Recovery Potential Metrics
Summary Form

Indicator Name: WATERSHED SIZE

Type: Ecological Capacity

Rationale/Relevance to Recovery Potential: Related more to rate of recovery than absolute capacity to recover. As a general principle, smaller ecological systems are known to recover faster than larger ones if all else is equal. Also, size is correlated with many additional, directly and indirectly contributing recovery factors: for example, increasing complexity of larger systems delaying full recovery, larger systems' restoration often being more complex and expensive, larger watersheds usually having more complex ownership and multiple jurisdictions, larger lakes' far longer residence time, and larger river systems affected by more upstream factors that are less easy to isolate and address as part of a smaller system's restoration can often do.

How Measured: Direct measurement of watershed area. An alternate size-relevant but coarser surrogate for watersheds with flowing waters is Strahler stream order.

Data Source: For digital data on watershed boundaries, numerous watershed scales have been delineated nationally as part of the Watershed Boundary Dataset (WBD) (see: http://datagateway.nrcs.usda.gov). Custom watershed boundary delineation can be done by aggregating NHDplus catchments (see: http://www.horizon-systems.com/nhdplus/) or WBD HUC12 watersheds. This metric requires the watershed defined by the impaired segment's downstream terminus (e.g., not necessarily coincident with standard HUC units). ArcGIS tools can be used to derive area measures for any set of polygons of interest.

Indicator Status (check one or more)
_______ Developmental concept.
___x__ Plausible relationship to recovery.
_______ Single documentation in literature or practice.
___x__ Multiple documentation in literature or practice.
_______ Quantification.

Comments: Potentially applicable at local to national at a range of scales. Clear instructions for calculation using the NHDplus catchments dataset would be very useful. Also the 2002 baseline dataset needs to reside online where its watershed size/Strahler order data can be accessed.

Supporting Literature (abbrev. citations and points made):

- (Hillman, M. and G Brierley 2005) The range of biophysical scales at which stream rehabilitation must operate are seldom matched by institutional structures (Dovers, 2001; Tippett, 2001; Rogers, 2002). The process of scaling-down a vision to subcatchment and reach-based actions inevitably engages with differing interests at each level.
- (Parkyn 2003) First,it may not be possible to achieve all water quality, habitat, and ecological goals at a particular site, especially when upstream areas and tributaries remain impacted. Our results suggest that canopy closure, long buffer lengths, and protection of small tributaries and headwaters are needed to reduce water temperatures and, in turn, rehabilitate invertebrate communities. [This point supports higher priority for small-med watersheds as more recoverable if the large w'sheds are assumed to be impacted by upstream impairments as well as local loadings]
- Watershed size is an under-utilized measure with implications for ecological condition and recovery. Schlosser (1990) pointed out that the life history traits of fishes in

headwater streams are more suited to recovery from disturbance. Fish in headwater streams tend to have shorter life spans, earlier sexual maturity, and smaller body size.

- Smaller streams (i.e., with smaller watersheds) also may be more likely to recover from nutrient over-enrichment than larger streams. The ability of streams to remove nutrients decreases with increasing discharge, and high order streams may actually conserve nutrients (Smith et al. 1997, Alexander et al. 2000, Peterson et al. 2001).
- (Morita and Yamamoto 2002) The occurrence of white-spotted charr increased with increasing watershed area, with decreasing isolation period, and with increasing gradient (1320).
- (Morita and Yamamoto 2002) Nevertheless, our results revealed that probability of occurrence decreased with decreasing watershed area (a surrogate for habitat size), with increasing isolation period, and with decreasing gradient (1321).
- (Rahel 2007) Colonisation of new aquatic habitats becomes increasingly easier as the spatial extent of the catchments under consideration decreases (701).
- (Holl, Crone and Schultz 2003) Restoration efforts have typically focused narrowly on how to restore a given piece of land or waterway, and these efforts have not received much attention from academic ecologists. It is widely recognized that the long-term success of these efforts depends on the landscape matrix in which the projects are embedded (Hansson et al. 1995, Bell et al. 1997, Hobbs 2002).
- (Holl and Crone 2004) Local factors explained more of the variance in understorey plant communities, but much of the variance remained unexplained. Our results provide weak support for the predictions of island biogeography theory and the importance of landscape-scale variables. These theories did not have strong predictive power in this applied restoration context at this temporal scale. Given limited resources, efforts to restore understorey plant communities in this highly fragmented system should focus on local-scale restoration methodologies, such as increasing cover of native overstorey species and reducing cover of exotic plants.
- (Nakamura, Tockner and Amano 2006) Thus, Japan provides an excellent model for integrated catchment management practices, not only because of its relatively small catchments that respond rapidly to management practices, but also because of the strong social linkages between upstream and downstream human communities.
- (Verhoeven, Soons, Janssen and Omtzigt 2008) Our aim is to provide guidelines for combining ecological knowledge on the spatial requirements of species with the spatial distributions and connections of ecosystem processes in order to develop more effective regional conservation strategies. The OLU (Operational Landscape Unit) approach aims to preserve and, where necessary, restore those landscape elements that key species and ecosystem functions require to operate successfully. Preservation and restoration of a carefully selected subset of small landscape elements in an area will often be less costly but at least as effective as conservation of a large area. Preserving or restoring corridors and hydrological pathways will maintain ecological networks. This will be more effective than the preservation and restoration of small isolated areas within the landscape.
- (Budy and Schaller 2007) In spite of these efforts and expenditures, however, there are few examples where stream-restoration projects have been deemed effective at meeting their overall goal (NRC 1996, Wissmar and Bisson 2003). As such, there is a long list of reasons why many stream restoration efforts may fail to recover the targeted animal population, including (1) our understanding of highly variable and dynamic riverine ecosystems is incomplete (e.g., Roper et al. 1997, Wissmar and Bisson 2003, Juracek and Fitzpatrick 2004, Montgomery 2004) and (2) other factors (chemical, biological, or other physical) that may occur at larger spatial and temporal scales and that persist after habitat restoration and continue to limit the population (Frissell and Nawa 1992, ISG 1999, Rieman et al. 2001). This history of frequent failure in stream-restoration efforts points to the need for approaches that are less mechanical, more holistic, and based on the concept of restoring ecological function at the appropriate spatial and temporal scale for targeted species (Kauffman et al. 1997, Beechie and Bolton 1999, Lepori et al. 2005).

- (Gore and Shields Jr. 1995) Restoration and rehabilitation projects on small streams and rivers have been common practice for many years, and a considerable body of knowledge on restoration techniques and expectations of success exist (Gore 1985, Newbury and Gaboury 1993). However, restoration and rehabilitation projects for large river systems are far less common (Regier et al. 1989), and there is little ability to predict success or monitor recovery (Gore and Milner 1990). Furthermore, restoration projects for large rivers, particularly those with high channel erosion potential are extremely expensive (Kern 1992).