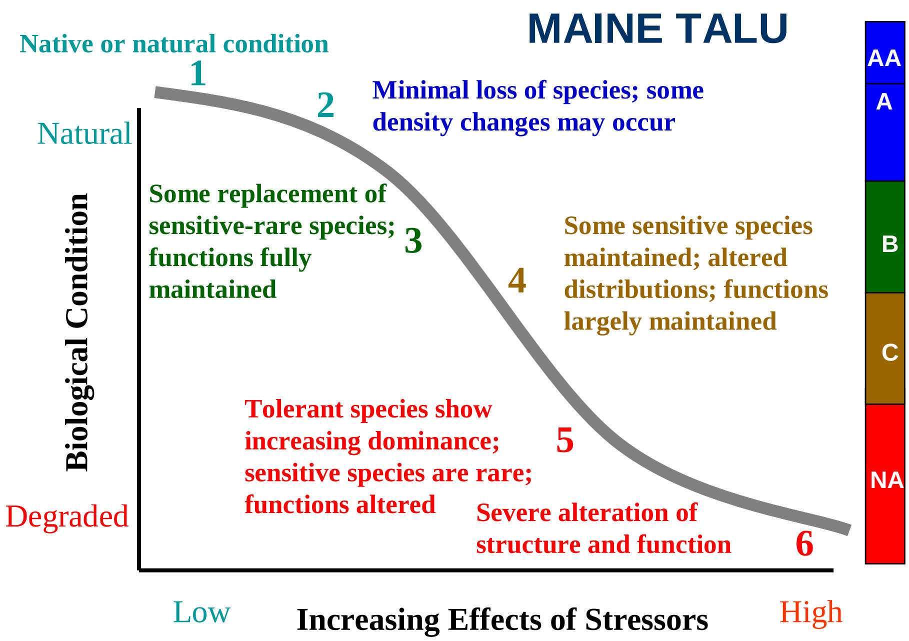

Figure 8.2. Tiered Aquatic Life Use model used in Maine.

APPLYING PREDICTIVE RELATIONSHIPS

Two fundamental reasons are commonly considered for using biological attributes in developing nutrient criteria. The concepts basically promote the use of biotic responses or biocriteria to nutrient enrichment, i.e., both rationales support evaluation of physical and chemical conditions in conjunction with biological parameters when establishing water quality criteria. The first reason is that the primary goal of environmental assessment and management is to protect and restore ecosystem services and ecological attributes, which are often closely related to biological features and functions in ecosystems. Therefore, it is the effects of nutrients on the living components of ecosystems that should become the critical determinant of nutrient criteria, rather than
the actual nutrient concentrations. The second reason for using biocriteria is that attributes of biological assemblages usually vary less in space and time than most physical and chemical characteristics measured in environmental assessments. Thus, fewer mistakes in assessment may occur if biocriteria are employed in addition to physical and chemical criteria. In those environments where biological attributes change fairly rapidly, such as in Louisiana’s coastal wetland environment where salinity can vary dramatically in response to wet versus drought years, other techniques will need to be developed. Information on some other techniques can be found at: Louisiana State University’s School of the Coast and Environment

[http://www.wetlandbiogeochemistry.lsu.edu/] and also in interagency efforts through the Los Angeles Department of Natural Resources) to assess coastal area ecology. [http://data.lca.gov/Ivan6/app/app_c_ch9.pdf]

Multimetric indices are a special form of indicators of biological condition in which several metrics are used to summarize and communicate in a single number the state of a complex ecological system. Multimetric indices for macroinvertebrates and fish are used successfully to establish biocriteria for aquatic systems in many States, and several States are developing multimetric indices for wetlands (see http://www.epa.gov/owow Web site).

Another recommended approach is to identify threshold or non-linear biotic responses to nutrient enrichment. Some biological attributes respond linearly with increasing nutrient concentrations, whereas some attributes change in a non-linear manner. Non-linear changes in metrics indicate thresholds along environmental gradients where small changes in environmental conditions cause relatively great changes in a biological attribute. In an example from the Everglades, a specific level of P concentration and loadings was associated with a dramatic shift in algal composition and loss of the calcareous algal mats typical of this system (Figure 8.3). Overall, metrics or indices that change linearly (typically higher-level community attributes such as diversity or a multimetric index) provide better variables for establishing biocriteria because they respond to environmental change along the entire gradient of human disturbance. However, metrics that change in a non-linear manner along environmental gradients are valuable for determining where along the environmental gradient the physical and chemical criteria should be set and, correspondingly, how to interpret other biotic response variables of interest (Stevenson et.al., 2004a).

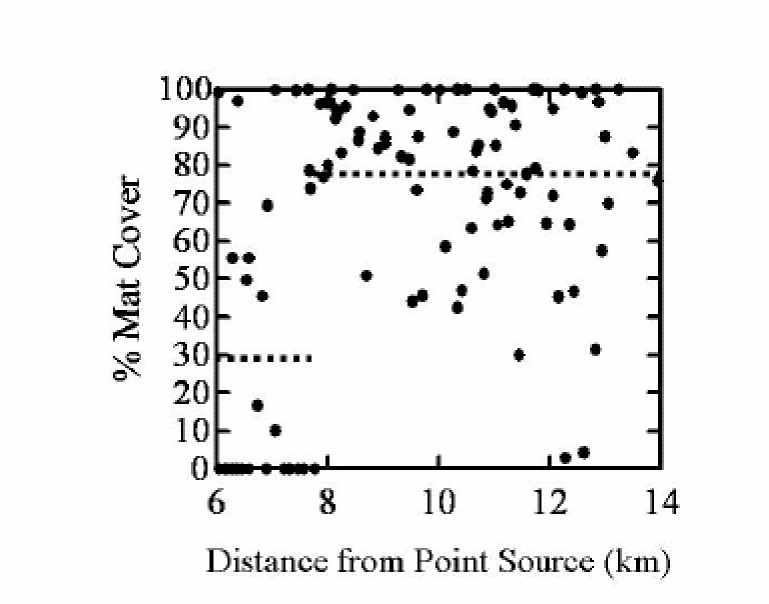

Figure 8.3. Percent calcareous algal mat cover in relation to distance from the P source showing the loss of the calcareous algal mat in those sites closer to the source (Stevenson et.al., 2002).

USING DATA PUBLISHED IN THE LITERATURE

Values from the published literature may be used to develop nutrient criteria if a strong rationale is presented that demonstrates the suitability of these data to the wetland of interest (i.e., the system of interest should share the same characteristics with the systems used to derive the published values). Published data, if there is enough of it, could be used to develop criteria for: (1) reference condition; (2) predictive (cause and effect) relationships between nutrients and biotic response variables; (3) tiered criteria; or, (4) criteria that exhibit a threshold response to nutrients. However, published data from similar wetlands should not substitute for collection and analysis of data from the wetland or wetlands of interest.

CONSIDERATIONS FOR DOWNSTREAM RECEIVING WATERS

More stringent nutrient criteria may be appropriate for wetlands that drain into lentic or standing waters. For example, it is proposed that 35 μg/L TP concentration and a mean concentration of 8 μg/L chlorophyll *a* constitute the dividing line between eutrophic and mesotrophic lakes (OECD 1982). Natural nutrient concentrations in some wetlands may be higher than downstream lakes. In addition, assimilative capacity for nutrients without changes in valued attributes may also be higher in wetlands than lakes. Nutrient criteria for wetlands draining into lakes may need to be lower than typically would be set if only effects on wetlands were considered. This is because EPA's regulations require States to take into consideration the water quality standards of downstream waters when designating uses of a water body and adopting appropriate criteria to protect those uses. (See 40 CFR 131.10(b).) Therefore, when adopting nutrient criteria for wetlands draining into lakes, States should take into account the protection of the downstream waters of receiving lakes in addition to wetlands.

8.3 EVALUATION OF PROPOSED CRITERIA

Following criteria derivation, an expert assessment of the proposed criteria and their applicability to all wetlands within the class of interest is encouraged. Criteria should be verified in many cases by comparing criteria values for a wetland class within an ecoregion across State boundaries. In fact, development of interstate criteria should be an integral part of a State's water quality standards program. In addition, prior to recommending any proposed criterion, it is recommended that States take into consideration the water quality standards of downstream waters to ensure that their water quality standards provide for attainment and maintenance of the water quality standards of downstream waters. (see 40 CFR 131.10(b)). Load estimating models, such as those recommended by EPA (USEPA 1999), can assist in this determination (see External Nutrient Loading in Chapter 5.3). Water quality managers responsible for downstream receiving waters also should be consulted.