Recovery Potential Metrics Summary Form

Indicator Name: BIOTIC COMMUNITY INTEGRITY

Type: Ecological Capacity

Rationale/Relevance to Recovery Potential: The very complex concept of natural processes integrity is difficult to impossible to represent well using generalized geographic or impaired waters assessment data in a screening process. Nevertheless, several primary natural processes are exceedingly important influences on the prospects of recovery. As a substitute for measuring them all, biotic integrity integrates all other processes reasonably well. This recovery potential metric orients toward Karr's five major factors determining the condition of the water resource: flow regime, chemistry, habitat structure, biotic factors, and energy. Severe degradation in any of the five likely represents severely reduced recovery potential. Many other more narrowly defined recovery metrics relate to one or more of these factors; this concept as a metric presents an opportunity to capture any other severe limiting factors that may be known but are unaddressed by the other recovery metrics in use. The increasing use of biotic integrity indices in state biomonitoring provides an important source of at least the biotic component of natural structure and process.

How Measured: Components of any of Karr's five factors may be measurable in generalized terms or on a site-by-site basis as data allow. Biological indices may provide the best single measure for addressing this complex of factors, due to the biotic integration of multiple factors not measurable individually and because biotic indices and data have been compiled systematically in an increasing number of state impaired waters programs.

Data Source: Usually limited to specific components only. Index of Biological Integrity (IBI) data on fish or benthic invertebrates are available in some state monitoring program datasets (for example, the Benthic IBI for the Puget Sound Lowlands, see: http://www.cbr.washington.edu/salmonweb/bibi/). NatureServe provides ecological integrity assessments for wetland mitigation in some regions of the country (See: http://www.natureserve.org/getData/eia_integrity_reports.jsp).

Indicator Status (check one or more)

___x__ Developmental concept.
___x__ Plausible relationship to recovery.
______ Single documentation in literature or practice.
___x__ Multiple documentation in literature or practice.
______ Quantification.

Comments: In principle, describing waters as having lesser recovery potential based on a known, severe degradation of a primary process is broadly defensible in theory but usually very data-limited.

Examples from Supporting Literature (abbrev. citations and points made):

- (Hillman, M. and G Brierley. 2005) An ecosystem-based approach recognizes that key biophysical processes should be the main guide to intervention in river systems rather than technology or economics (Cullen, 1997). Retention of biophysical processes and functions is a key determinant of the capacity of river systems to cope and adapt to human or natural disturbance (Healthy Rivers Commission of New South Wales, 2002). In a broader context, an ecosystem approach is integral to the concept of sustainable development, balancing the triple bottom line of economics, society and environment (Oliver, 2000; Dourojeanni, 2001).

- (Hillman, M. and G Brierley. 2005) The key to developing proactive programmes that pre-empt change and enhance natural recovery lies in recognizing and working with catchment-scale linkages of biophysical processes and negating the potential for off-site impacts. Projects that fail to consider current trends in sediment delivery and the dominant fluvial processes in the reach are likely to require costly maintenance, or fail to achieve their intended goal (Sear *et al.*, 1995; Sear, 1996).
- (Rahel 2007) Whereas enhancing biotic connectivity is likely to increase biotic homogenization, restoring natural habitat conditions, including natural flow regimes, may reduce biotic homogenization by favouring native regional species over widespread and often non-native species (Travnichek, Bain & Maceina, 1995; Marchetti & Moyle, 2001) (706).
- (Rahel 2007) Streams with degraded habitat and poor water quality typically have simplified fish assemblages dominated by a few tolerant species that are often non-native (Paul & Meyer, 2001). Restoring historic habitat conditions will often allow regionally distinctive native species to return to these areas and thus help to reduce biotic homogenization (Scoppettone et al., 2005; Scott, 2006) (706).
- (Poiani et al., 2000) Natural disturbance is a key aspect of environmental regimes and plays a critical role in the dynamic fluctuation of habitat availability and biotic diversity. When environmental regimes and natural disturbances are pushed outside their natural ranges of variability by human influences, changes in ecosystems and species will follow (139).
- (Poiani et al., 2000) In the interim, restoration of previously cleared areas located at the outer fringes of the floodplain and revegetation of denuded stream banks should be considered a high priority because they would help restore geomorphic processes (144).
- (Russell et al., 1997) Regional hydrology is the single most important factor influencing the structure and function of wetland ecosystems, as well as the long-term success of wetland restoration efforts (Kusler & Kentula 1990; Mitsch & Gosselink 1993) (58).
- (Wall et al., 2004) At the regional scale, focus might be on ecological drainage units with the most high-priority habitat (e.g., EDU1, EDU2) or where fish reproduction is good, stressors few (e.g., landscape change, introduced species), and ecological processes intact (e.g., hydrograph) (969).
- (Palmer et al., 2005) Degraded running water systems (e.g. following dam construction) are typically characterized by a major reduction or alteration in variability (Baron *et al*. 2002; Pedroli *et al*. 2002). Often the limits have been so far exceeded that resilience has been lost (Suding, Gross & Housman 2004). Unless some level of resilience is restored, projects are likely to require on-going management and repair, the very antithesis of self-sustainability. Thus, we argue that, to be ecologically successful, projects must involve restoration of natural river processes (e.g. channel movement, river–floodplain exchanges, organic matter retention, biotic dispersal). Restoring resilience using hard-engineering methods should not be the first method of choice as they often constrain the channel. However, there are situations in which engineered structures may enhance resilience (e.g. grade restoration facilities that prevent further incision and promote lateral channel movement, Baird 2001; projects providing fish access to spawning reaches through culvert redesign or by establishing pathways to the floodplain, NRC 1992) (211-212).
- (Roth et al., 1996) Land uses at larger spatial scales, whether the entire catchment upstream of a site or the entire riparian corridor upstream of a site, were the most effective predictors of site to site variation in IBI scores. Measures of local riparian vegetation at site and reach scales typically were ineffective predictors.
- (Roth et al., 1996) Correlations were strongest at the catchment scale (IBI with % area as agriculture, $r2=0.5$, HI with agriculture, $r2=0.76$) and tended to become weak and non-significant at local scales. The important controllers of stream ecological integrity operate on the larger spatial scale.

- (Lammert & Allan 1999) Local land use (within 100-m of the stream) and habitat were better predictors of biotic integrity than regional land use. This contrasts with findings of a previous study (Roth et al., 1996) of the River Raisin watershed that found regional land a stronger predictor of fish assemblages than local habitat. It should be noted that the scale of measurement in the present study was most appropriate for determining the effects of local variation.
- (Roth et al., 1996) Stream biotic integrity and habitat quality were negatively correlated with the extent of agriculture and positively correlated with extent of wetlands and forest. Local riparian vegetation was a weak secondary predictor of stream integrity. In this watershed, regional land use is the primary determinant of stream conditions, able to overwhelm the ability of local site vegetation to support high-quality habitat and biotic communities.
- (Roth et al., 1996) Species richness was higher at sites whose upstream catchments were predominantly wetlands.
- (Lammert & Allan 1999) Habitat and immediate land use predicted biotic integrity. IBI scores were more strongly correlated to land use/cover than were macroinvertebrate indexes, which were very strongly correlated to local habitat measures.
- (Lammert & Allan 1999) Local stream habitat could be traced to catchment-wide impacts as well as local land use and inherent characteristics of the land immediately adjacent to the stream.
- (Wan et al., 2010) Greater taxa richness tends to indicate less human impact, and presumably rare taxa are more likely to thrive in unimpacted conditions.
- (Roth et al., 1996) Stream biotic integrity is more strongly influenced by landscape than by local land uses. Although the maintenance of vegetated riparian buffer zones can be expected to convey numerous advantages to stream ecosystems, our results cast doubt on the effectiveness of localized efforts.
- (Roth et al., 1996) Catchment land uses and riparian vegetation likely play a strong role in structuring habitat features, which in turn influence the composition of the fish community.
- (Roth et al., 1996) Steedman (1988) reported that biotic integrity of Ontario streams was related to the proportion of stream channel length with riparian forest coverage. Although the extent of forested land (not counting wooded and shrub/scrub wetland) within 50-m riparian buffers was not an effective predictor of IBI values.
- (Roth et al., 1996) Riparian measures from aerial photographs did not correlate strongly with Habitat Indicator scores.
- (Roth et al., 1996) Local riparian vegetation may make some contribution to stream integrity and local patches of high-quality riparian vegetation may be necessary to prevent isolated stream reaches from suffering extreme degradation, but may not be sufficient to maintain highest quality habitat. There may be a threshold of vegetation needed to maintain high habitat scores.
- (Miltner & Rankin 1998) Protecting existing high quality riparian buffers, or otherwise restoring them, is an obvious first step towards maintaining biotic integrity.
- (Roth et al., 1996) The removal of streamside vegetation may cause a shift from allochthonous (terrestrial) to autochthonous (algal) production within low-order streams.
- (Roth et al., 1996) Habitat alteration is cited as a contributing cause in the decline of 73% of fish species extinctions in North America. Similar patterns of habitat degradation and corresponding declines of fish species have been noted in a number of Midwestern watersheds.
- (Roth et al., 1996) Habitat index values were good predictors of IBI scores. The biological integrity of the fish assemblage, as quantified by the IBI, was directly correlated with habitat quality.
- (Lammert & Allan 1999) Species richness was most highly correlated to the total IBI score.
- (Lammert & Allan 1999) HI scores were most highly correlated to the substrate size and embeddedness.

- (Lammert & Allan 1999) Indexes based on macroinvertebrates and fishes give somewhat different indications of stream condition.
- (Lammert & Allan 1999) IBI scores correlated most strongly with the coefficient of variation of channel width and flow stability. Fish abundance was strongly correlated to measures of channel morphology.
- (Lammert & Allan 1999) Analysis of both landscape and habitat variables showed that multiple factor models were better predictors of biotic integrity.
- (Lammert & Allan 1999) Simple indexes can be as effective as indexes that require additional analysis to assign taxa to functional groups.
- (Wan et al., 2010) Rare taxa may exhibit higher sensitivity to environmental disturbances and have more specialized habitat requirements, and serve as early indicators of water quality degradation or of the loss of particular habitat types.
- (Wan et al., 2010) Each taxonomic group, e.g., macroinvertebrate, periphyton, or fish, may need to be considered differently with regards to these factors.
- (Miltner & Rankin 1998) High TP concentrations across the range of stream sizes observed in this study reflects both phosphorus enrichment and degraded habitats.
- (Miltner & Rankin 1998) The control of primary nutrients to maintain biotic integrity has not been widely implemented.
- (Roth et al., 1996) Omernik et al. (1981) found that stream nitrate and phosphorus concentrations were strongly related to watershed land uses, but not to land use near the stream margins.
- (Miltner & Rankin 1998) Although concentrations are strongly related to watershed land uses, adjacent land use influences nutrient export to the stream and habitat quality within the stream may influence nutrient processing. Degraded stream channels with poorly developed riparian habitat exacerbate deleterious effects of residual nutrients via decreased riparian uptake, increased retention time due to siltation and wider channels, and by allowing full sunlight to reach the stream.
- (Miltner & Rankin 1998) Relatively small increments in nutrient concentrations in streams should have measurable effects on biological communities. Nutrients may serve as surrogates for other variables (e.g. habitat degradation, toxic substances) affecting community structure.
- (Miltner & Rankin 1998) IBI scores were negatively correlated with increasing concentrations of Total Inorganic Nitrogen (TIN) and Total Phosphorus (TP) in headwaters and wadable streams and TIN in small rivers, but no relationship was evident for large rivers. Biotic integrity of rivers and streams is negatively correlated with increasing nutrient concentration, especially phosphorus, and that differences in the indices are most defined in low order streams.
- (Miltner & Rankin 1998) Macroinvertebrate community structure may be more sensitive than are fish to water column chemistry.