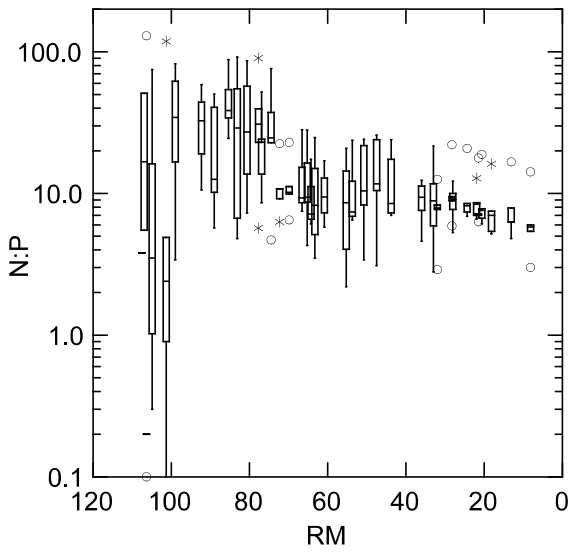
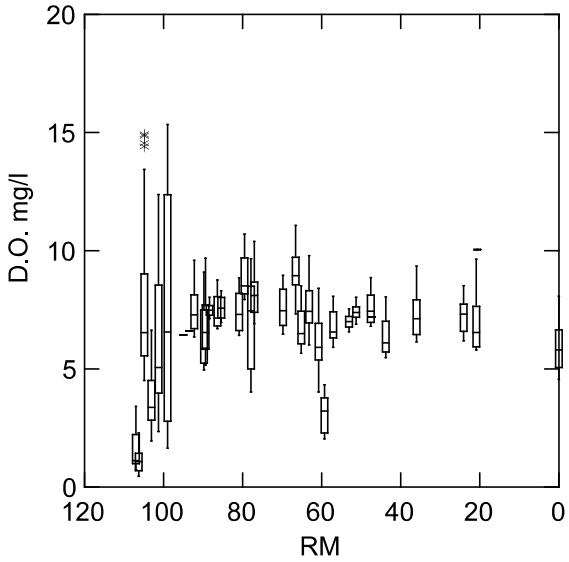
Appendix C: Target Development for Total Phosphorus

Total Phosphorus as the Limiting Nutrient

Nutrients were cited as a cause of impairment to various stream segments in the upper Little Miami River basin in the 1996 305b report, which resulted in those segments being listed as impaired on the 303d list. The 305b report cites nutrients generically rather than differentiating between specific nutrients as the primary cause, identifying the limiting nutrient, or whether the nutrient enrichment is a secondary consequence of organic enrichment. For impaired segments in the upper Little Miami River basin phosphorus is the limiting nutrient, and where it is present in excess, wide diel swings in dissolved oxygen have been measured. For example (as illustrated in the figures below), nitrogen to phosphorus ratios typically approach or exceed 30:1 in the Little Miami River upstream from where it receives municipal wastewater. Where the ratio falls below 10:1, as in the reach upstream from RM 100, dissolved oxygen swings between daytime and nighttime were extreme due to the masses of filamentous algae observed there. Therefore, as phosphorus is the limiting nutrient and is responsible for stimulating alga growth, TMDL restoration efforts should focus on reducing loads of phosphorus from both point and nonpoint sources to this and all similar segments listed as impaired by nutrient enrichment.

In and downstream from the Dayton-Xenia area, where the river receives large quantities of wastewater, the N:P ratio averages around 10. Here both nitrogen and phosphorus are present in excess of algal requirements. Although wide diel swings were not evident like those observed upstream, as wide swings would not be expected in a large and turbulently mixed river, dissolved oxygen concentrations did fall below water quality standards at several locations in this reach, and the composition of both fish and macroinvertebrate communities showed signs of nutrient enrichment. Although phosphorus in this reach is not limiting given the N:P ratio of about 10, reducing phosphorus concentrations by half to meet the targets recommended in Ohio EPA 1999 (the Load Allocation report) is more financially and technologically feasible than reducing nitrogen concentrations by two-thirds.





Phosphorus Target Development

Total phosphorus concentrations in the range of 0.17 mg/l are considered protective of eventual attainment of the Exceptional Warmwater Habitat biological criteria in small rivers in the Eastern Corn Belt and Interior Plateau ecoregions when the following factors are considered.

Biological Factors

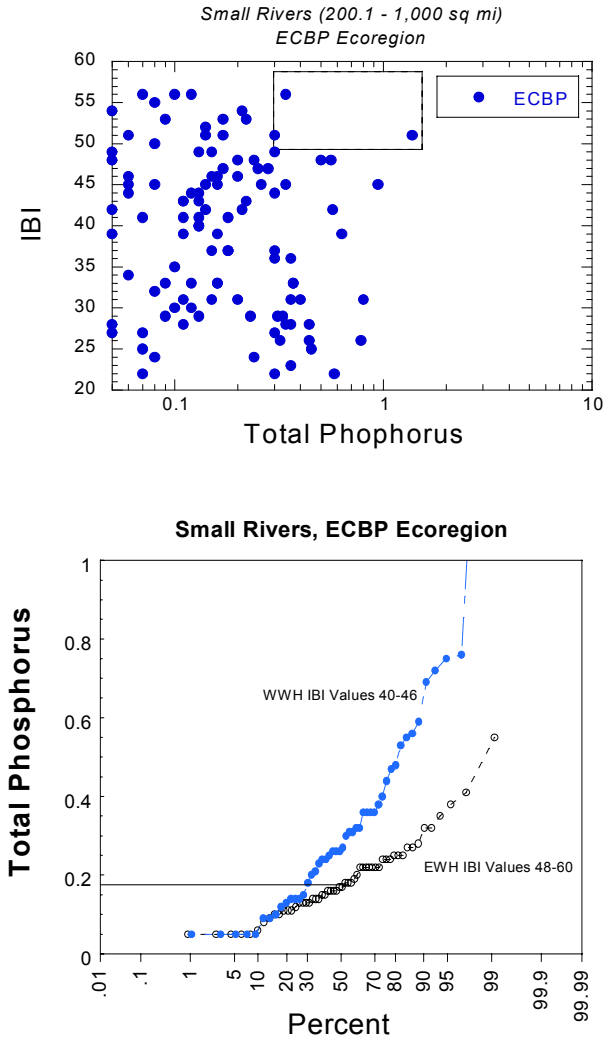


Figure 1. Scatter plot of IBI versus total phosphorus (ug/l) in small rivers in the ECBP ecoregion (top) and probability plots of subsets of the data in top figure where the IBI scores approximate at WWH ranges and EWH ranges of the IBI.

The distribution of data points, especially in nearby waters, as well as specific statistics (e.g., medians and 75th percentiles) can be useful in deriving target values. For example, the median total phosphorus value for reference sites in the ECBP ecoregion for small rivers is 0.17 mg/l. However, examination of a scatter plot of values in similar sized streams in the ECBP ecoregion indicates that a substantial number of streams frequently achieve a EWH IBI value of 50 or greater at levels above the median total phosphorus value, but below 0.30 mg/l or so (Figure 1). For small rivers in the ECBP ecoregion with total phosphorus concentrations above 0.30 mg/l, IBI scores attaining a EWH level are much less frequent (Figure 1, dashed box).

By plotting the data in Figure 1 using a probability plot (total phosphorus where IBI scores approximate attaining WWH or EWH rivers), it can also be determined that a target value of 0.17 mg/l is well within the main distribution of the data points and is not an "outlier". Although some argument can be made for an even higher target more toward the tail of this distribution, this value 1.) provides a margin of safety, 2.) takes into consideration that small rivers in Ohio can contain large pool habitats that could be more strongly affected than more flowing upstream areas and 3.) still represents a significant load to large downstream river reaches (e.g., Ohio River) where nutrients effects can be more obvious.

Targeting nonpoint sources of nutrients that also reduce sediment delivery to streams and considering habitat restoration and protection should enhance the stream's ability to assimilate nutrients. Other similar size rivers in the ECBP ecoregion attain an EWH biocriteria with total

phosphorus concentrations above the statewide WWH median target value of 0.17 mg/l (small rivers). Thus, the target value of 0.17 mg/l is appropriate. Future monitoring, after implementation of the nonpoint source controls, will allow us to refine the link between various control measures, habitat, and the success of nutrient reduction in various stream types in Ohio.

Habitat

The inter-relationships between stream habitat and nutrient concentrations are complex and not completely understood. Basic research has shown the ability for streams to assimilate some levels of nutrients without impairing aquatic life. Natural stream systems with intact instead and riparian habitats also work to trap and sequester nutrients before they reach the stream and during flood events when these waters come into contact with their floodplains, bars, etc.

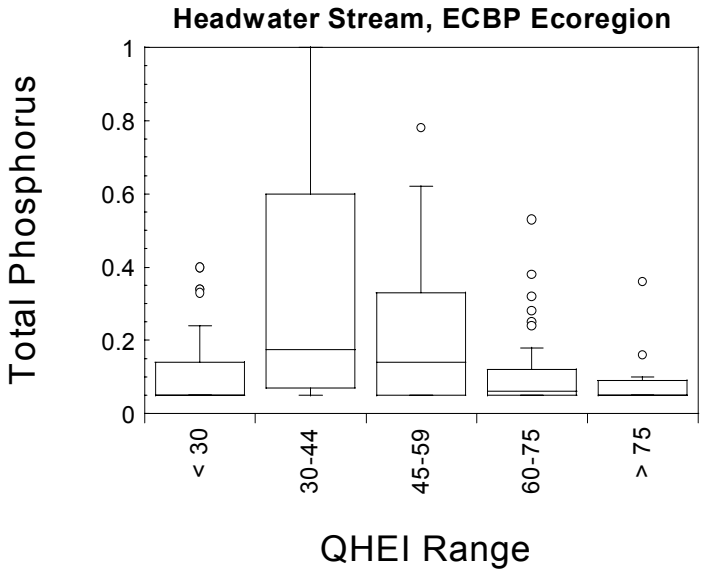


Figure 2. QHEI vs total phosphorus for reference sites less than 20 sq mi drainage in the ECBP ecoregion. Boxes represent the 25th, median, and 75th percentiles.

Data from reference sites in Ohio, especially headwater streams, show that total phosphorus during low flow is lower in stream sites with higher quality habitats as measured by the QHEI (Figure 2). Total phosphorus is not highly correlated with habitat in larger rivers (most interception of nutrients occurs in lower order streams, see Figure 2).

Habitat is still important in small rivers, however. A reference database from the ECBP for small rivers illustrates the positive relationship between habitat and IBI in these rivers.

The proportion of the phosphorus that is assimilated instead by improving habitat quality versus the proportion of nutrient load kept from reaching the stream compared to poor quality habitats is not known although as shown above small streams are a key place to focus. Further work is needed to examine specifically how instead and riparian habitat mediates nutrient assimilation in Ohio streams.

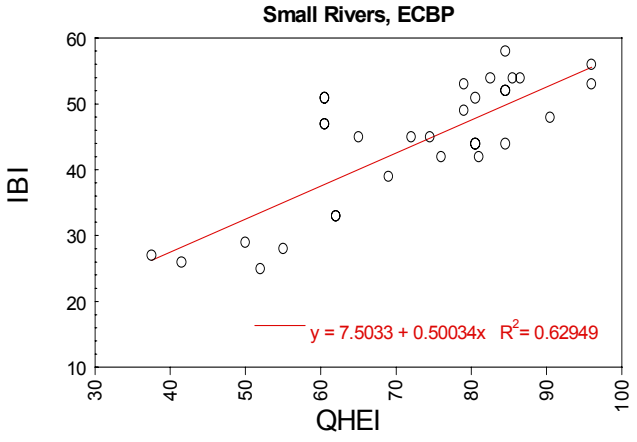


Figure 3. Correlation between habitat (QHEI) and IBI in small rivers of the ECBP ecoregion. (Reference sites.)