3 Site Disturbance Characterization

3.1 Purpose

Bioassessment is based on a comparison of conditions in assessable waterbodies to sites with relatively natural environmental conditions, which are referred to as reference sites. Reference sites serve several purposes, including index calibration, site classification, and setting of biocriteria thresholds. Biotic indices (like IBIs) are calibrated based on a disturbance gradient. Capturing the full gradient, from best to worst, is important for index calibration. Reference sites are used to identify metric expectations with the least levels of disturbance. When a set of stressed sites are identified using criteria at the opposite end of the disturbance scale, the response of metrics along the resulting stressor gradient can be detected. The direction and strength of response can be used for selecting candidate metrics for inclusion in an assessment index (like an IBI) and properly scoring them.

Reference sites are also used for classification. The biological characteristics associated with the natural environmental setting are best recognized when they are not confounded by the effects of human disturbance. In the site classification process, the distribution and abundance of biota or the distribution of metric values in minimally or least disturbed sites are used to identify biological groups and responses to natural gradients. By accounting for such natural biological variability, an IBI can be specifically calibrated to the natural stream type and the responses to disturbance that might be unique to each stream type.

3.2 Approach

To develop a disturbance gradient for a population of sites, it is necessary to specify criteria for the least disturbed and most disturbed sites. The criteria should be clearly defined and documented and based on *a priori* measures of condition that are independent of the biology (U.S. EPA 2013). There is no universal method for designating reference sites but most entities use a combination of desktop screening of landscape-scale factors (watershed and local scale), water quality, habitat scores, best professional judgment (BPJ), and site visits. The land use/land cover criteria (whether single index or multiple measures) may be based on partial catchments, buffers around a stream, or for the entire watershed. Land use categories that are commonly summarized and used as criteria include forest, natural cover, agriculture, and urban (U.S. EPA 2013).

For this exercise, we used a modified version of the disturbance index that was developed during calibration of the MassDEP 100-count riffle habitat IBI (Jessup and Stamp 2020). We used the same seven metrics: ICI, IWI, percent urban land cover, percent agricultural land cover (local catchment), density of roads, dam storage volume, and modeled mean rate of fertilizer application + biological nitrogen fixation + manure application (Table 5). The low gradient disturbance index differed from the one used for the MassDEP riffle habitat IBI in that:

- We switched to version 2.1 of the ICI and IWI (in place of version 1) and adjusted the ICI and IWI metric thresholds to account for this change
- We switched to the 2016 NLCD land cover metrics (in place of NLCD 2011)
- We used two spatial scales (local and total watershed) instead of one
- Land cover statistics were based on exact watershed delineations

Table 5. Seven disturbance variables were used to assign sites to preliminary disturbance categories. Information on variable selection can be found in the MassDEP 100-count riffle habitat IBI report (Jessup and Stamp 2020).

Disturbance variable	Spatial scale	Source	Units	Description
Index of catchment integrity (ICI 2.1)	Local catchment (Cat)	Version 2.1	0 (worst) -1 (best)	A measure of overall watershed condition, based on six components: hydrologic regulation, regulation of water chemistry, sediment regulation, hydrologic connectivity, temperature regulation, and habitat provision
Index of watershed integrity (IWI 2.1)	Upstream watershed (Ws)			
Percent Urban land cover	Maximum value across two scales (1-km upstream, total watershed)	NLCD 2016	percent (0-100)	Percent of area classified as developed, high + medium + low-intensity land use (NLCD classes 24+23+22)
Road density	Maximum value across two scales (Cat, Ws)	Road layer = 2010 Census Tiger Lines	km/km^2	The density of roads within the area
Percent Agricultural (hay/crop) land cover	Maximum value across two scales (1-km upstream, total watershed)	2016 NLCD	percent (0-100)	Percent of the area classified as hay and crop land use (NLCD classes 82+81)
Mean rate of fertilizer application + biological nitrogen fixation + manure application	Maximum value across two scales (Cat, Ws)	EnviroAtlas	mean rate kg N/ ha/yr	[Mean rate of biological nitrogen fixation from the cultivation of crops (CBNF)] + [Mean rate of synthetic nitrogen fertilizer application to agricultural land within area (Fert)] + [Mean rate of manure application to agricultural land from confined animal feeding operations within area (Manure)]
Dam storage volume	Maximum value across two scales (Cat, Ws)	Army Corps of Engineers (ACOE)	m^3/km^2	Volume all reservoirs per unit area. Based on typical volumes stored within reservoirs (NORM_STORA in NID)